EDN

computer hardware In this Issue

exclusively for designers and design managers in electronics

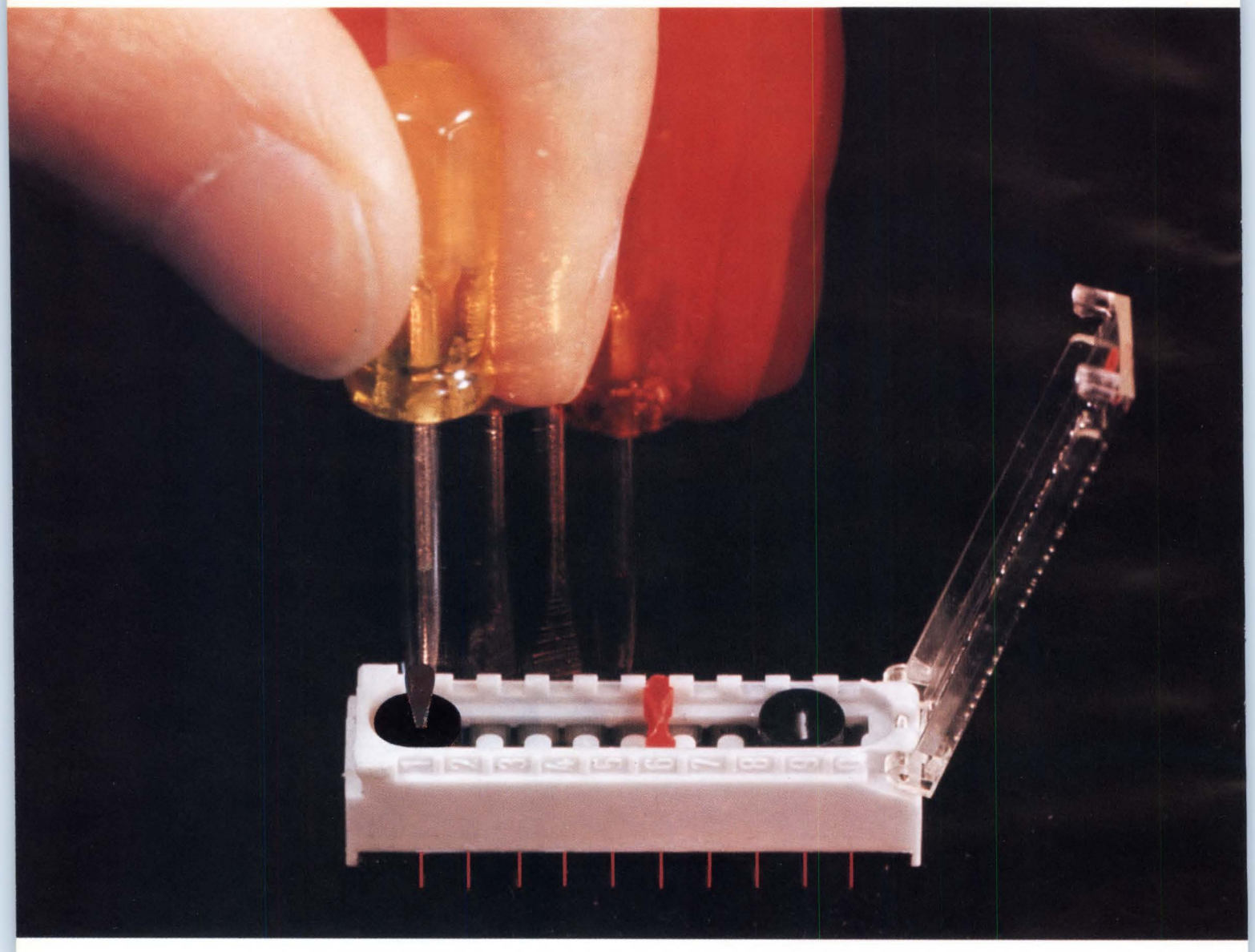
EEE

Miniature switches squeeze into tight spaces

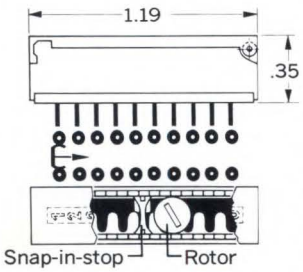
A CAHNERS PUBLICATION

MARCH 15, 1972

Siemens



Introducing the rotary slide switch for PC boards. Ten positions. Multi-circuit switching. Low profile package.



Siemens is introducing a completely new kind of programming switch for closely racked PC boards and for other tight-space applications.

To set the switch just snap open its transparent dust cover and twist the rotor with a screwdriver. This moves the switching element linearly from one of the detented positions to another.

The compact switch has ten pairs of gold-plated contacts and is available with additional rotors for independent switching of up to three circuits. Easy-to-insert snap-in stops separate circuits.

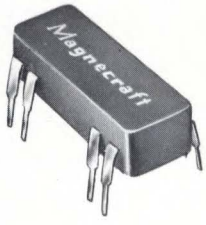
Siemens Corporation,
186 Wood Ave. So.,
Iselin, N.J. 08830.
Call 201-494-1000.

SIEMENS

CIRCLE NO. 1

DIP

DUAL-INLINE-PACKAGED REED RELAYS



Magnecraft is proud to announce its new DIP (dual-inline-package) line of 8-pin reed relays. These new relays are designed not only to be compatible with the standard packaging developed for integrated circuits, but to offer Magnecraft quality at a low cost. This unique design gives further savings by offering the user the optimum in automated insertion and other economical installation techniques associated with printed circuit applications.

These fantastic new epoxy molded reed relays are ideal for use in circuits where high density packaging is essential. The 5VDC IC compatible versions of these relays will operate directly from TTL or DTL circuits.

Other standard coil voltages are available from stock in 6, 12, and 24VDC as well as contact configurations in 1 form A, 2 form A, 1 form B, and 1 form C. Most versions are also offered with a choice of an internal clamping diode.

Magnecraft® ELECTRIC COMPANY

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FREE!

REED RELAY HANDBOOK

The purpose of this 120-page handbook is to assist the design engineer in specifying the proper reed relay for a given application. The book contains a glossary of terms, principles of operation, applications and design requirements as well as specifying and testing data. New products include the complete line of DIP Reed Relays.

See you at IEEE Booth 1408

CIRCLE NO. 2

Sorensen solutions to line voltage problems.

Whether you have brownout, line noise, or other AC problems, Sorensen has the solutions... ACR regulators and FR conditioners. Both help end costly equipment downtime, or even catastrophic failure. ☐ The ACR Series is an amazing combination of price, power, performance, packaging, and ruggedness. Eight models cover the field. With 0.5 to 15 kVA, remote sensing and programming, and full load efficiency to 95%. ☐ FR's are something else. Fast! Response and impulse settling time: 50 microseconds or less. 100 decibels of common mode rejection. Harmonic distortion of 0.2%. Regulation to 0.05%. Peak amplitude instability of less than 0.01%. 2.5 crest factor. With FR, you get just what you want — pure AC power. ☐ Sorensen offers more. Solid state circuitry, conservative thermal design, compact packaging. See the table below. For more complete data, write Sorensen Power Supplies, Raytheon Company, 676 Island Pond Road, Manchester, N.H. 03103. Telephone (603) 668-1600.

ACR Series

Model	Output		Input		Voltage Regulation		Price*
	Voltage (Vac) (Settable Range)	VA	Voltage (Vac)	Freq (Hz)	Line	Load	
ACR500		500			±0.1%	±0.1%	$ 380
ACR1000		1000			±0.1%	±0.1%	$ 450
ACR2000		2000			±0.1%	±0.1%	$ 575
ACR3000	110	3000	95	47-53	±0.1%	±0.1%	$ 700
ACR5000	to	5000	to	or	±0.15%	±0.15%	$ 850
ACR7500	120	7500	130	57-63	±0.15%	±0.15%	$1025
ACR10000		10000			±0.15%	±0.15%	$1450
ACR15000		15000			±0.15%	±0.15%	$1775

FR Series

Model	Output		Input		Combined Regulation	Price*
	Voltage (Vac)	VA	Voltage (Vac) (Switch Selectable)	Freq (Hz)		
FR516A**	115	500	95-115/105-125/115-135	59-61	±0.05%	$ 925
FR1016A	115	1000	95-115/105-125/115-135	57-63	±0.05%	$1500
FR1015A	115	1000	95-115/105-125/115-135	47-53	±0.05%	$1500
FR1026A	230 (115 opt.)	1000	190-230/210-250/230-270	57-63	±0.05%	$1650
FR1025A	230 (115 opt.)	1000	190-230/210-250/230-270	47-53	±0.05%	$1650
FR2516A	115	2500	95-115/105-125/115-135	57-63	±0.05%	$3425
FR2515A	115	2500	95-115/105-125/115-135	47-53	±0.05%	$3425
FR2526A	230 (115 opt.)	2500	190-230/210-250/230-270	57-63	±0.05%	$3650
FR2525A	230 (115 opt.)	2500	190-230/210-250/230-270	47-53	±0.05%	$3650
FR5016A	115	5000	95-115/105-125/115-135	57-63	±0.05%	$6800
FR5015A	115	5000	95-115/105-125/115-135	47-53	±0.05%	$6800

**No CM Rejection

*USA List

Sorensen
POWER SUPPLIES

CIRCLE NO. 3

Try our straightforward method of reducing fixed resistor costs.

You can't blame engineers or purchasing agents for trying to save every last penny on resistors these days. But lowest price doesn't necessarily mean lowest cost. For example, most manufacturer's color bands won't stand up to the cleaning methods used to remove excess flux. Or they darken and become illegible from the heat produced in normal usage. This can mean costly identification errors on your production line. The unnecessary expense of rework. Our solution? A-B quality. Bright, crisp identification of Allen-Bradley's specially formulated paints. Baked on to stay on. Designed to resist aging. Discover the other ways to save money. Ask your nearest A-B distributor for our free booklet "7 ways to tell the difference in fixed resistors." Or write Allen-Bradley Electronics Division, 1201 South Second Street, Milwaukee, Wisconsin 53204. Export: Bloomfield, New Jersey 07003. Canada: Galt, Ontario. United Kingdom: Bletchley, Bucks.

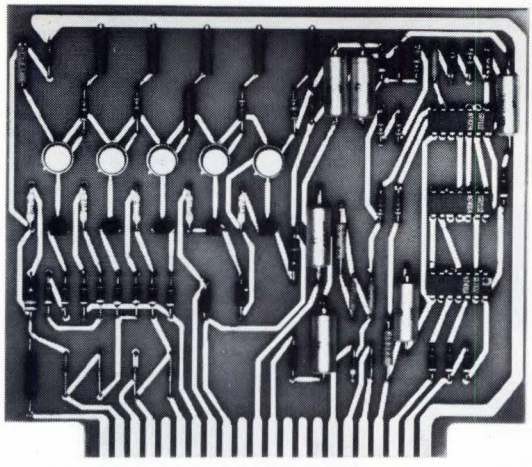
NEW DIMENSION ELECTRONICS

ALLEN-BRADLEY

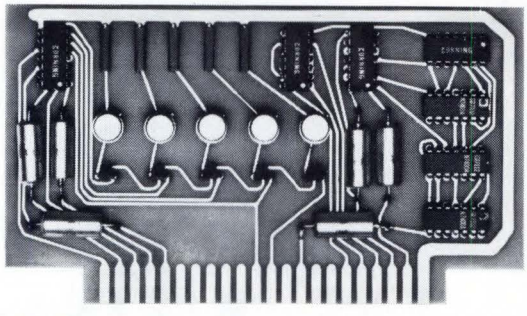
A-B QUALITY

CIRCLE NO. 4

IC's let you make your board smaller.



CORDIP™ component networks let you make your board even smaller.



With Corning's new CORDIP component networks, all the space-saving and insertion cost-reducing benefits of IC's are extended to outboard discretes.

Not a screened network, but a network of discrete resistors, capacitors, and diodes in a dual in-line package.

With up to 20 components in a standard 14-pin package. Up to 23 in a 16-pin package. With all inter-connections inside the pre-tested package.

So you get greater reliability, have fewer parts to order and keep track of. And get rid of production-handling errors.

CORDIP component networks are fully compatible with automatic IC sequencing insertion equipment, too.

With CORDIP component networks it's simple to put more circuitry on the same board or the same circuitry on a smaller board.

CORDIP component networks. They save you a lot more space and a lot more work.

Write or call for complete technical specifications.

Corning Glass Works, Electronic Products Division, Corning, New York 14830.
(607) 962-4444, Ext. 8684.

SPECIFICATIONS

	Resistors	Capacitors	Diodes
Range	10Ω-150K	10-27,000 pF	Low Signal
Tolerance	from 1%	from 5%	
TC	from 50 ppm	+ 2%, −10%	Silicon Planar
Ratio	>15,000:1	>2,700:1	Types

CORDIP™ COMPONENT NETWORKS
From

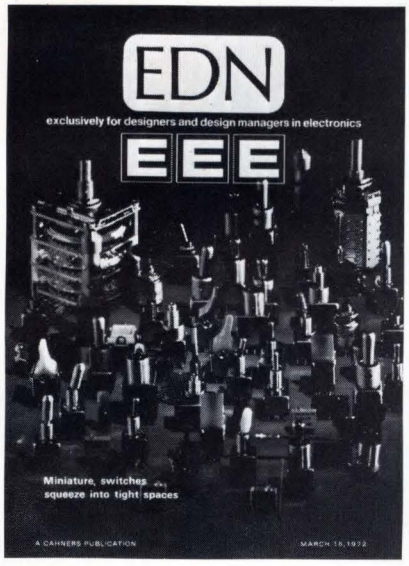
CORNING
ELECTRONICS

CIRCLE NO. 5

MARCH 15, 1972
VOLUME 17, NUMBER 6

EDN/EEE

EXCLUSIVELY
FOR DESIGNERS
AND DESIGN MANAGERS
IN ELECTRONICS



COVER

The vast array of miniature switches available to designers is highlighted in photo supplied courtesy of Cutler-Hammer, Milwaukee, Wisconsin, Donald N. Emmerich, photographer. See story on p. 28.

DESIGN NEWS

DESIGN FEATURES

PROGRESS IN PRODUCTS

DESIGN PRODUCTS

DESIGN DEPARTMENTS

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ELECTRONICS WEEKLY
EDN/EEE
ELEKTRONIK
ELEKTRONIK-ZEITUNG
INTER ELECTRONIQUE

Everybody wants your components business.

But we're doing 6 things to earn it.

1 We build extra reliability into all our components. Documented reliability from ER through industrial, from precision through general purpose. To let you build extra reliability into all of your systems.

2 Our pricing is more than just competitive. If it weren't, why else would our customers have made us the largest supplier of metal film resistors in the country? And that metal film market includes glazed resistors.

3 We insist on delivery you can count on. Our "ball parks" are dependable. And our distributors provide off-the-shelf delivery from an inventory in excess of 50,000,000 components. To let you reduce expediting and inventory levels.

4 Our QC and unique product configurations make your production more efficient. Many of our customers find they can totally eliminate incoming QC testing of our parts. Others find our parts greatly simplify both hand insertion and automatic insertion operations.

5 Our new products can give you better alternatives. Like our FAIL-SAFE™ flame proof resistors. They open – never short – under overload. Plus they're economical replacements for non-inductive and semi-precision power wirewounds.

6 We back everything with the best support team in the business. We have the industry's largest technically-trained field force. And a select team of the industry's most service-oriented distributors. Because we know it takes top service to compete for your business.

Like everyone, we want your components business. But we're intent on doing more to earn it. Let us prove how much more on your next project. Write: Corning Glass Works, Electronic Products Division, Corning, New York 14830 or Call: (607) 962-4444, Extension 8381

CORNING
ELECTRONICS

Resistors & Capacitors

for guys who can't stand failures

CIRCLE NO. 6

SAVE $$$ // GAIN performance

over any other 50-MHz, plug-in oscilloscope.

50-MHz oscilloscope with:

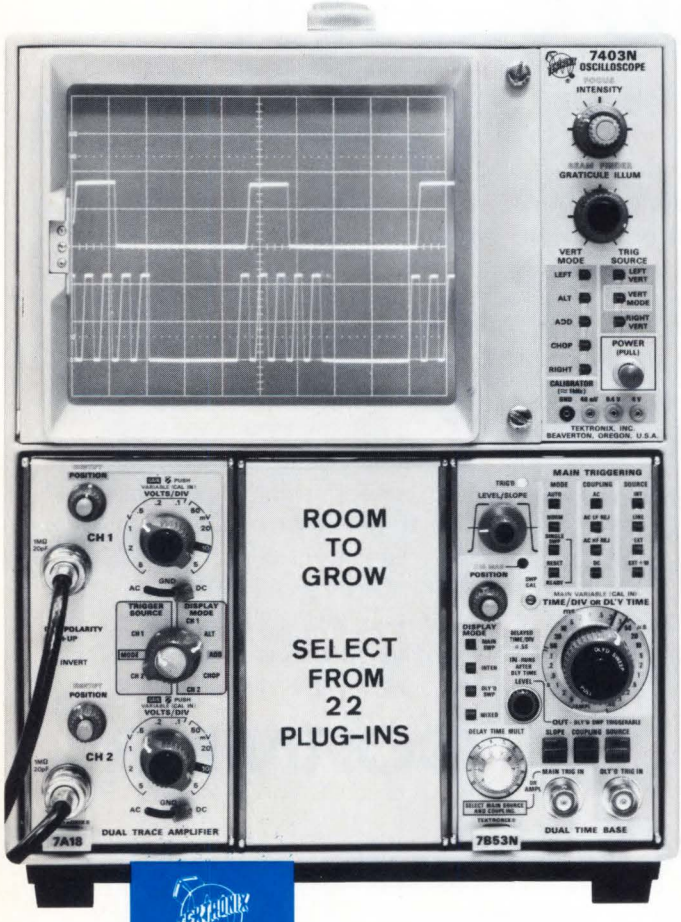
5-mV dual-trace amplifier and delaying sweep **$2200**

5-mV dual-trace amplifier and single time base **1900**

5-mV single-trace amplifier and single time base **1670**

AND LOOK AT THESE BONUSES:

- ☑ 3 plug-in compartments and mainframe mode switching
- ☑ 6½-inch CRT — 50% larger than 8 x 10 cm CRT's
- ☑ time bases have 5 ns/div sweep rate
- ☑ amplifiers and time bases accurate within 2%
- ☑ high writing-rate CRT gives a brighter trace
- ☑ 5¼-inch rackmount version



If you wish, select a plug-in for the second vertical compartment to give you 10 μV/div at 1 MHz *or* 1 mV/div at 55 MHz *or* 1 mA/div at 55 MHz *or* another dual-trace unit for 4-trace capability, etc., etc. Plug-in prices start at a low $270. Call your nearby TEKTRONIX Field Engineer today for a demonstration, or write: Tektronix, Inc., P.O. Box 500, Beaverton, Oregon 97005.

7403N Oscilloscope	$950
R7403N Oscilloscope	$1050
7A18 Dual-Trace Amplifier, Option 1	$500
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committed to technical excellence

CIRCLE NO. 7

Editorial

Do we really want to scuttle the shuttle

While visiting a large electronics plant recently, we overheard a heated argument between two engineers over NASA's proposed space shuttle.

One fellow was for the development of the shuttle because, as he put it, "the aerospace industry needs the program to get back on its feet." The other engineer was opposed because he felt it would result in the 1960's all over again—with a booming aerospace business, lots of jobs and high pay, and then BOOM—the bottom would fall out.

Both of these positions have some merit and were honest expressions, we're sure, of how the two engineers felt. (We found out that both had at one time worked in the aerospace industry.) We question, though, whether the future of the space shuttle should be argued on the basis of whether it's good for the aerospace industry, or how many jobs it would provide and for how long.

No doubt about it. The shuttle, if developed, will represent vast Federal expenditures. NASA's present plans call for the program to be carried out over the next six years at a total cost of about $5.5 billion. To date almost $200 million of this has been appropriated, with another $227.9 million requested this year for Fiscal 1973. This leaves over $5 billion to go, which is a lot of bucks no matter how you look at it.

The critical question, it seems to us, is what will we get for the money? And will it represent an investment in the future or a giant boondoggle?

As we see it, there are good, substantial reasons for going ahead with the space shuttle. First, given any reasonable amount of space activity in the future, the shuttle should make manned and large unmanned launchings less complex and costly thanks to its reusable nature.

Second, the shuttle will make it possible to do things in space which are now impossible. And this includes scientific, civilian and military applications. For example, communications and weather satellites could be repaired or modified while in orbit. This would not only save money, but would make it practical to develop satellite systems with much greater capability than we now have.

The shuttle would also make it possible for nations now excluded from space because of the exorbitant launching costs to participate in the scientific end of space exploration. This is no small goal, inasmuch as the Earth and its space environs belong to all nations, and we Americans have no monopoly on scientific wisdom and expertise.

Notwithstanding the fact that we have all sorts of social and environmental problems that could use large doses of Federal funds, we feel that the space shuttle represents a worthwhile program for the 1970's.

Frank Egan

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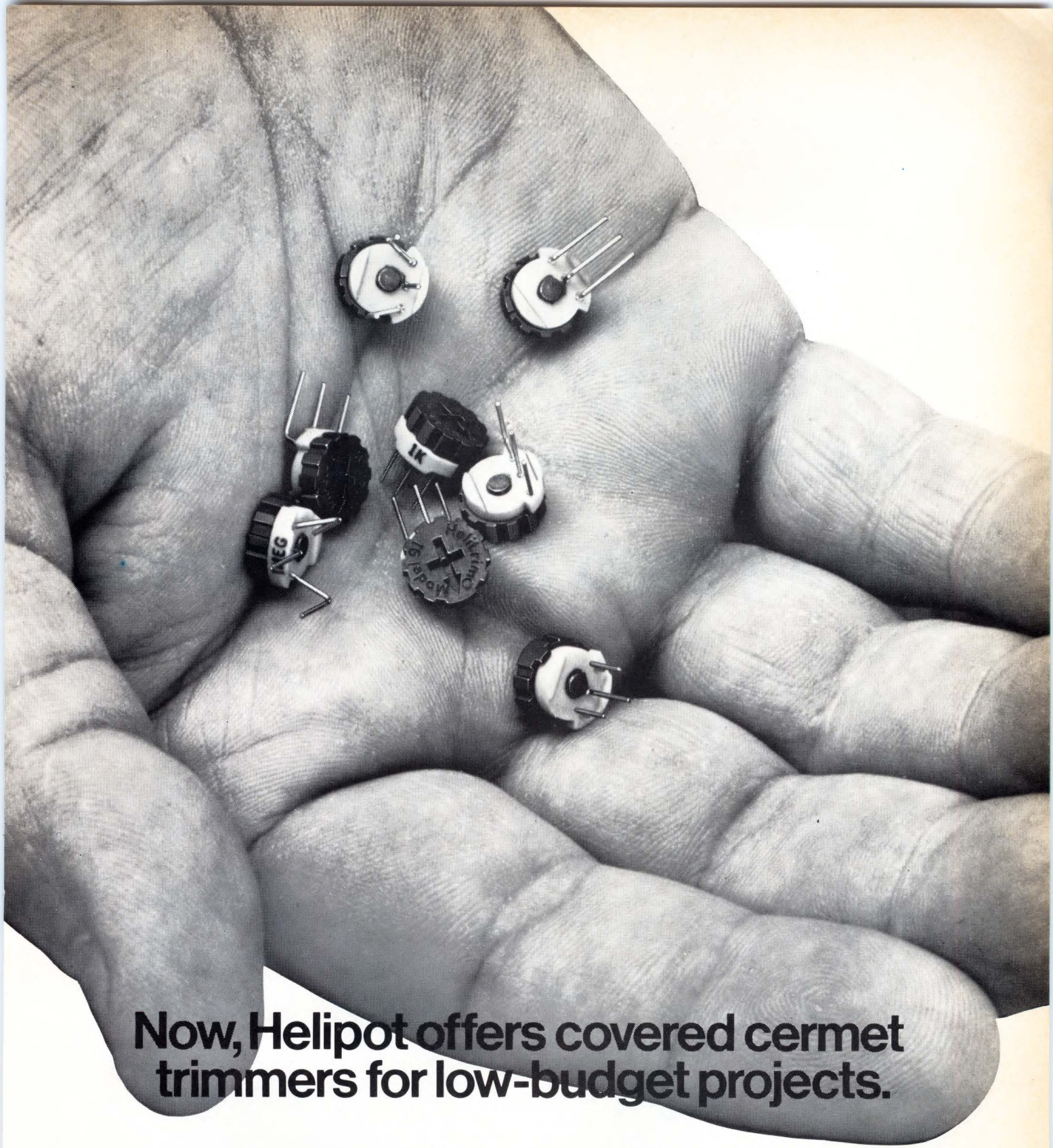

Now, Helipot offers covered cermet trimmers for low-budget projects.

There's not much sense in using cheap wirewound or carbon trimmers anymore. Not when the new Helipot Series 91 Cermet Trimmers are available *off-the-shelf* for a few cents more.

These single-turn, 3/8", covered trimmers come in 10 different mounting styles and 19 standard resistance values from 10 ohms to 2 megohms. Covered construction helps protect against moisture, corrosive atmospheres, dust, oil and other contamination. Which means, in addition to cermet stability and better resolution, you get long-term dependable performance.

The breakthrough price is just 35¢ each in the 50,000 piece quantity, and they're equally well-priced in other quantities.

Send now for complete data on the Series 91 Trimmers... the finest of their class. We've made them for your projects where the budget may be tight, but you don't want to compromise performance.

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CIRCLE NO. 9

P&B solid state hybrid relays work up to 100 times longer than conventional relays.

More than 10^7 operations.

The expected minimum life of P&B Solid State Hybrid Relays is in excess of 10 million operations for standard load current and ambient temperature combinations.

This uncommon longevity, plus exceptional reliability and a wide range of switching options, offers solutions to many critical switching problems. For example, you can interface semiconductor logic circuits with inductive loads like motors, solenoids and contactors.

P&B Solid State Hybrids will switch up to 7 ampere loads with input control signals as low as 60 microwatts. And they come in a variety of package sizes and terminal styles.

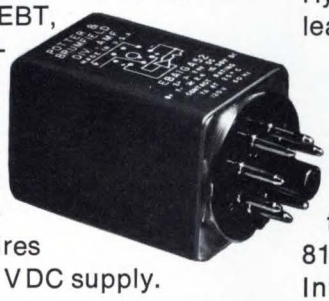
Special triac, special reed

P&B Hybrids owe much of their reliability and outstanding performance to the combining of a reed relay and triac, each having characteristics specially selected to complement the other. This careful mating of semiconductor and relay greatly enhances the reliability of each and, in combination, produces a switching function of consistently superior performance.

Special snubber network

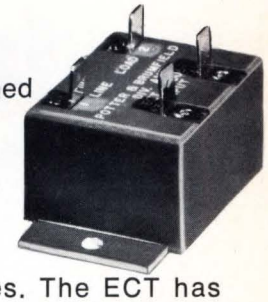
The internal RC network across the "contact" is tailored to the triac specifications and "contact" load ratings to limit sporadic, transient-induced conduction, to provide reliable turn-off of inductive loads, yet to minimize the off-state 60 Hz leakage current.

EBT Series switches 7 amps, 60 Hz @ 25° C ambient with normal load voltage of 120 V. Rated 5 amps. rms 60 Hz @ 55° C ambient. Operate time, 2 msec. Release time, 10 msec. Coil voltages from 6 to 48 VDC at nominal power of 290 mW. Has conventional octal-type plug-in terminals for mounting convenience. Fits P&B KR Series 8-pin sockets for conversion to screw terminals.



EBA Series has the same switching characteristics, package and mounting of EBT, but with control signal amplifier. Standard sensitivity is 60 microwatts. Requires 12, 18, or 24 VDC supply.

ECT Series has similar specifications as EBT but with a special package designed for direct to chassis mounting. Widely used in business machines and appliances. The ECT has quick-connect terminals. Screw-terminal adapters available.



JDB Series is a Dual Thin-Line reed-triggered triac for use on printed circuit boards. Designed for interfacing solid state circuits to 120 V 60 Hz loads such as contactors, fractional HP motors and solenoids. Form A contacts will switch 1.7 amps. at 25° C ambient or 1.0 A rms 60 Hz at 55° C ambient.

Potter & Brumfield Solid State Hybrid relays are available from leading electronic parts distributors. For complete information call or write your nearest P&B representative or Potter & Brumfield Division of AMF Incorporated, Princeton, Indiana 47670. Telephone 812 385-5251. In Europe, AMF International Limited, Oxford, Oxon, England and AMF Electrica, S.p.A., Milan, Italy.

AMF
Potter & Brumfield

P&B makes more of more kinds of relays than anybody in the business.

Anybody.

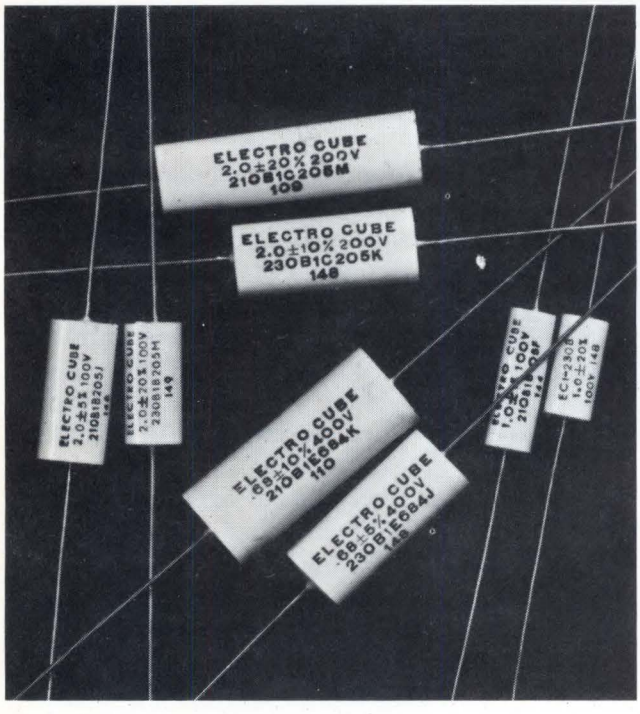
CIRCLE NO. 10

Electrocube metallized mylar capacitors are first with the least.

We mean the least volume. As little as 39% of standard units. A 2.0 mfd 100 VDC unit is only .25 x .34 x .78 instead of .33 x .49 x .95. Look at the before and after comparisons below. And they're smaller without changing performance or price.

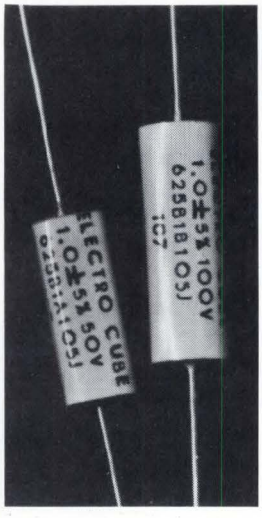
Capacitance values are from .0010 to 50.0 mfd. Voltage ratings are 100, 200, 400 and 600 VDC. More than 840 case sizes and six case styles, including epoxy and hermetically sealed metal cases are available in this new 230 series. We're ready to ship them from stock in small quantities, and in 4-5 weeks for production.

Our 230 series is first with the least, but some of our other series were first with the most. Like our full lines of AC rated metallized polycarbonate, and 50 V metallized polycarbonate capacitors. See brief descriptions at the right.



50 V metallized polycarbonate

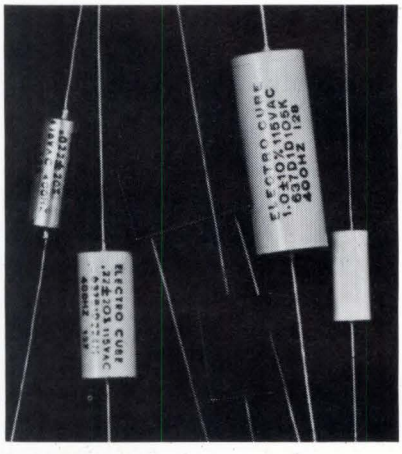
Smallest polycarbonate capacitors. As much as 30% less volume. .33 x .73 instead of .47 x 1.20 for 1.0 mfd units, for example. Values range from .0010 to 50.0 mfd. More than 140 standard case sizes, and ten case styles are available.



AC rated metallized polycarbonate

241 different units. Values from .0010 to 2.0 mfd, for 115 VAC, 400 Hz. Six case styles are available. But the real plus is full AC rating. Every unit is manufactured, tested and screened for AC operation. These aren't just derated DC units.

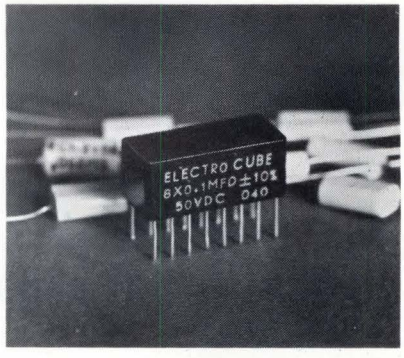
We'll send you data sheets and a bulletin that discusses problems in using DC capacitors for AC applications.



DIP packaging

Up to eight different capacitors in a case .33 x .38 x .815 inch. Eight 0.1 mfd 50 VDC metallized polycarbonate or .068 mfd 100 VDC metallized mylar, for example.

Call (213) 283-0511, TWX 910-589-1609, or write to 1710 South Del Mar Avenue, San Gabriel, California 91776.

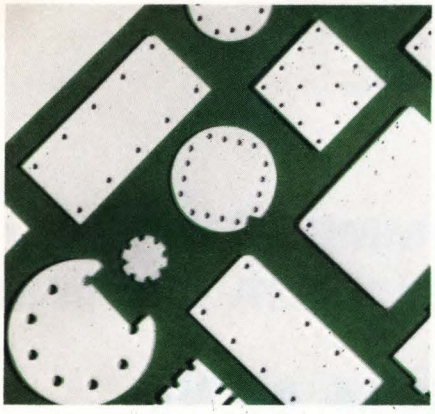


electrocube

Capacitors, EMI filters,
RC networks, transformers, ballasts

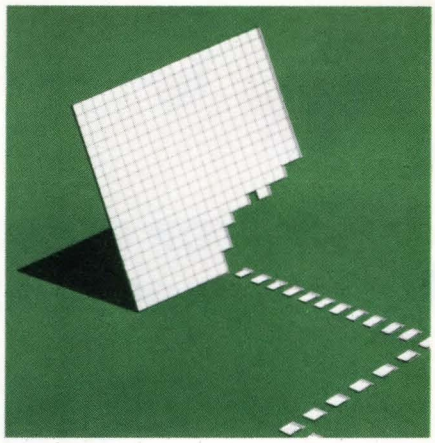
CIRCLE NO. 11

AlSiMag® BRAND COMPONENTS FOR HYBRIDS



SUBSTRATES

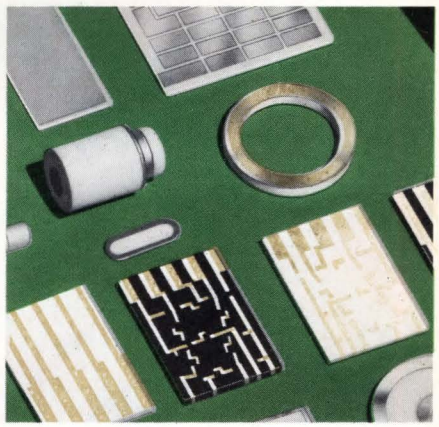
Many advanced ceramic substrate materials for thick film, thin film and microwave applications are available to suit your exacting requirements. Many sizes are stocked for immediate delivery. Custom prototypes can be quickly manufactured. High volume production fulfills your needs. New Bulletin 712 on request or phone 803/682-3215.



SNAP-STRATES

Originated by American Lava, these monolithic parts can be snapped into individual substrates after circuit work is completed. Tooled Snap-Strates permit odd shapes, holes, slots, etc. Laser Snap-Strates permit very small or thin parts of great accuracy.
Phone 803/682-3215.

CIRCLE NO. 81



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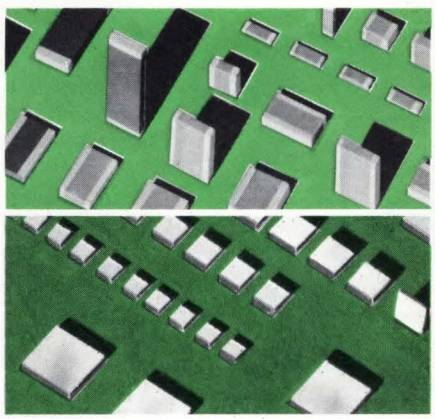

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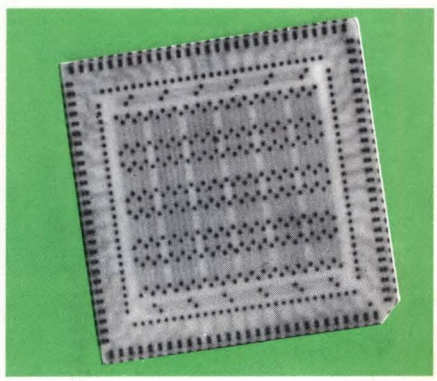

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No wonder this Select-Compare Data Register for industrial control systems or computers has a total quiescent power dissipation of just 25 μW at 5 V_{DD} and operates virtually regulation free over a 3 to 18 V range.

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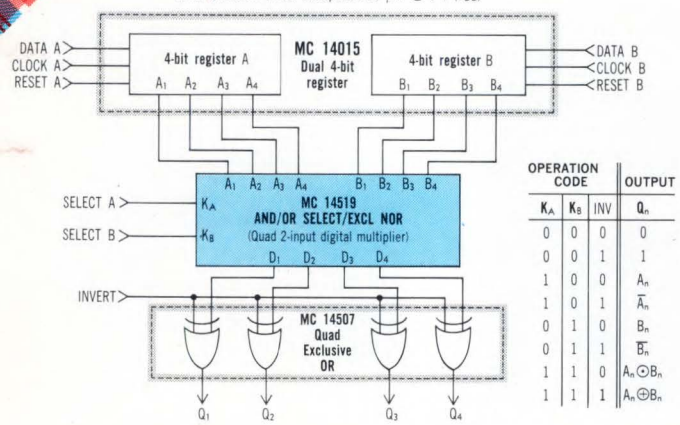
Select-Compare Data Register

Total Quiescent Power Dissipation 25 μW @ 5 V (V_{DD})



OPERATION CODE			OUTPUT
K_A	K_B	INV	Q_n
0	0	0	0
0	0	1	1
1	0	0	A_n
1	0	1	$\overline{A_n}$
0	1	0	B_n
0	1	1	$\overline{B_n}$
1	1	0	$A_n \oplus B_n$
1	1	1	$A_n \oplus B_n$

McMOS FAMILY

Motorola Device #	Function	Replaces Pin for Pin	Price (100-999)
MC14001AL	Quad 2-Input	CD4001AD	$ 4.15
MC14001CL	NOR gate	CD4001AE	1.18
MC14002AL	Dual 4-Input	CD4002AD	4.30
MC14002CL	NOR gate	CD4002AE	1.22
MC14011AL	Quad 2-Input	CD4011AD	4.15
MC14011CL	NAND gate	CD4011AE	1.18
MC14012AL	Dual 4-Input	CD4012AD	4.30
MC14012CL	NAND gate	CD4012AE	1.22
MC14013AL	Dual type D	CD4013AD	5.95
MC14013CL	Flip-Flop	CD4013AE	2.40
MC14015AL	Dual 4-bit shift register	CD4015AD	12.65
MC14015CL	serial in/parallel out	CD4015AE	5.60
MC14507AL	Quad Exclusive-OR	CD4030AD	4.74
MC14507CL	gate	CD4030AE	1.86
MCM14505L	64-bit RAM	—	25.00
MC14501AL	Triple Gate	—	4.30
MC14501CL		—	1.99
MC14508AL	Dual 4-bit latch	—	24.70
MC14508CL		—	13.75
MC14519AL	4-bit	—	4.75
MC14519CL	AND/OR Select	—	2.10
MC14021AL	8-bit P/S shift register	CD4021AD	12.24
MC14021CL		CD4021AE	5.20
MC14027AL	Dual J-K	CD4027AD	6.60
MC14027CL	Flip-Flop	CD4027AE	3.18

Recent Introductions

MOTOROLA MOS
Directions in digital designs

CIRCLE NO. 12

HP's Family Plan:

or how to add extra value to spectrum analysis.

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SIGNAL ANALYZERS

CIRCLE NO. 13

R&D famine leaves ISSCC in rut ... but some new developments emerge

Philadelphia—If anybody doubts that the severe cutbacks in U.S. Government spending on R&D have not had an effect, they only had to attend this year's ISSCC (International Solid State Circuits Conference). They would have seen a subdued gathering of mature old hands—the survivors of the golden era of the '60's—listening to what amounted to largely updated papers of work that was gotten off the ground before the ax fell.

Here are some examples:

•Intel Corp.'s 4096-bit random-access memory (Paper 1.1). (This was most impressive, as so much of the support circuitry is also on the chip, but nevertheless a continuation of work announced in the 1970 ISSCC.)

•Stanford U. graduate students work in developing low-power medical electronic circuits and systems. Prof. Jim Meindl is to be commended for the steady progress made by his group but at least two of the four papers they presented (papers 2.5 and 16-1) had roots in work reported at previous ISSCC's.

•RCA report on performance of CMOS products made on its SOS (silicon-on-sapphire) pilot production line (Paper 8.5).

•Philips' progress on bucket-brigade charge-transfer shift registers (Paper 12.5).

This list could easily be expanded. It is not that these "update papers" are not valuable; for some of them in their continuity represent the most valuable work going on.

Among the few original announcements noted at ISSCC were:

•Sony paper, 16.3, "Nonvolatile, Electrically-Alerable MAOS Memory." The built-in ability to hold charge and change the MOS devices' gate thresholds was reported to be exceptionally stable with time: the authors predicting it would last for 100 years.

•Motorola's "upside down" amplifiers for automotive applications. PNP transistors were used in a configuration (**Fig. 1**) that allows differential action referenced to ground despite a single-polarity supply. (Paper 10.2)

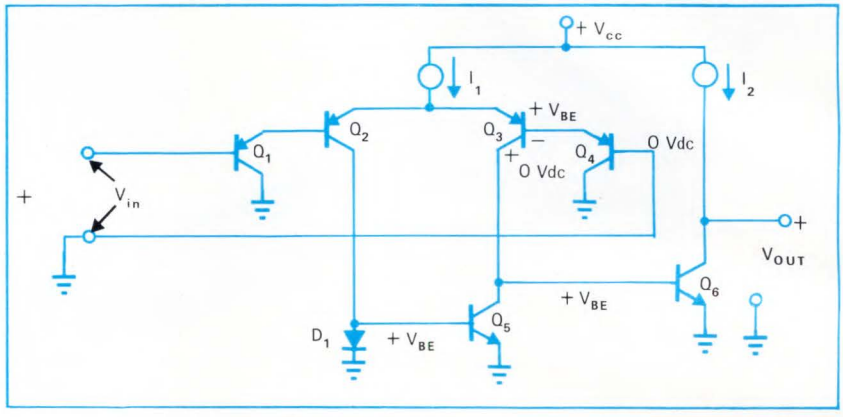


Fig. 1—**"Upside down" amplifier** developed for automotive applications by Motorola will handle differential signals referenced to ground despite its single-ended power supply.

•Stanford U. development of a way of making CMOS circuits that will operate at voltages as low as 0.3V (paper 16.5)

•Texas Instruments perfection of a MOSFET for detecting surface waves that should be useful for future delay lines and signal correlators (paper 16.4).

There were a scattering of circuit-system papers that were individually intriguing. The high-speed hybrid correlator (paper 8.4) and the high-speed A/D converter (paper 13.2) were examples of papers that would have pleased died-in-the-wool circuit designers, that supposedly dying breed of man for whom the ISSCC was originally intended. So also, would have the papers on low-cost A/D conversion (Nos. 13.4 and 13.5).

Still, many attendees that EDN question agreed that there was a slowdown in young, fresh circuit creativity. One ISSCC past chairman speculated that those who are still doing creative circuit work are now more likely to be developing new products for the commercial market and not "playing around" on government contracts. Private companies hoping to develop new products for today's competitive markets have little to gain by letting their designers tip their hands at ISSCC, for past history has shown that the ISSCC audience is quick to appropriate designs that have commercial potential. (Witness the large number of companies that came out with multipliers based on the circuit Barry Gilbert announced at the '68 ISCC.)

Get out and hustle LSI!

One irrefutably new element in the meeting was the sudden interest in technological market forecasting, with two speakers being particularly noteworthy. These were J. Fred Bucy, Texas Instruments, Inc., and G. Villa, electronics division, Fiat Company, Italy.

Bucy pounded home a point that has become painfully apparent to our industry: if you want to see the wonders of our technology earn a living for us, you have got to get that technology to the end customer. You can't just hope that equipment makers will incorporate more electronics in their products, because we have already saturated most of the equipment makers who are sympathetic to electronics. To get our maximum bite into the GNP, we must go right to the end customer, see what his problems are

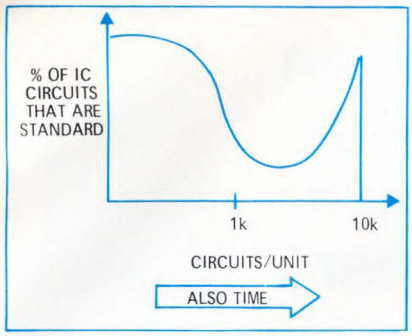


Fig. 2—As LSI grows toward the 10k circuits per chip level, it will again become more standard, Bucy of T. I. predicts.

that we can solve and transform our technology into these products. If this means bypassing the traditional equipment and product and service providers in certain markets, that is what we must do.

Bucy was sarcastic about the ISSCC audience and their childish faith that their solid-state innovations would keep their stomachs full. We don't need any more inventions—we need to turn our present oversupply of inventions into products that the rest of the nation and world will pay us for. The economics of LSI (**Fig. 2**) will take the labor content out of electronic products and solve the foreign competition problem, he added, especially when whole subsystems are standardized on single chips.

The reward for getting products into real-world marketing loops will be that we will continue to experience our high rate of growth and have $110 billion share of the Free-World GNP, Bucy said. Otherwise, we'll drag along; there will be little incentive for anybody to support your salaries, he warned the audience of R&D types.

Villa of Fiat gave some very pointed directions to designers interested in getting in on the automotive electronics market boom. He said that European car designers were more sensitive to the need for electronics because their smaller cars can't support the bulk and weight of the gears and levers needed to accomplish functions in the traditional mechanical manner.

Villa forecast the main growth in automotive electronics would come in the 1974 to 1978 period, when the electronic content would jump from its present virtually zero per cent to 10% (or from $60 to $150 for average priced cars). He predicted that while the first electronic systems for functions like skid-control would be individual analog units, soon all the electronics (except the sensors and actuators) would be integrated into a small central digital computer. These computers would use CMOS logic because of its immunity to battery voltage variations and noise spikes. ■

Memory topics cover wide span at ISSCC

N-channel MOS, charge coupled devices, and self-refreshing techniques were the major semiconductor topics covered at the SJCC. Honeywell Information Systems described an inverting cell concept that cuts storage power in half and refreshes automatically. Using a 3-MOS-transistor cell, the Honeywell technique inverts the stored data in their 2048-bit RAM at each refresh clocking. Integral logic circuits decode the output, since a stored bit may be not only a one or zero but true or false at any given time. Another self-refreshing technique using a gated capacitor in a 1024-bit MOS-RAM was described by Electronic Arrays, and GE described a charge-pump RAM and a surface charged RAM.

A working CCD memory

IBM Components Division revealed a working charge-coupled device memory which is plug compatible with IBM systems. The memory cards, shown in **Fig. 1**, measure 3 by 4 inches and contain 5760-bits of memory and all support circuitry. Six memory chips of 960-bits each are used in the system with each storage cell requiring only 0.05 mil² of chip surface. Typical access time for the

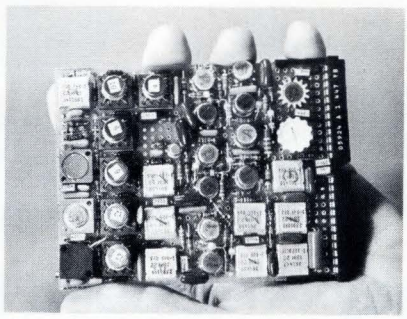


Fig. 1—Operational charge-coupled device memory built for evaluation by IBM was unveiled at ISSCC. Operated as a buffer memory, it has proven compatible with present IBM systems.

memory is 25 msec at a data rate of 5 MHz.

4096-bit MOS-RAMs

The opening paper of the memory sessions described the Intel 2107, a 4K-bit dynamic RAM which quickly became one of the most widely discussed devices at the conference. It's a N-channel, silicon-gate dynamic RAM, with its high density (2 mil²/cell) achieved through a unique three-transistor memory cell geometry. All interfaces except the clock input are TTL compatible. A 12-bit address code can select any cell in the 64 by 64 bit matrix, and an on-chip address buffer-register requires a stable address for only 100 nsec.

The 2107 uses a single high-level clock, from which all internal timing signals are triggered. The precharge input used in most dynamic RAMs has been eliminated, with preconditioning being done automatically between active memory cycles. Access time for any bit is < 300 nsec, cycle time is < 500 nsec. Power required is 100 mW/bit in the active mode and 1 mW/bit in standby.

Intel stresses that they are **not** taking orders for the 2107 yet. Their response to queries on availability is that, "introduction of the 2107 is not imminent, but it's not as far away as our competitors hope, either."

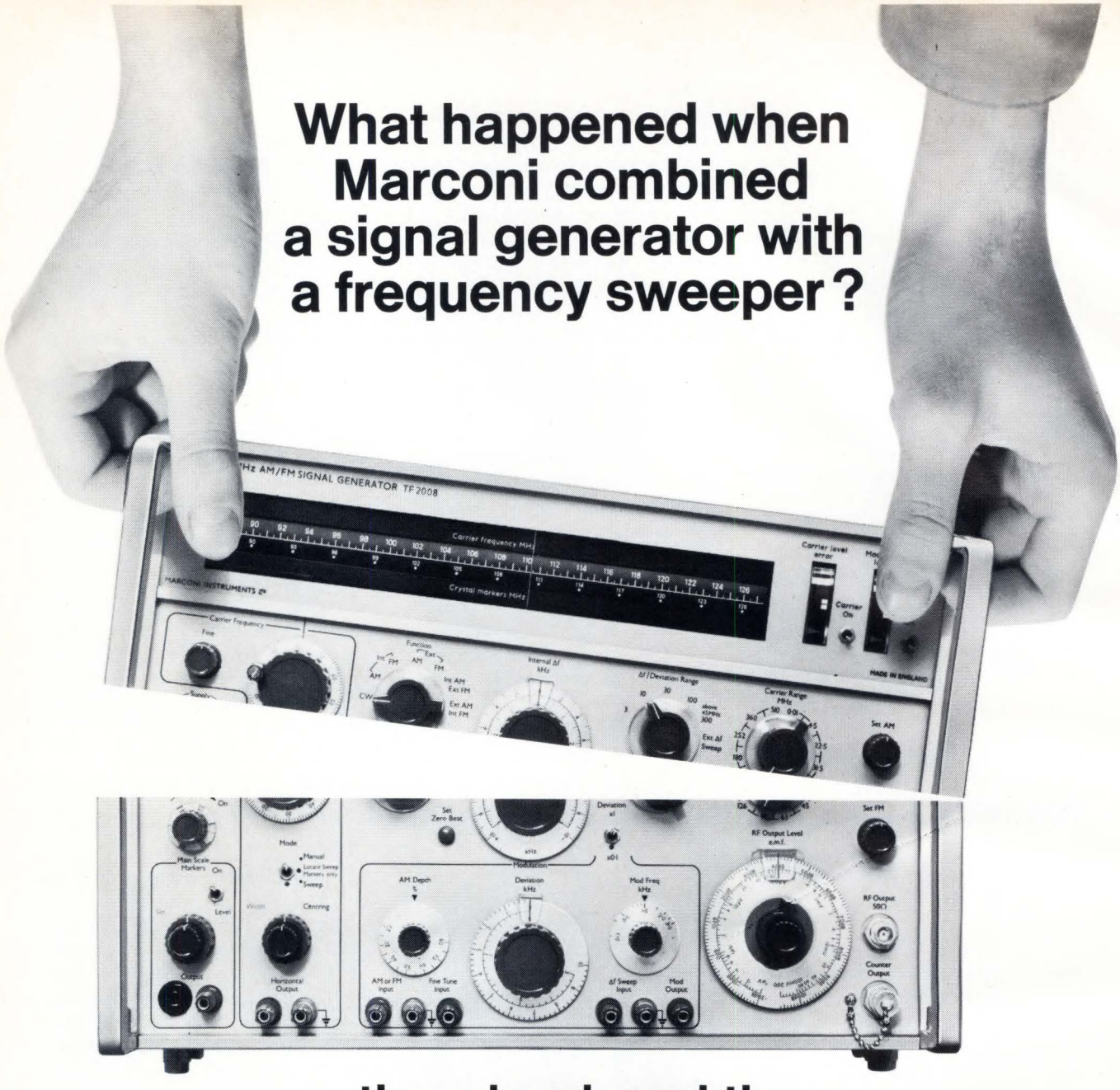
Memory addressing circuits

Reduction of power and increases of speed in solid state memories have been phenomenal, but support circuitry has lagged well behind. Dr. Jerry Mar of Bell Telephone Labs has squared off directly against this problem, and developed accessing circuits which he described as "Transient Selection Gates using breakdown."

The transient selection gates, one of which is depicted in **Fig. 2**, require no

continued on pg. 22

What happened when Marconi combined a signal generator with a frequency sweeper?



they developed the Dynamic Transmission Simulator

Marconi gives you a Sweeper and Generator in our new Dynamic Transmission Simulator, Model 2008 . . . a complete test source for all measurements in the LF/MF/HF and VHF ranges and beyond.

This remarkable new instrument offers many unique features . . . exceptionally wide frequency range starting in the VLF Band (10KHz) and going up to UHF (510MHz) in eleven ranges each with a 1 to 1.5 cover . . . internal or external sweep adjustable to entirely span any tuning range . . . full FM and AM capabilities which can be retained in the swept mode. Write for detailed specifications.

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- Direct reading incremental frequency control.
- Built-in frequency sweeper.
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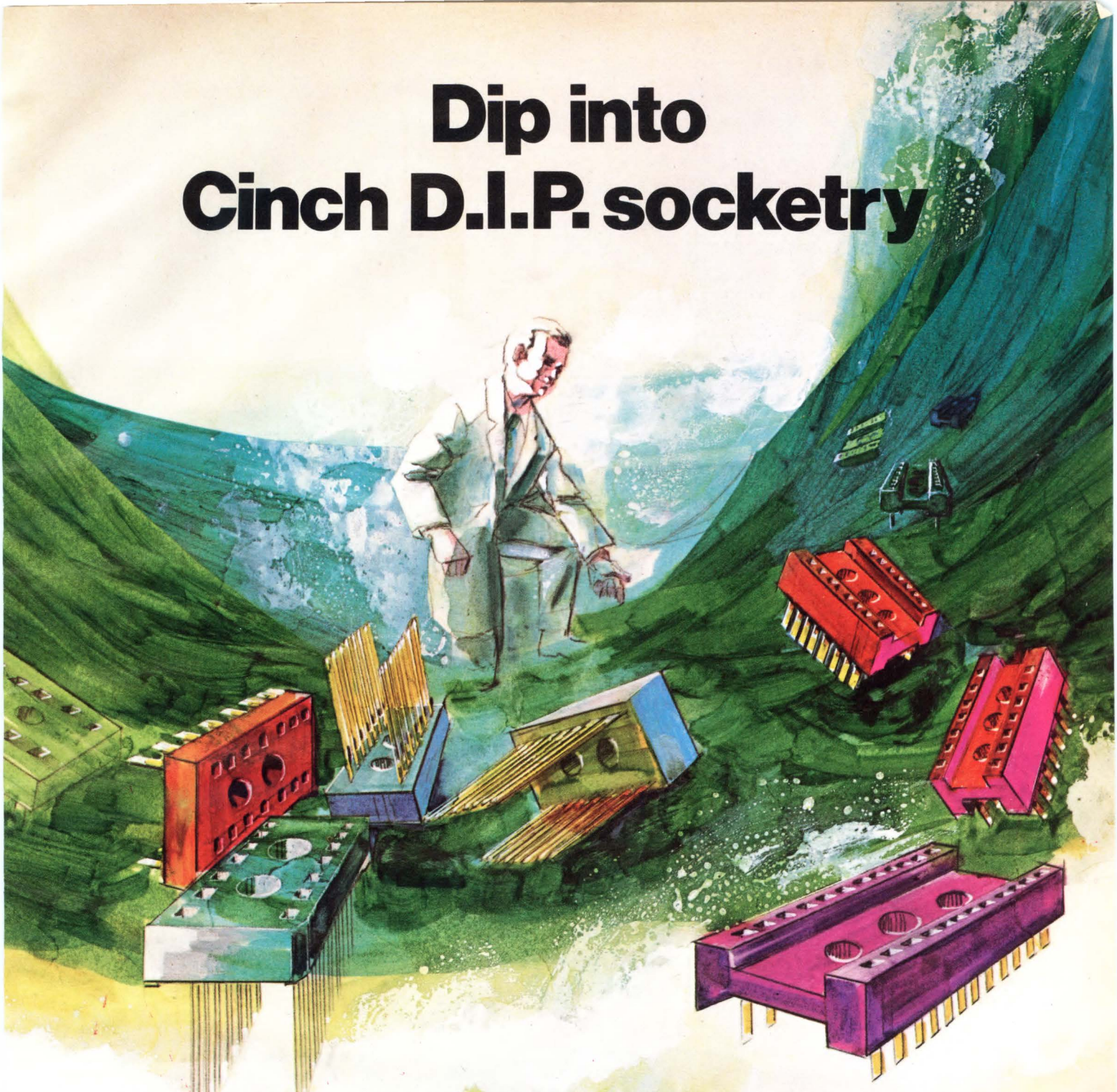
SEE US AT IEEE - BOOTH 2233
CIRCLE NO. 14

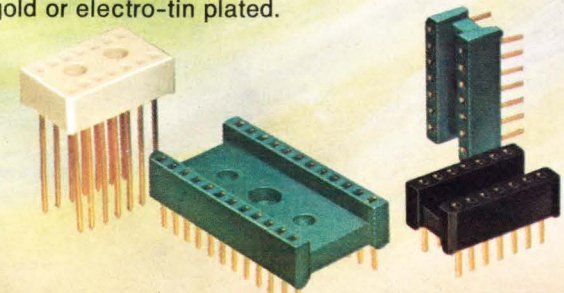
Dip into Cinch D.I.P. socketry



You'll find the 14, 16 or 24 pin DIP socket you need in the Cinch line. Try it . . . you'll like it!

Cinch sockets have a unique bowed pin contact that provides high contact forces but permits easy insertion and removal of the DIP. Broad contact surfaces give you maximum wiping action on two sides of the DIP terminal, be it flat, round or square.

You can choose from high performance diallyl phthalate or economical GP black phenolic monoblock insulators. The contacts are of beryllium copper for the best temperature stability, either gold or electro-tin plated.



Sockets with Wire Wrap* terminals and closed entry, one-piece insulators are also available in a variety of insulations and terminal materials . . . in addition to our DIP sockets with dip solder terminals.

Many styles are available off-the-shelf from Cinch distributors nationwide.

You can find out all about these sockets from your Cinch Distributor, Cinch Sales Office or by writing to Cinch Connectors, an Operation of TRW Electronic Components, 1501 Morse Avenue, Elk Grove Village, Illinois 60007, (312) 439-8800.

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CIRCLE NO. 21

TRW®
CINCH CONNECTORS

dc biases, are designed to operate with dynamic memories, and are activated only when needed. This gate is designed to pass negative pulses when pulsed **on** (at "S") or block those same pulses when pulsed **off** (at "R"). D_1 and D_2 are breakdown diodes which conduct in a reverse direction at ≈ 6V, charging or discharging the transistor junction capacitances to effect pulse steering. Power required is 55 mW/gate and pnp devices can be fabricated for positive pulse gating.

Evening sessions

An example of why these groups are necessary, and valuable, was the "Subnanosecond Logic, Why Not?" session. It began with most of the computer and semiconductor people explaining that "yes it's possible, but who needs it," and "packaging is so costly that there is no place to peddle it."

Then, the communications people moved in with, "I'm working on 1-Gigabit data transmission, and I'd pay a premium price for the hardware if I could move to 10-Gigabit," and "In ten years we'll all be working at 1-gigabit." With that, the semiconductor representatives wanted to know "how much will you pay and how many devices do you need?" This meeting became one of the most interesting discussions of the day, and everyone left better informed than they came. □

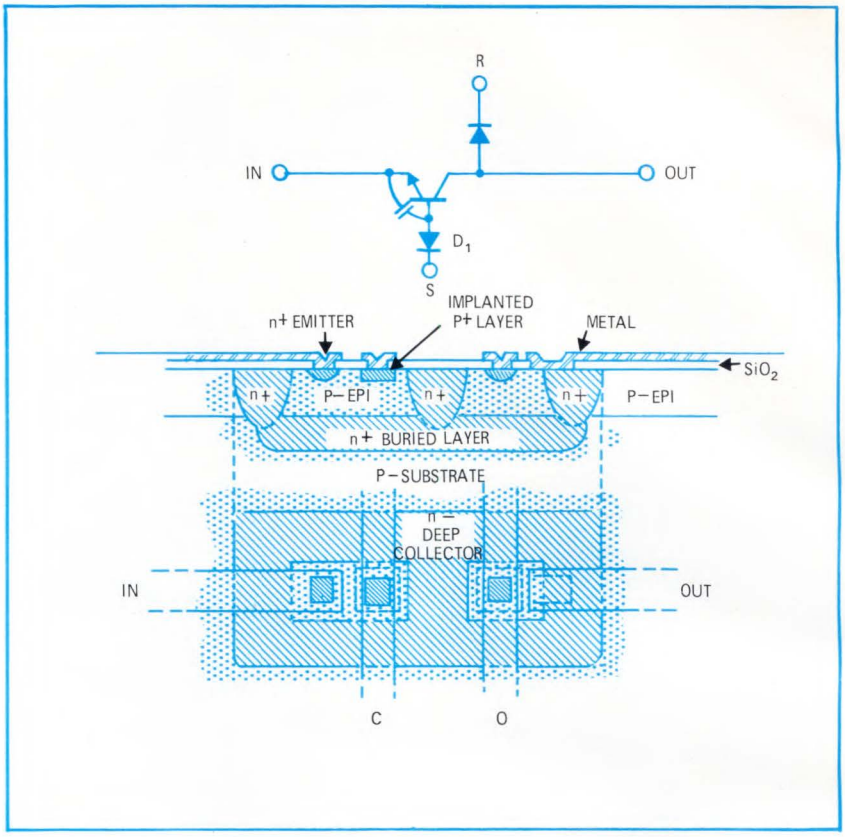

Fig. 2—Breakdown-diode steering gates, developed by Bell Telephone Labs, use no power in standby-mode, and can presently operate at 20 nsec or less propagation delay.

No-tuneup 50,000-mile ignition system helps cut auto pollution

Setting out to produce a 50,000-mile, "hands off" automobile ignition system to help the auto industry's fight against emissions, the Prestolite Co. of Toledo, Ohio has unveiled a new breakerless inductive ignition system. Although strictly developmental at this time, the system could eliminate engine tuneups for at least 50,000 miles and keep them well-tuned to meet stringent, Federal low-level emission standards, due to take effect in 1974.

The system, which does not use contact points or a condenser, includes an electronic spark advance that monitors a number of engine conditions, calculates their net effect and automatically adjusts ignition timing to obtain optimum engine operation and reduce exhaust emissions.

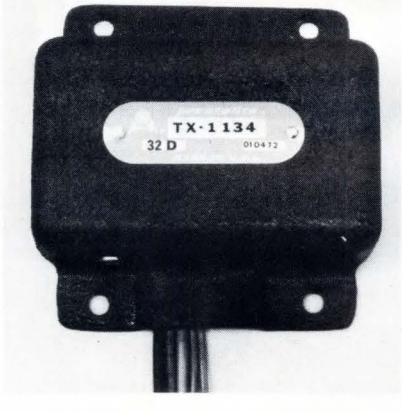

Fig. 1—Helping cut down pollution, the newest inductive ignition system from the Prestolite Co. uses no breaker points or condenser—components found in conventional ignition systems. It keeps engines well-tuned for 50,000 miles.

The system was described by Prestolite's manager of new product development, S. A. Florio, as "a marriage of the power switch from a transistorized ignition system and the breakerless pickup from a capacitor-discharge system"—two systems currently being produced by Prestolite.

Inductive ignition systems have been used with gasoline engines for years, and their performance characteristics are well suited to gasoline engine ignition requirements. Capacitor-discharge ignition systems in use, while not as well suited in this application, do have the ability to fire fouled or dirty spark plugs. This is very important in two-cycle engines, where the gasoline-oil mixture inherently leads to plug fouling. In four-cycle

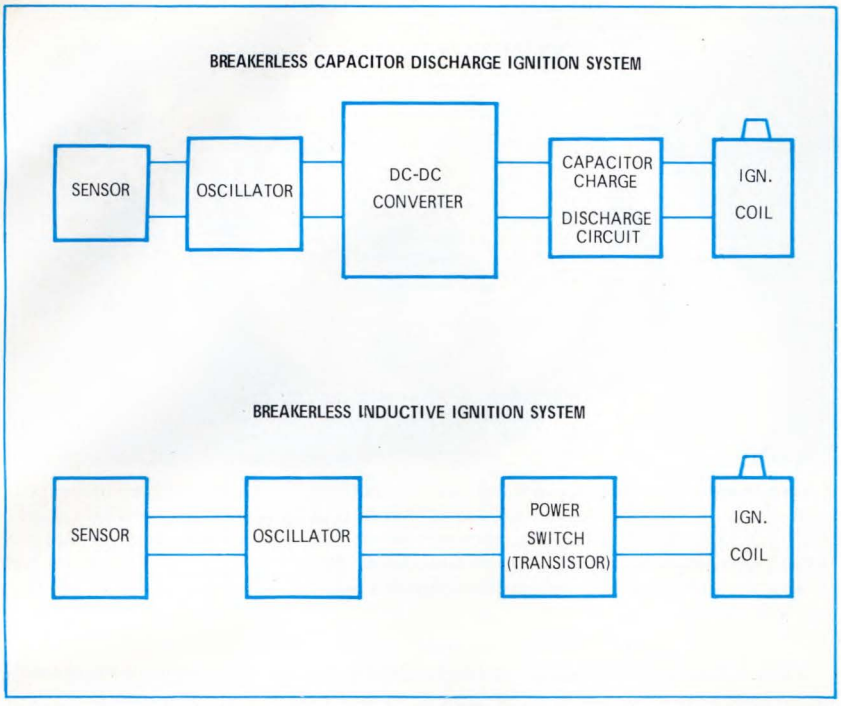

Fig. 2. A breakerless inductive system is less costly than a comparable capacitor system mainly because of the elimination of the dc-dc converter.

automotive engines, on the other hand, spark plug fouling is not as serious a problem. It is also becoming less serious with more and more lead being removed from fuels, as is being done to help resolve emission problems.

Fig. 1 shows a photo of the new breakerless inductive ignition system. It is simpler and less costly than a breakerless capacitor-discharge system. The major difference is elimination of the usual dc-to-dc converter (**Fig. 2**). In the capacitor-discharge system, the converter is needed to take 12V from the battery and boost it to the 350V required to charge the capacitor, which is later discharged into the ignition coil. This high voltage is not involved in the inductive system.

Compared with a conventional inductive system, which has breaker points acting as both a switch and a power element, the new breakerless system divides these two functions. It has a timing mechanism—equivalent to the rubbing block and cam—which provides the system with information about when to switch, and a power element (a power transistor) which performs the power-switching function in response to the breakerless timing mechanism.

In place of breaker points, the system uses a patented electronic nonmagnetic proximity detector, which is not speed-sensitive. Because the nonmagnetic pickup head (**Fig. 3**) is not affected by speed, the new system is capable of functioning at any distributor speed above zero and has demonstrated an ability to start an engine at distributor speeds less than 15 rpm. Being breakerless, the pickup design eliminates contact problems and rubbing block wear for the complete life-

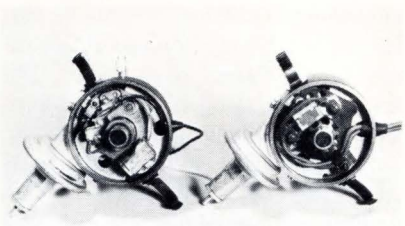

Fig. 3—Comparing two distributors. View into bowl of conventional distributor (left) shows breaker points, condenser and rotor. Distributor for new breakerless inductive ignition system (right) has no breaker points or condenser. It uses a patented electronic, non-magnetic proximity detector (pickup head) which is not speed-sensitive.

time of the automobile engine.

The system's circuit design has eliminated the need for a primary capacitor. As a result, it has a spark rise time (the time required to deliver full spark voltage) that is 30% faster than current inductive ignition systems, which use a primary capacitor. Hence, it is more capable of firing fouled spark plugs. Contributing to system simplicity is the fact that improved semiconductor technology has made it possible to utilize a conventionally-wound production-type ignition coil.

The electronic system has been designed with a self-regulating circuit, eliminating the need for a ballast resistor. Built-in voltage regulation provides higher output voltage at low temperatures to better match engine requirements and provide much greater starting capabilities.

RFI characteristics are similar to those of a standard ignition system, and standard suppression techniques can be used. However, better suppression is generally achieved because of the absence of contacts. With no contacts in the distribution system, the possibility of contact arcing is eliminated and RFI control problems are reduced. ■

Solar energy holds promise of long-life lasers for use in space communications

A sunlight-powered laser that provides the long-life required for practical space communications systems has been developed by GTE Sylvania. Sylvania is performing the work as part of an Air Force program aimed at determining the feasibility of satellite optical communications.

By means of lenses and mirrors, the new device collects and focuses rays of the sun which stimulate material in the laser to produce beams. The beams can be used to carry voice, data, TV and other communications.

"Present lasers are powered by electric discharges or lamps and are not yet capable of operating the required five to seven years in a com-

munications satellite," explains Dr. Donald E. Caddes, Manager of Sylvania's Electro-Optics operations. "The sun-powered laser promises to provide not only the necessary longevity, but economies of weight and size as well. The power output and data transmission rate of the new laser will be equal to those of present solid-state lasers," he said.

A team of GTE Sylvania scientists headed by Dr. Lloyd Huff has obtained 1.5W of output power from a working model neodymium YAG (yttrium aluminum garnet) laser. Current efforts are being directed at improving the efficiency of the solar collection system and the equipment which divides the laser's continuous output into a codable stream of pulses.

The team is also investigating the possibility of powering the laser by auxiliary lamps or light-emitting diodes when the sun is not visible from the satellite.

A sun-powered laser that provides the long life required for practical space communications systems is demonstrated by Dr. Lloyd Huff of GTE Sylvania's Electro-Optics operation. The 24-in. mirror in the background collects solar energy and directs it into the laser's end (center). By means of lenses and mirrors, the experimental device collects and focuses the sun's rays. The rays in turn stimulate material in the laser to produce data-carrying beams.

Interest has been generated in laser communication systems because they will ultimately be capable of sending more data while requiring equipment of less power and weight than present systems, such as radio. ■

Helmet mounted sighting device aims weapons where pilot looks

After almost eight years of development and testing, a helmet-mounted sighting device, designed to improve Navy pilots' ability to fix weapons on enemy targets, has been delivered for installation on F-4 "Phantom II" jet fighters.

Designed and built by the Honeywell Government and Aeronautical Products Division, the sighting device causes the aiming point of the aircraft's weapons to follow the pilots head as he looks for possible targets.

The helmet-mounted sight, or Visual Target Acquisition System, includes two infrared light sources mounted on the aircraft, sensors to pick up the infrared signals, and a signal processor. In operation, the pilot aligns a reticle (target ring) that is generated on a small circle of glass in front of his eye with the target. The see-through device, about the size of a dime, is attached to the end of a four-inch retractable rod on the helmet.

The infrared sensors on the helmet monitor the two separate infrared sources that are attached to the aircraft on either side of the cockpit slightly behind the pilot's head. As the pilot turns his head to look at a target, the signal processor notes the time it takes the infrared energy to reach the different sensors on the helmet and calculates the difference through triangulation to find out exactly where the pilot is looking; in other words, his line of sight.

Together, the helmet sensors and sight weigh less than three-quarters of a pound. And since there is no attachment to the aircraft, the pilot has freedom of head movement. ■

The small "monocle" attached to the helmet lets the pilot aim his weapons on a target merely by looking at it. There is no attachment from the helmet to the aircraft.

Minilever®. The switch for people in a hurry.

There they are, waiting in line with their credit cards. Or, rushing to check a hotel or airline reservation. All done by remote computer terminals. The operator of that terminal has to be fast and accurate or those nice people will get angry. And that's where Minilever comes in.

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CIRCLE NO. 22

Teradyne's L100 Automatic Circuit Board Test System speaks for itself.

```
        PASSED

   GOOD: 43
   BAD:  8
```

```
              FAILED
FAILURE COUNTERS (BAD/TOTAL):
          FTEST  0/36
          MTEST  5/83
          BTEST  0/1
          TTEST  0/2
```

```
MT44  D8
THIS  TEST  PASSED

MTEST  ON  PINS:  M

        LIMIT  :+  500.  MV
        ACTUAL:+  248.  MV
```

```
TT39
THIS  TEST  FAILED

TIME  FROM  PIN   18  TO  21
   ACTUAL:      00.195  US
     TMIN:      00.050  US
     TMAX:      00.190  US
```

```
FT35
THIS  TEST  FAILED
<ALARMS>S1
FAILING  PINS:  20  Z  K
```

```
FT15
THIS  TEST  FAILED

FAILING  PINS:  S  R  P  N  M  L  J
```

If you test circuit boards, you get the message. The L100 doesn't just tell you a bad board is bad. It helps you find out why. And in a fraction of the time you'd usually spend trouble-shooting. We'd like to send you a brochureful of reasons why the L100 is the most money-saving system you can buy.

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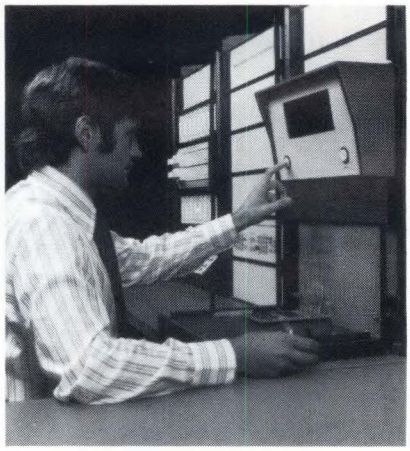

See the L100 at the IEEE Convention, New York Coliseum, Booth 2332, March 20-23.

CIRCLE NO. 40

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

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

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

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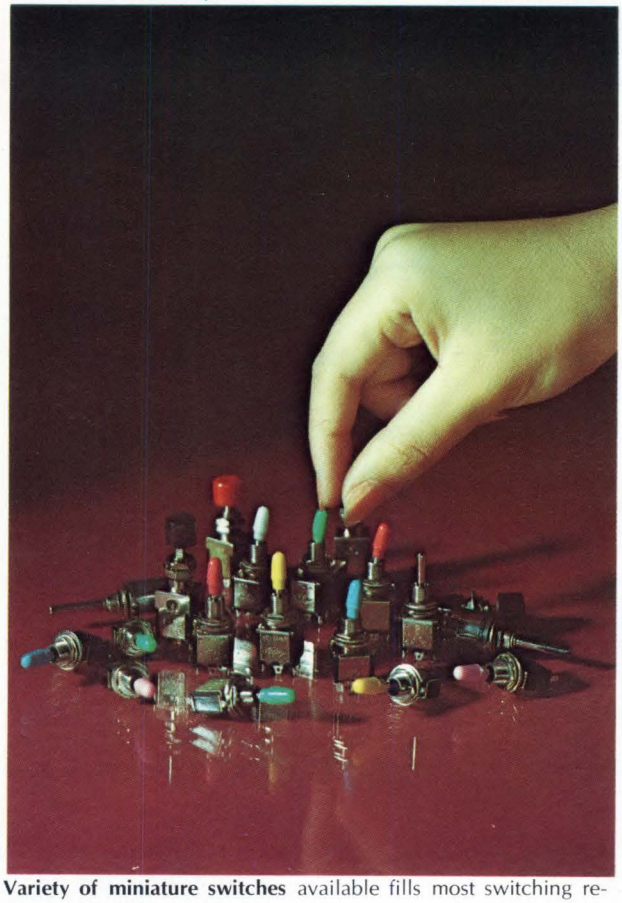
FLUKE

CIRCLE NO. 24

Miniature switches shrink in size yet pack a lot of punch

A brief look at what's available in miniature switches show that they are getting smaller and smaller; however they carry loads equal to their big brothers.

Roy W. Forsberg, Boston Editor



Variety of miniature switches available fills most switching requirements. (**Alcoswitch**)

Just because the world of electronics is shrinking toward ultra-miniaturization with it's MSI/LSI integrated circuits, it doesn't mean that electromechanical devices like switches will disappear. On the contrary, not only are they keeping pace by getting smaller, but now there is also a greater variety to choose from. Miniature switches are also increasing in reliability, carrying higher currents and voltages, and are coming down in price. This report won't give a run-down on every miniature switch made, nor will it attempt to cover all manufacturers. It will, though, summarize what is available according to type of switch.

What is a miniature switch?

Simply stated, a miniature switch is a scaled down version of its big brother counterpart. However, it is scaled down in size and weight only, not in quality or load-carrying capacity. A traditional rule of thumb says that a miniature switch is less than one-half inch square. In this report, that rule is violated in areas where the device is quite small, relative to what has been available in the past. Included will be toggle, slide, paddle, rocker, rotary, pushbutton and precision snap-action switches.

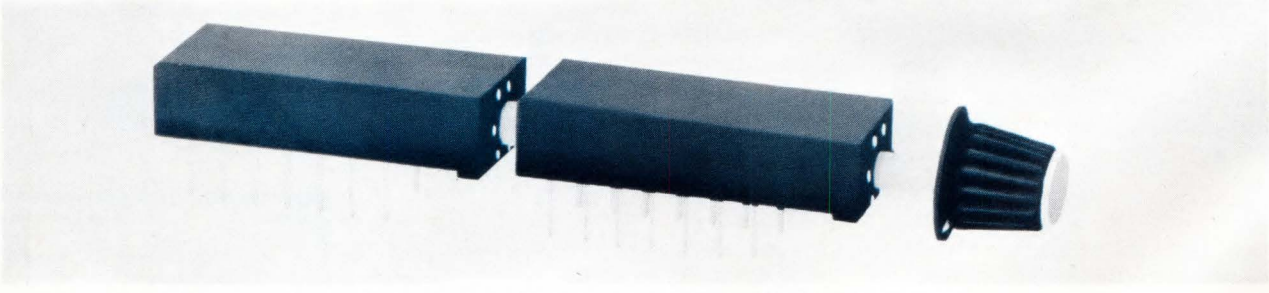
Although miniature switches carry heavy loads and are rugged and reliable, they are not indestructible, and like their larger counterparts, they require special handling and care. While some of the guidelines listed are unique to miniature switches, others apply to all types and are worth repeating since these are the ones manufacturers most often encounter.

Toggle switches

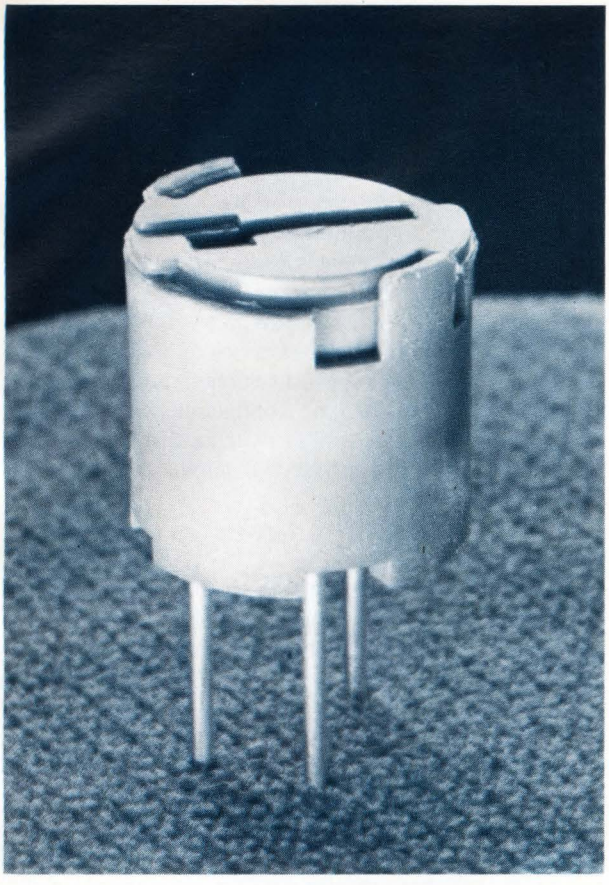
Nearly everyone in the miniature switch business makes a toggle switch. In this line the slogan could be, "just tell us what you need because we probably already make it." Not only is there a great variety in size, shape, poles, throws, and ratings, but also such things as mounting-means, life, waterproofing and more.

The industry has standardized bushing mounted switches with a bushing size of 1/4-40. However, for the users who want to retain the look and feel of the standard toggle switches yet cannot afford the equivalent behind-panel space, most manufacturers offer a standard 15/32 inch bushing and large bat handle mounted on the same miniature switch body.

For those who want to mount a toggle switch directly on a pc board, this type of mounting is also available. Such



Two six-pole, six position switches in DIP package can be mounted in tandem. (**Edison Electronics**)



Miniature SPDT low-cost trim switch mounts on pc board and measures 3/8-inch diameter. (**Oak Mfg. Co.**)

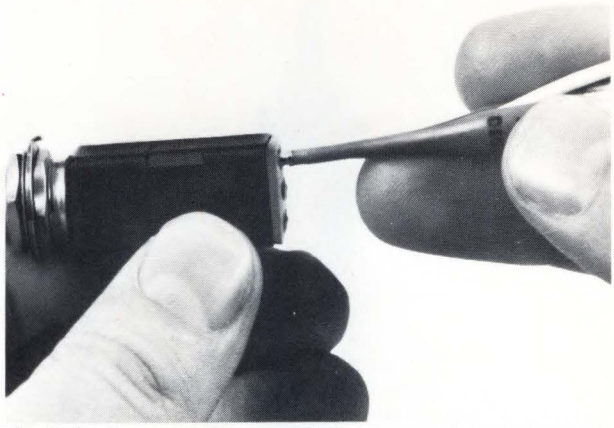
switches can be mounted with the lever parallel to the board and terminals perpendicular to the lever (right angle), lever perpendicular to the board, terminals parallel to the lever (straight), or lever parallel to the board and terminals parallel to the lever (end connected).

You have a choice of throws from single-pole, single-throw (SPST) up to 4-pole, double-throw (4PDT). Within this range you may select, center-position OFF, no center position, and momentary contact in any position. For applications requiring prevention of accidental switching, there is a "lever-lock" feature. Here the lever can be locked in any or all positions, and can only be released by first pulling out the lever.

Current ratings range from 2A @ 125V ac inductive to 10A @ 125V ac resistive, and 2A @ 28V dc inductive to 6A @ 28V dc resistive. Most switches have 1000V breakdown between terminals and between terminals and case ground.

Size, of course, will vary according to the number of poles and throws selected and range from about 1/4 × 1/2 × 3/8 inches high for SPST to about 7/8 × 1/2 × 5/8 inches high for 4PDT. There are also round SPDT and DPDT versions at about 1/2-inch diameter.

Most switches are UL rated, some meet IEC European standards, and others meet MIL spec 202 for shock and vibration. Other features to look for are waterproof switches, bat, baton, and flatted levers, plastic sleeves for levers in as many as nine colors and lifetimes ranging from 25,000 to 250,000 cycles at rated load. Terminals are usually combination quick-connect/solder tab; however, one manufacturer has a plug-in lead feature.



Plug-in leads are quickly assembled or removed using insert-extract tool. (**Micro Switch**)

Paddle switches

Functionally, these are similar to toggle switches but are more stylish and generally less expensive. Paddle switches feature a flat plastic paddle, which comes in up to eight colors, in place of the toggle's bat lever. They are rectangular in shape and snap into the panel from the front, a convenient assembly feature. Paddle switches are only available in SPDT and DPDT versions and sizes are roughly 1/2 × 1/2 × 3/4 inch high. Center OFF and momentary contact in any position except center are also featured.

Contact ratings are 3-6A @ 125V ac and 3-5A @ 28V dc. All have 1000V breakdown between terminals and between terminals and case ground. Lifetimes, where available, average about 25,000 cycles at rated load. Terminals are the combination solder/quick-connect type.

Rocker switches

These are mechanically the same as paddle switches except that they have a plastic rocker button in place of the paddle. This is also a snap-in type switch and the rocker is available in eight colors. As an option they can include an indicator light. The rocker itself snaps out easily allowing users to change colors without changing the switch. Like the paddle switch, they come only in SPDT and DPDT versions, and also feature center OFF and momentary contact in all positions except center.

Unlighted types are the same size as paddle switches while lighted ones average about 5/8 × 5/8 × 7/8 inch high maximum. Contact ratings as well as lifetimes and terminations are also the same.

Pushbutton switches

Like the toggle switch, these are made by almost all miniature switch manufacturers. They all offer the standard 1/4-40 bushing mounting and some provide the larger 15/32 inch bushing and also pc mounted versions. Switching can be snap-action push-ON, push-OFF, or slow-make, slow-break momentary contact. Switching function can be SPST, normally-open or normally-closed, and up to 4PDT.

Pushbutton switches come in all sizes and shapes depending on contact rating and switching actions. You can get a SPST as small as 1/4 inch diameter × less than 1/4 inch high, a SPDT as small as 1/4 × 1/2 × 3/16 high, and up to a 4 PDT, 6A switch at about 1/2 x 3/16 x less than 1 inch high. Lighted switches are only slightly larger; how-

20-position rotary switch can have up to 8-poles per deck and up to 10 decks, all within a 9/16 inch body diameter (3/4 inch including terminals). (**Edison Electronics**)

ever, some manufacturers add a section to a standard switch which adds about 1 more inch in height.

Contact ratings start at 1/4A for the smallest SPST (NC) switch and go up to 7A @ 125 ac resistive and inductive, 6A @ 28V dc resistive and 2A @ 28V dc inductive. Some are also rated up to 5A @ 250V ac resistive and inductive. Virtually all have 1000V breakdown.

Lifetimes range from 20,000 operations at rated load up to 250,000 operations, with the average at about 30,000. Except for pc mounted switches, terminals are usually of the solder/quick-connect type.

Switch buttons offered are both round and square in a variety of sizes, and come in up to eight colors.

Also available are splashproof or waterproof models which can withstand a 3.3 foot head of water for 30 min, and others which meet Mil spec 202 for vibration and shock.

Rotary switches

The variety of types, and number of manufacturers of rotary switches is much greater than would be expected in this specialized switch area. It is a revelation to see the amount of switching that is packed into a tiny package. For example, there is a 14-pin DIP that holds a six-pole, six position switch, and each pole can be separately programmed. Or how about a 0.300 inch diameter × 0.406 high 10-position switch for pc mounting—or a 3PDT pc mounted switch 0.375 inch diameter × 0.359 inch high—or a 1/2 inch diameter × 0.605 inch high 1-4 pole, 10-position pc mounted switch capable of switching 1/2A @ 125V ac—or a 3/4 inch diameter × 1/4 inch high pc mounted 10-position BCD coded switch that can switch 1/4A @ 115V ac? This is just a sampling of what's available in rotary switches.

Not all rotary switches are for pc mounting. These have the standard 1/4-40 bushing, are in the 1/2 to 3/4 inch diameter range, have up to 12 positions, 1-4 poles per deck, and up to 12 decks (the latter barely over 4 inches long). There is even one 20-position switch with up to 8-poles per deck and up to 10 decks that is less than 3 inches long.

Typically, current ratings are under 1A @ 125V ac with breakdown voltages between 500 and 1000V. Lifetimes at rated load range from 1000 full cycles to 50,000, with the average at 10,000 cycles. Most switches can be had in either shorting or non-shorting configurations. Splashproof models are available as well as switches that can be internally coded to give BCD or decimal outputs, or can be used as input to a Johnson counter.

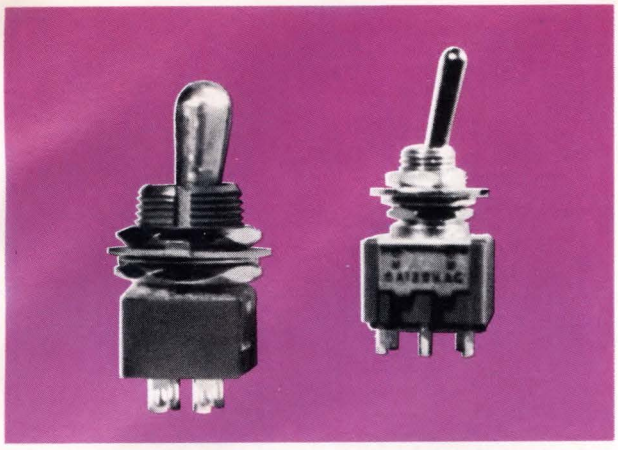
Slide switches

There are not as many manufacturers making slide switches as there are making other types. Slide switches do, however, offer a wide variety of switch types. The variety is not so much in mounting means or physical dimensions as in the switching category. You can get SPDT, DPDT, 4PDT, 4P3T switches that are pc mounted in both upright or right-angle positions, and a 6PDT switch that mounts only in an upright position. They all switch 0.3A @ 125V ac and range in size from about 1/4 × 1/2 × 3/8 inches up to about 3/4 × 3/8 × 1/2 inch. These are make-before-break switches and have rated lifetimes of 15,000 cycles. A non-pc mounting type that is rated at 2A @ 125V ac and 1/2A @ 120V dc is also made and it has a rated lifetime of 250,000 cycles.

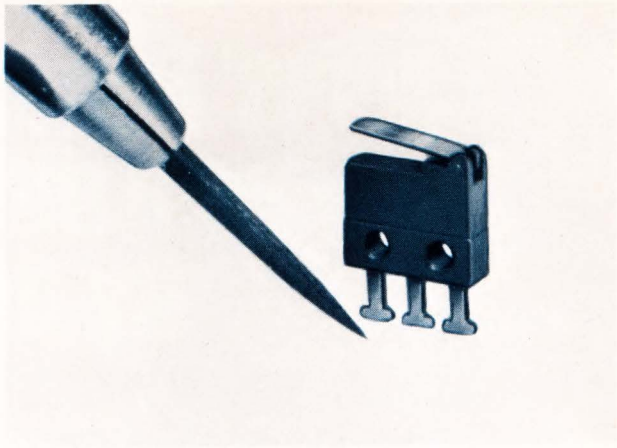
Precision snap-action switches

Not to be overlooked are those switches that often find themselves being used as limit switches. Unless ganged, they are all SPDT, and some carry brutish currents for their

10-position BCD coded rotary switch measures 3/4 inch diameter and mounts on pc board. (**AMP, Inc.**)



Miniature toggle switches come in both standard 1/4-inch bushing or the more familiar 15/16-inch bushing. (**Micro Switch**)



Tiny precision snap-action switch carries up to 2A current and are often used as limit switches. (**McGill Mfg. Co.**)

size. The tiny one (0.300 × 0.100 × 0.250) carries 2A @ 125-250V ac, while the largest one classified as a miniature switch (1.0 × 0.400 × 0.625), carries up to 15A @ 125V ac.

Actuation means include pin lever, short, medium and long straight levers, short and long formed levers, and short and long levers with rollers.

Other optional features are low-force, low-differential-travel, sealed, high-temperature, and hermetically sealed models.

The do's and don'ts of miniature switches

- **Do use** only enough flux to do a clean soldering job. Otherwise flux can enter the switch and damage contacts.
- **Don't** solder a switch upside-down unless terminals are sealed. Flux will enter the switch causing damage.
- **Don't** try to remove excess resin from solder connections with solvents. This merely dissolves the resin which can run down into the contacts.
- **Don't** use excessive heat. This can damage switch body or loosen terminals.
- **Don't** lay a mounted toggle switch on its lever or push the lever in with excessive force. This can drive the lever into the switch.
- **Do** use proper switch installation tools.
- **Don't** attempt to alter position of a bushing-mounted switch by twisting the body. Loosen the fastening nut first. Otherwise contact misalignment or permanent damage can occur.
- **Don't** bend switch terminals unless the manufacturer specifies a procedure for doing so.
- **Don't** add lubricants unless specified by the manufacturer.
- **Don't** dump switches randomly into a container, especially rotary switches. Terminals can lock together and be damaged.
- **Do** keep silver coated switches in closed shipping containers. Many containers are specially treated to prevent sulphur in the cardboard or air from tarnishing the silver.
- **Don't** hold rotary switches by sections while rotating index assembly. Misalignment will result. Hold at or close to the front plate.
- **Do** protect unsealed switches from contamination by dirt, liquids or damaging vapors.
- **Don't** modify switches by drilling, sanding, milling, etc.
- **Do** use switches within their voltage and current ratings.
- **Don't** test switches under higher loads than those expected in application.
- **Do** test switches under all conditions of actual end use.
- **Don't** mistake environmentally sealed switches for hermetically sealed ones.
- **Don't** use set screws on outer shafts of dual concentric switches.
- **Do** check with your local manufacturer if you have any questions regarding your application. He may save you time and money. □

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McGill Manufacturing Co., *Valparaiso, Indiana 46383* **364**
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Oak Manufacturing Co., *Crystal Lake, Illinois 60014* **366**
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Harris' Family of Op Amps. They're a different breed. By design.

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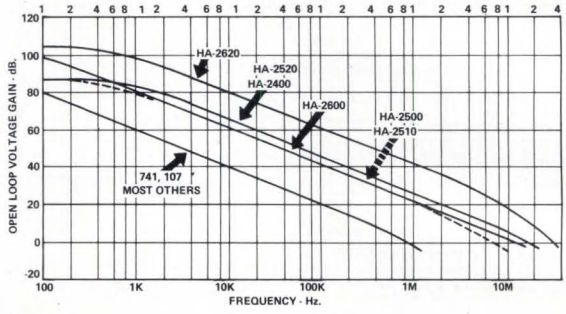

Harris wide band general purpose op amps offer:

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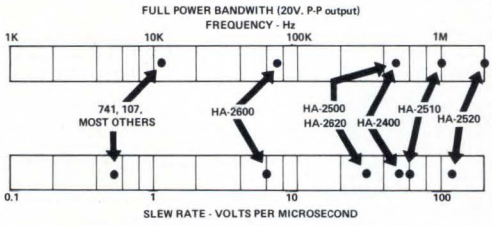
☐ Much lower closed loop phase shift, lower gain error, and lower distortion at all frequencies.



☐ Superior response at higher gains.

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

Harris high slew rate series offer:

☐ The only monolithic high slew rate amplifiers that are true operational amplifiers. They can be operated inverting, non-inverting, or balanced with fast settling times. In fact, they provide improved performance in virtually any standard hookup. ☐ The fastest settling time of any monolithic op amp. (For example, the HA-2520 settles in 250 ns to 0.1%). ☐ Higher output voltage swing at high frequencies. (If you have ever tried to put a 10V peak 1MHz sine wave through a 741 type, you know what we mean.)

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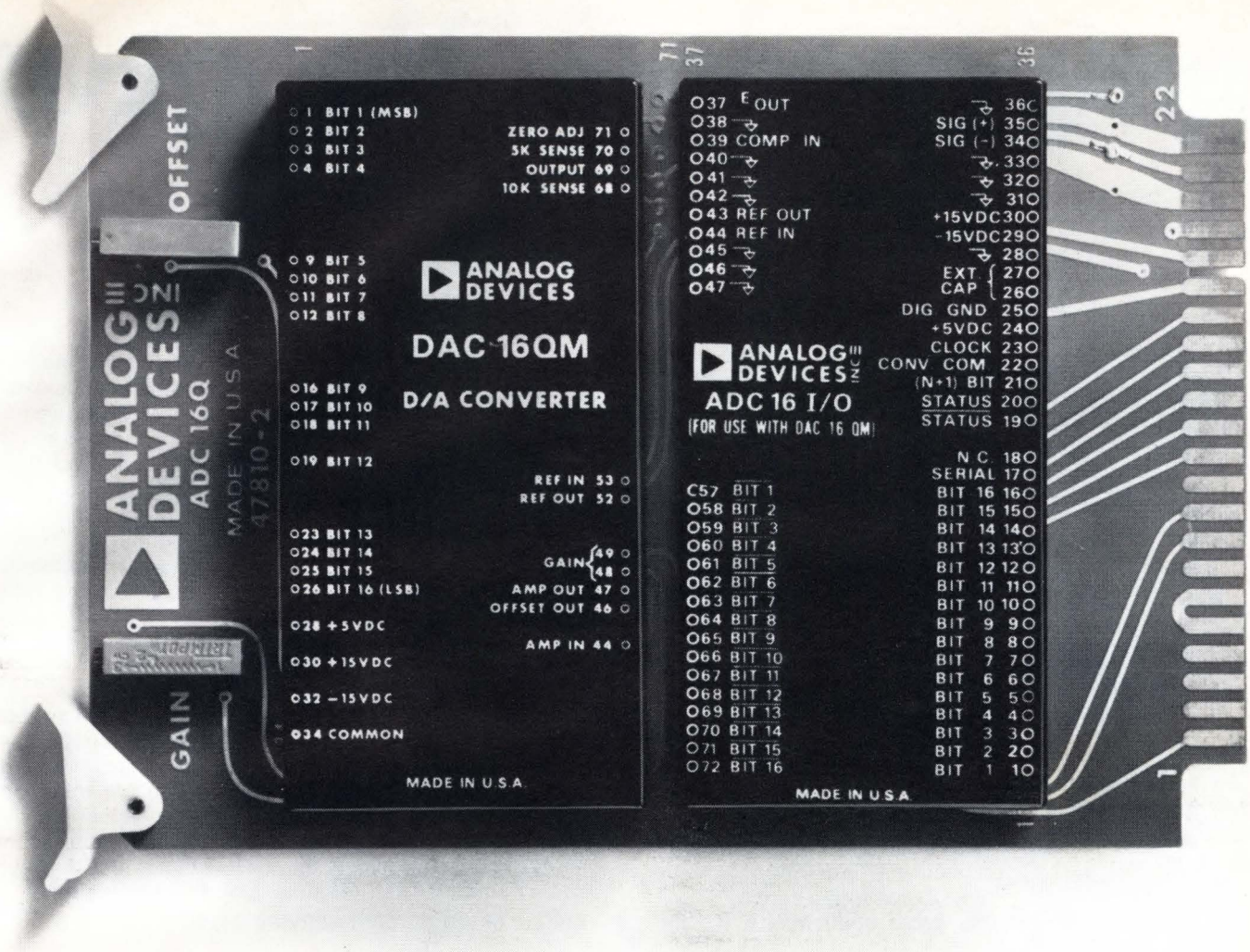

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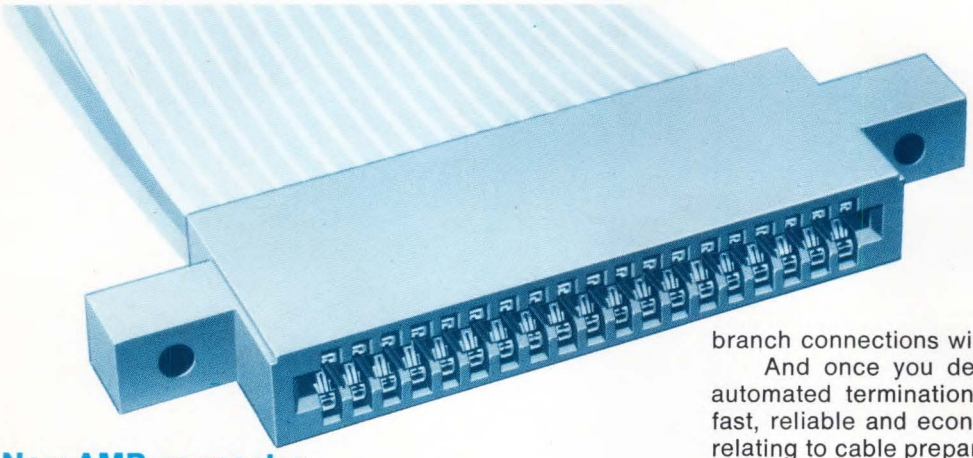

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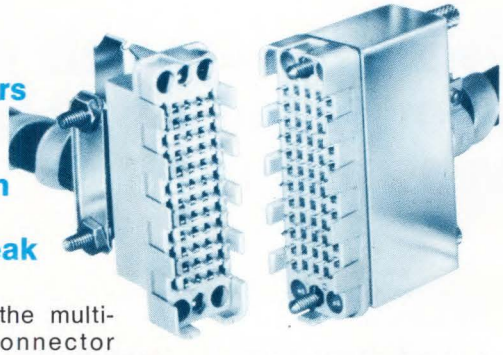

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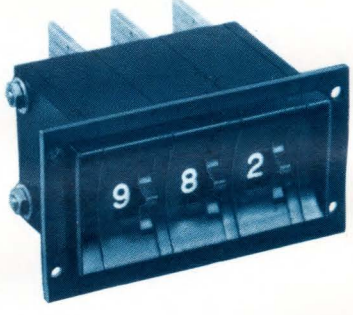

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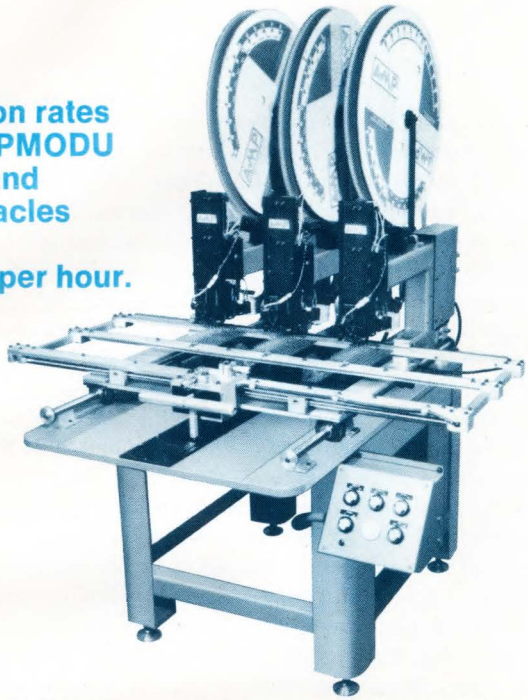

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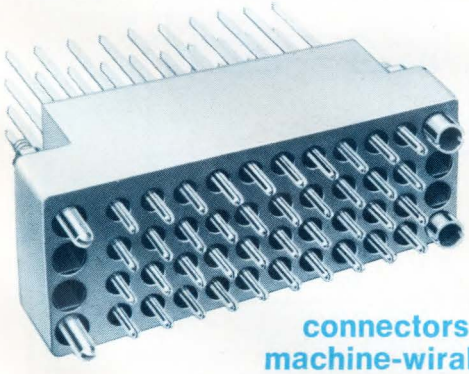

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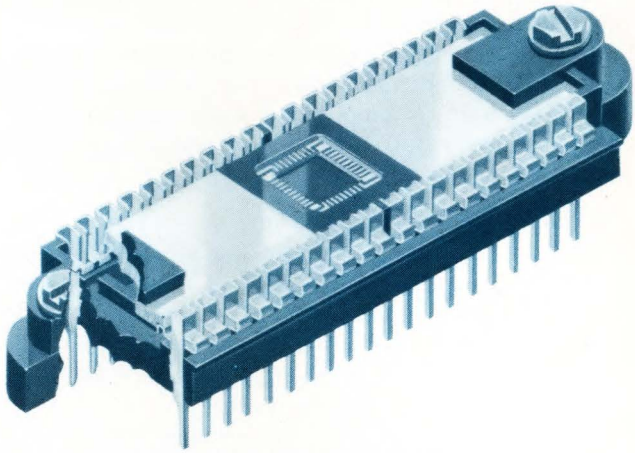

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Low-power digital phase locked loop utilizes CMOS logic

Phase locking can improve data transmission efficiency greatly, and with this circuit the penalty is only 10 mW of power.

David A. Johnson, Avco Electronics

Phase locked loops are normally used in a digital communication receiver to insure bit synchronization between a locally generated data clock and the information-bearing wave train. The phase locked local clock is then used to retime the incoming data to eliminate noise such as edge jitter introduced in the transmission link.

Analog techniques can be used to implement the loop, but this creates interfacing problems, and power consumption can be excessive. The phase locked loop described in this article uses digital techniques and low-power complementary symmetry metal-oxide semiconductor (CMOS) ICs. This results in a loop that exhibits excellent performance, draws only 10 mW of power and operates with a non return to zero (NRZ) input signal.

Digital phase locking is the key

The approach used in the system is to lock the locally generated data clock in phase with the received signal. This is done by dividing a high-speed local clock by a variable count. The actual count used is a function of the phase relationship between the zero crossings in the received signal and those of the locally generated signal.

A block diagram of the system is shown in **Fig. 1**. The binary input signal, in this case 19.2 kbps, is first processed through a recovery circuit which detects bits and "cleans up" the pulses. Noise-free serial data is then routed for further processing. The recovery circuitry consists of a low-pass filter for excluding out-of-ban noise, and a "1" or "0" decision making circuit (such as a crossover amplifier).

The timing-reference pulse generator derives timing information from the filtered signal by generating a pulse for each signal-level transition. This is necessary because the random NRZ bit stream has no discrete frequency components. There is no component at the bit rate; the spectrum of an NRZ wave has a null at the bit frequency.

In deriving timing information from the data level transitions, the time of a transition marks one boundary of an individual bit. A series of unidirectional pulses is generated to mark the transition times so that there will be a descrete component of the bit frequency in the generated pulse train, and the loop can be locked to it. The timing-reference-pulse generator comprises a differentiatior-rectifier circuit which produces a positive pulse for each data-level transition. **Fig. 2** shows the timing waveforms of the input NRZ wave, the timing reference pulses and the phase-locked data clock. Input in this instance is 9.6 kHz (19.2 kbps), with the timing reference pulses and the data clock being 19.2 kHz signals.

In **Fig. 1** the phase comparator provides information to the up-down counter (at the data rate) as to whether the

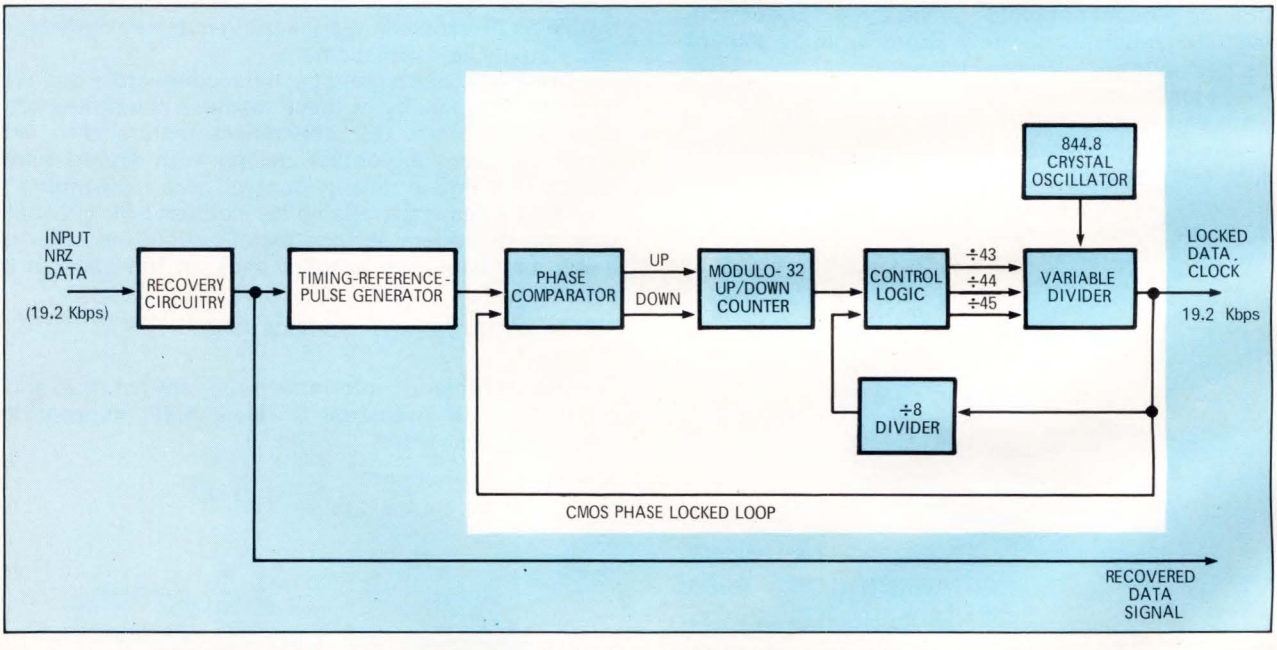

Fig. 1—In phase locking the data receiver to the transmitter bit rate, the recovery circuit first removes noise and edge jitter which may have been introduced in transmission. Clean pulses are then routed to the timing reference circuit where zero crossing pulses are generated for phase lock timing. The variable divider stretches or compresses data to maintain lock with the incoming signal.

phase of the incoming data is increasing, decreasing, or constant, when compared to the locally generated data clock. The up-down counter provides the low-pass filtering for the loop by integrating the phase information over a certain number of sample periods. These filtered phase errors are sent to the variable divider where they control the division rate.

The local data clock is generated in the variable divider by dividing the high-speed local clock (Φ) by a nominal value (N), except for a certain portion of the integration period. During this period, the high-speed clock is divided by $N - 1$ or $N + 1$, depending on the filtered phase-error samples. This insures that the local data clock is stretched or compressed by a finite number of high-speed bits to maintain lock with the incoming signal.

Both the phase locked data clock and the recovered data input are then fed to retiming circuitry. This circuitry uses the data clock to reclock the data input near the center of each bit; this eliminates noise and edge jitter.

Timing corrections maintain phase lock

Timing reference pulses are applied to the phase comparator along with the data-clock pulses. As depicted in **Fig. 2** these reference pulses should occur at the falling edge of the clock pulse. If the timing reference pulse is coincident with the more positive half of the data clock, a count-up command is generated. If the reference pulse is coincident with the more negative half, a count-down command is generated. This command is presented to the modulo-32 up-down counter along with the timing reference pulse.

The data-rate clock (approx. 19.2 kHz) is divided by 8, which determines the integration period over which the counts of the up-down counter are averaged. Decoders examine the up-down counter at the completion of the integration period and determine if the count is above (+1), below (−1), or within threshold (0). If the count is below threshold, the control logic directs the variable divider to divide by 43 during the sample period. If the count is above threshold the variable divider is set to divide by 45. If the count is within the threshold limits, the divider continues to divide by 44. In this way the phase of the data clock is adjusted to the phase of the incoming data.

Circuit operation

The schematic of the CMOS phase locked loop is shown in **Fig. 3**. One-half of CMOS dual, D-type flip-flop FF1A (RCA CD4013) serves as the phase comparator, with the timing reference pulse serving as the trigger for the flip-flop and the local clock being fed into the data input. The flip-flop is set or cleared by the incoming timing reference pulse, depending on the polarity of the data clock.

The modulo-32 up-down counter comprises dual flip-flops FF1B, 3A, 3B, 6A and 6B (all RCA CD4013), and associated CMOS gates G2A through D, G4A through D, and G5A through D (all Solid State Scientific SDS 5102). Decoding gates G7, 8A, and 8B determine whether the counter has counted up, down, or has remained at zero.

The variable counter utilizes a 7 stage CMOS binary counter FF10 (CD4004) which is driven by the 844.8 kHz high-speed clock. The counter is a feedback type, with decoding gates G11A, 11B and 12A producing the three possible divide ratios.

The counter divides by 44, except for every eighth period of the 19.2 kHz data clock. At the beginning of this sample the status of the modulo-32 up-down counter is examined by gates G13A, 13B, and 15A. The counter is then reset at the appropriate time to allow division by either 43, 44 or 45 during the sample period.

The ÷8 counter (flip-flops FF18B, 19A, and 19B and gate G12B) produces the integration period by division of the 19.2 kHz data clock. The decoded sample pulse, at a frequency of 2.4 kHz enables gates G13A, 13B and 15A, and also resets the updown counter to zero. The data rate clock is also shaped into a 50% duty-cycle wave before being sent back to the phase comparator. This shaping is accomplished by binary counter FF17, flip-flop FF18A and their associated gates. This is done by utilizing the high-speed clock (844.8 kHz), and provides equal probability that the timing reference pulse will coincide with the positive as well as the negative portion of the data clock.

If a phase error is detected, the CMOS phase locked loop divides the 844.8 kHz clock by either 43 or 45 during one cycle (sample period) of every eight cycles (integration period) of the data clock.

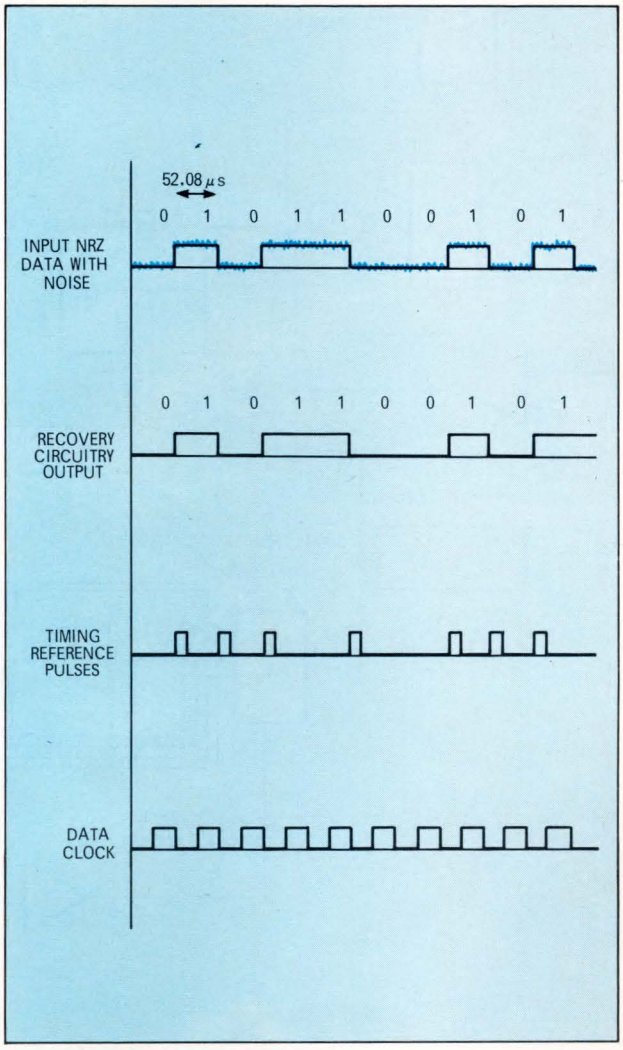

Fig. 2 — Timing waveforms show: (1) raw data input, (2) clean data output from the recovery circuit, (3) timing reference pulses, which are generated coincident to level shifts of the input data and (4) phase locked data-clock pulses. In this circuit the clock pulses are generated at 19.2 kHz.

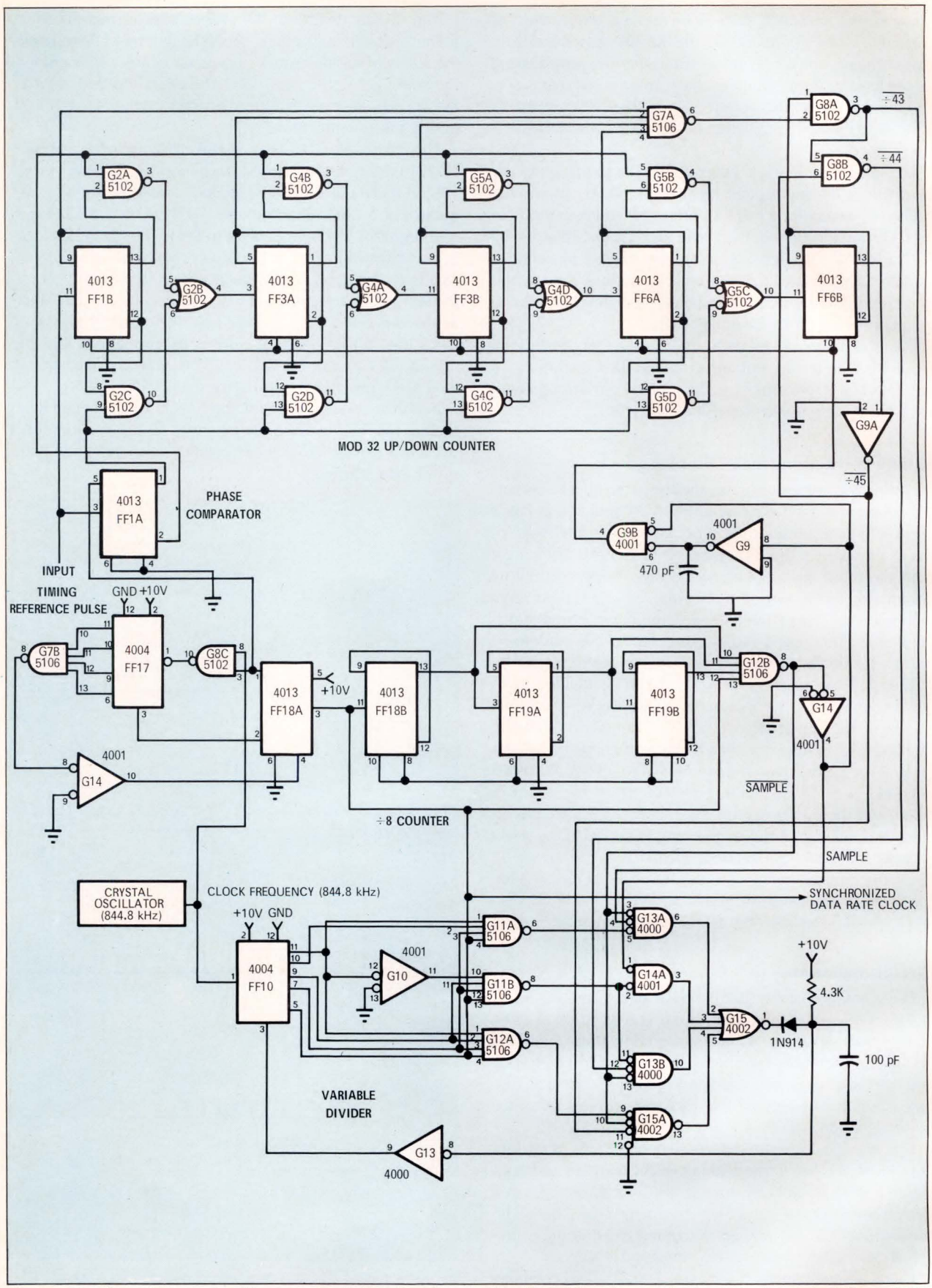

Fig. 3—Pulses from the crystal oscillator are divided by 44 at the variable divider circuit. If a synch phase error is detected, the division rate is altered to 43 or 45 to maintain phase lock. Since the phase locked loop is comprised entirely of commercially available CMOS ICs, and power dissipation is only 10 mW, the entire circuit could be readily incorporated into a single MSI device.

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This gives a possible phase correction for the sample period of,

$$d\phi = d\omega\, dt =$$

$$2\pi\left(\frac{844.8\text{ kHz}}{43} - \frac{844.8\text{ kHz}}{44}\right)\left(\frac{1}{19.2\text{ kHz}}\right)\left(\frac{180^\circ}{\pi}\right) = 8.37^\circ$$

Thus the loop can correct the phase of the data clock at a rate of 8.37 degrees per integration period. This gives a maximum frequency correction of,

$$df = \frac{d\phi}{2\pi\, dt} = \frac{8.37^\circ}{2\pi\left(\frac{8\text{ Hz}}{19.2\text{ kHz}}\right)}\left(\frac{2\pi}{360^\circ}\right) = 56\text{ Hz}$$

for a loop bandwidth of about 110 Hz, which is consistent with the value measured in actual operation. The loop lock-in time has been measured at approximately 10 msec.

The loop has no memory capability, and if the input signal fades, the data clock will be at an unsynchronized 19.2 kHz rate during the fade. This occurs because the modulo-32 up-down counter has no input timing reference pulse and will neither count up nor down during the integration period. Without this count, the decoded output will remain within the threshold and the variable counter will continue to divide by 44.

This CMOS phase locked loop has shown satisfactory operation (held phase lock) down to a signal-to-noise ratio of approximately O dB. The signal-to-noise ratio was measured at the input to the recovery circuit, and the noise was measured only within the bit-rate bandwidth.

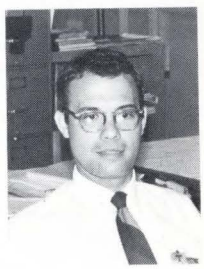
CMOS integrated logic circuits are used for the complete system. At relatively low clocking rates (below the 1MHz) CMOS circuits exhibit a substantially lower power dissipation than other types of digital circuits. They also offer very high noise immunity and high fan-out capability. The all-digital design has tremendous advantages over the relatively large power consumption of analog components.

The logic devices operate from a +10V dc supply, and the loop (excluding the 844.8 kHz oscillator) requires approximately 10mW of power. The phase-lock loop approach also offers small size and weight, and lends itself readily to microminiaturization and MSI techniques. □

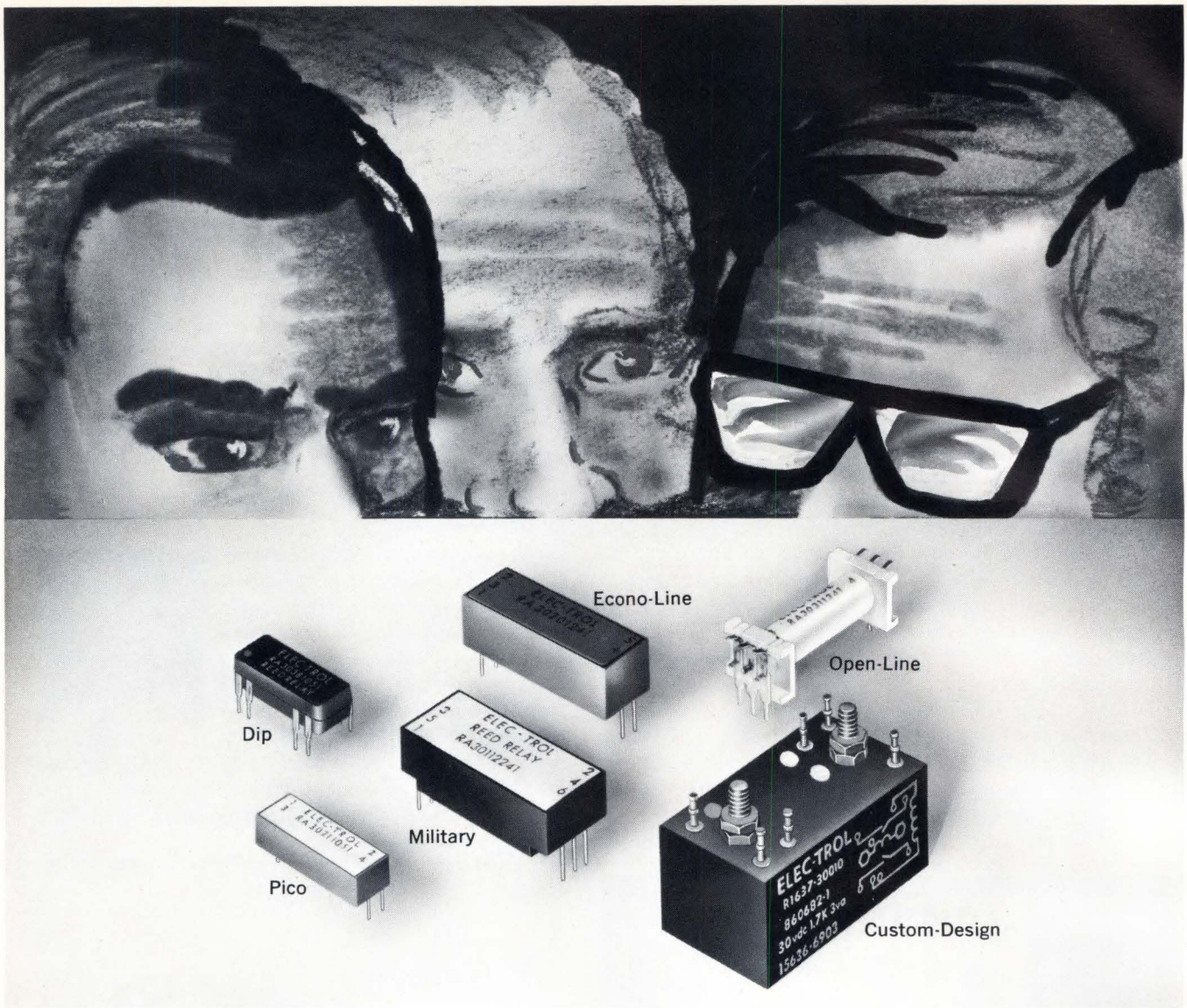
Reference

1. F. M. Gardner—"Phaselock Techniques" 1966, Wiley and Sons

Author's biography



David A. Johnson is a Senior Engineer at AVCO Electronics, Cincinati, Ohio. He received his BS and MSEE degrees from the University of Kentucky and is a member of ETA-KAPPA-NU. Mr. Johnson wishes to acknowledge that the circuit detailed in this article was developed under contract to the U.S. Army Electronics Command, Fort Monmouth, N. J. He would also like to express his appreciation to the contracting officers technical representative.



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Keeping up with new dimensions in IC applications

Here are some selected papers culled from the program of EDN/EEE's recent seminar on integrated circuit applications.

Today's designer is on a constant treadmill of technological change, going as fast as he can to keep from falling behind. And nowhere is the pace of change and advance more rapid than in the area of ICs and their applications.

New processes yield new devices which in turn open up new applications—replete with opportunities, as well as pitfalls. And the designer must be aware of all this, if he's to continue to do his job the right way.

The following articles are presented as an aid to that awareness. They were abstracted from the more than 30 papers presented at the 4-day EDN/EEE IC applications seminar recently held in Los Angeles. Space limitations prevent us from publishing all of the excellent material presented at that seminar.

Mate linear ICs with high-noise-immunity logic.

Dave Guzeman *and* **Dave Davies,** *Teledyne Semiconduct Div.*

There are many circuit requirements which fall into that ill-defined area which is neither completely digital nor completely linear. High Noise Immunity Logic (HiNIL) ICs that operate at either +12V or +15V are extremely appealing in these "hybrid" systems that use both linear ICs and digital ICs.

The marriage of HiNIL and linears can result in systems that operate from a single power supply, with significant savings in system costs. The use of 15V digital ICs allows them to be operated from the same power supply as linear ICs. The high threshold (6V) of HiNIL also offers some distinct advantages.

Fig. 1 is ideal for the temperature control of very small devices. The hysteresis resistor, R, causes the heater resistor to be switched on or off for greater efficiency. It can be adjusted for temperature changes as small as a fraction of a degree.

One application is for temperature control of a precision crystal controlled oscillator. While the heater element must be small, 600 mW or less, it is large enough to maintain the temperature in a small, confined space. In the event that a larger heating element must be controlled, a relay or a triac can be driven by the 301 (**Fig. 2**). This in turn can control a larger heater.

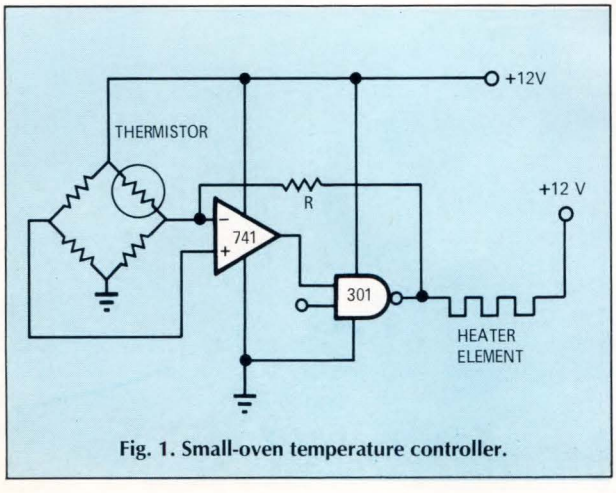


Fig. 1. Small-oven temperature controller.

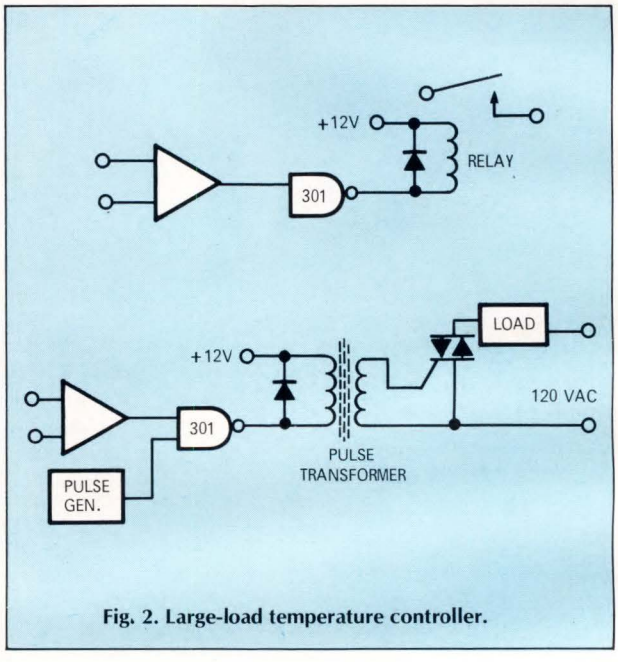


Fig. 2. Large-load temperature controller.

The pulse generator block can be either a free-running multivibrator (**Fig. 3a or b**) or can be derived from the 60 Hz supply, as shown in **Fig. 3c**.

Operate a 741 from a single-ended supply

A word about the operation of the 741 at +12V is in order. It is well known that a 741 will operate as low as ±6V. It will also operate at +12V and OV with certain restrictions. The restrictions are that, as far as the amplifier is concerned, the inputs operate near a point halfway between

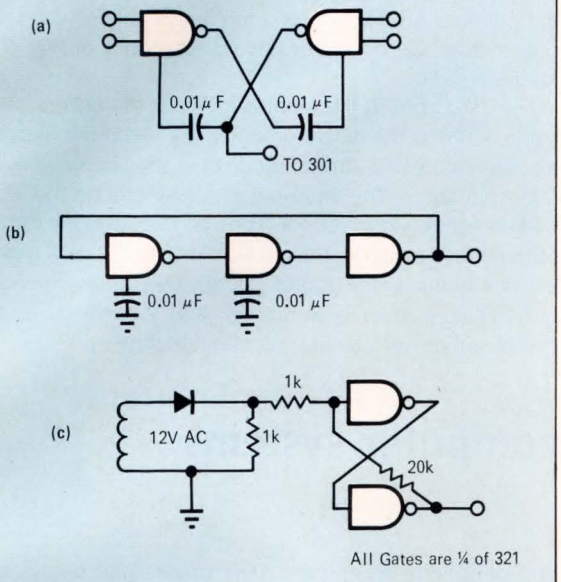


Fig. 3. Possible configurations for pulse generator of Fig. 2.

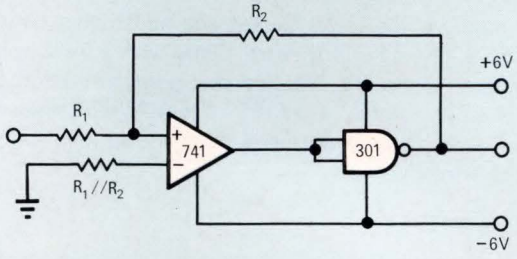


Fig. 4. Circuit for achieving high slew rate from 741 op amp.

the supplies, which is +6.OV relative to ground. Likewise, the output must operate between a volt or so above the lower supply to a volt or so below the upper supply.

If the amplifier is operated open-loop, as in **Fig. 1**, and its non-inverting input is connected to two equal low-value resistors, one of each terminating at each supply (ground and +12V), then the non-inverting input will be at precisely +6V. If the inverting input is driven a few millivolts more positive than +6V, the output will be driven to near ground potential, turning off the heater element. Conversely, if the inverting input drops a few millivolts below +6V, the heater element will be turned on.

Another interesting and useful application of HiNIL is to improve the slew rate of an op amp. Often a system requirement exists for one or two high slew-rate operational amplifiers. And rather than add one more part to your parts list, simply use a circuit similar to that shown in **Fig. 4**. Resistors R_1 and R_2 are selected in the usual manner, according to required closed-loop gain. Note that since the 301 is an

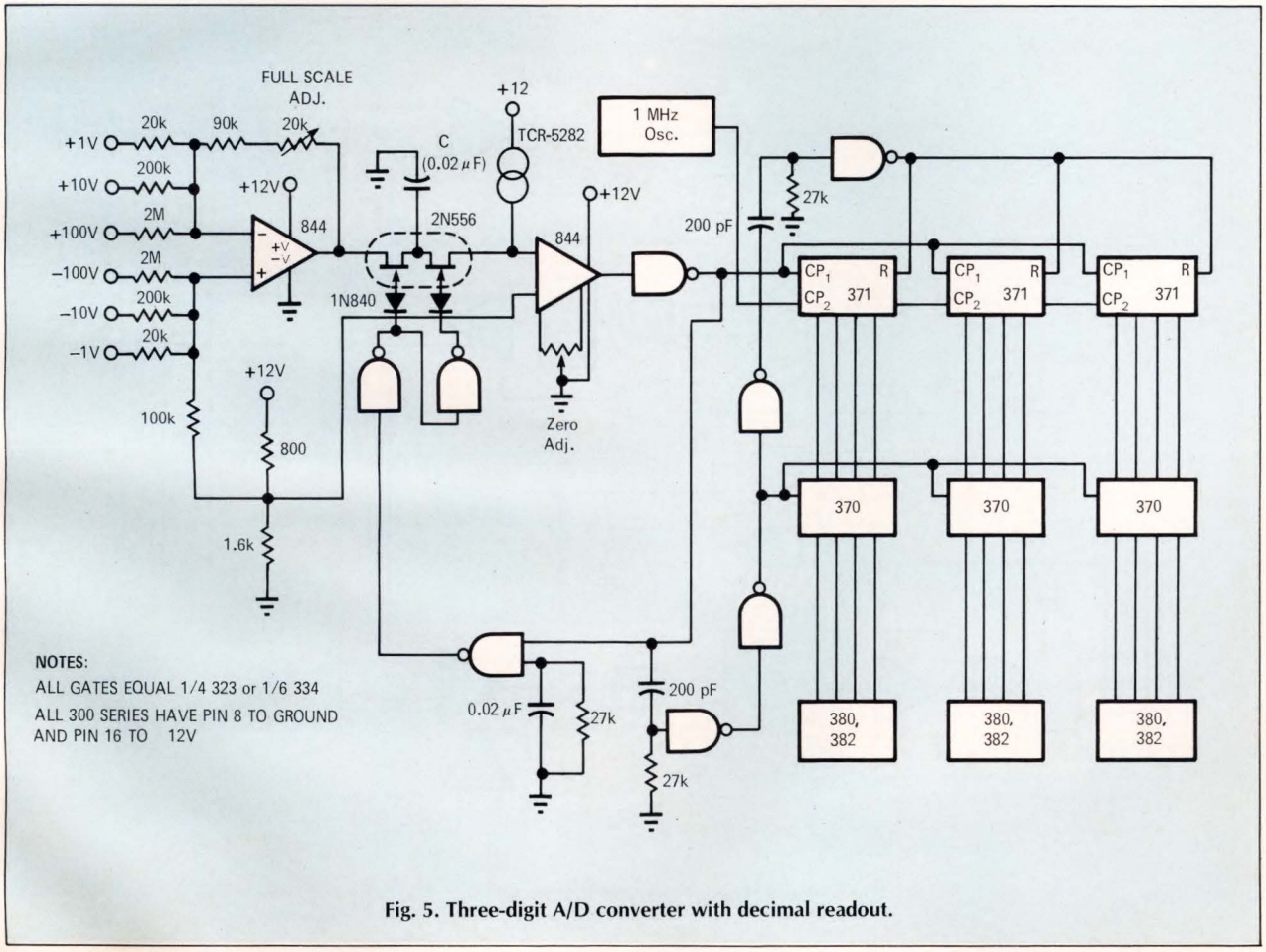


Fig. 5. Three-digit A/D converter with decimal readout.

inverter, the non-inverting and inverting inputs of the 741 need to be interchanged for the 741-301 combination. An added bonus is the lower impedance and higher current drive capability of the 301, particularly with ±6V supplies as compared to the 741. The slew rate is improved from the 0.2 to 0.7V/sec of the 741 to the 10 to 40V/sec range. Remember that this does not produce a fast op amp, only a higher slew-rate version.

A low cost DVM

A natural application for linear and digital circuits together is in A/D and D/A converters. Much has been written about 10, 12 and larger bit systems of high accuracy. However, there exist many applications for less-accurate systems using fewer parts. A simple 3-digit A/D converter which operates from a single 12-volt supply is shown in **Fig. 5**. The combination of the constant-current diode (TRC-5282) and the capacitor "C" is chosen to charge up 5 volts per millisecond. Therefore, a full 5-volt change gates 1000 pulses from the oscillator, giving a readout of 000 (over-range).

The 20kΩ pot in the feedback circuit of the first 844 op amp calibrates the maximum range for variations in capacitor value, constant-current diode operating point, and oscillator frequency. The input-offset adjustment on the second 844 serves as a zero set pot. The first stage sets the range by converting 0 to 1 volt, 0 to 10 volt, or 0 to 100 volt inputs to a 5-volt swing on the output. For positive inputs, the respective negative input is grounded, and vice-versa. Readout can be either gas tube or projection readout.

Line drivers are not limited to computer systems

Dale Pippenger, *Texas Instruments, Inc.*

With the rapid growth of both linear and digital ICs, there has been an increasing need for interface circuits—devices that contain both types of functions. Interface circuit applications is a very important area in today's world of computers and peripheral systems.

Line drivers and receivers perform many jobs

A very popular interface application is that of transmitting and receiving data between main computer consoles and peripheral equipment. Line drivers and receivers are used to perform this function.

There are many types of line drivers and receivers available, each designed with particular requirements in mind. Some are designed for party-line applications, some for use on single supply voltages, and some to meet special requirements such as military standard or EIA specifications. It should be kept in mind that these devices, although de-

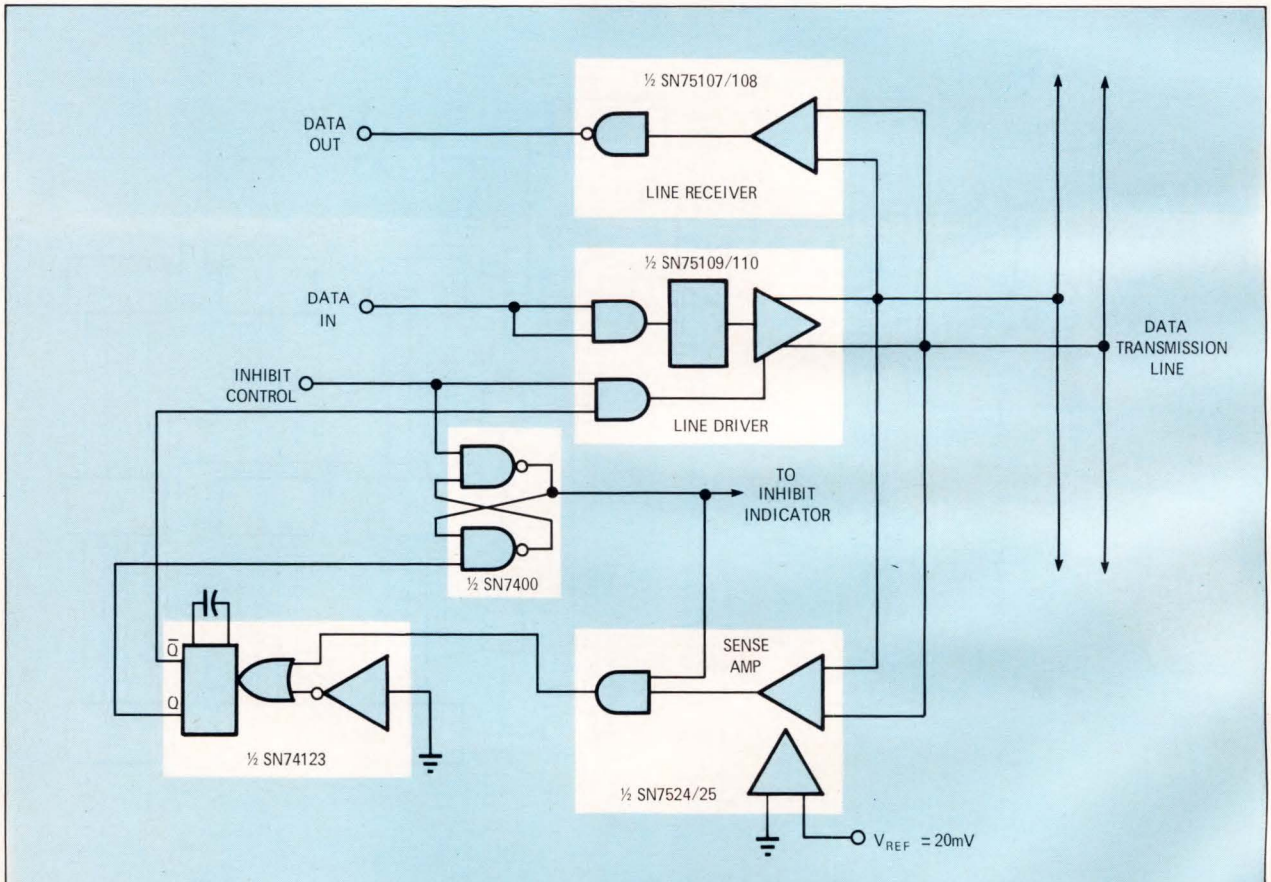


Fig. 1. Data terminal with Busy Inhibit.

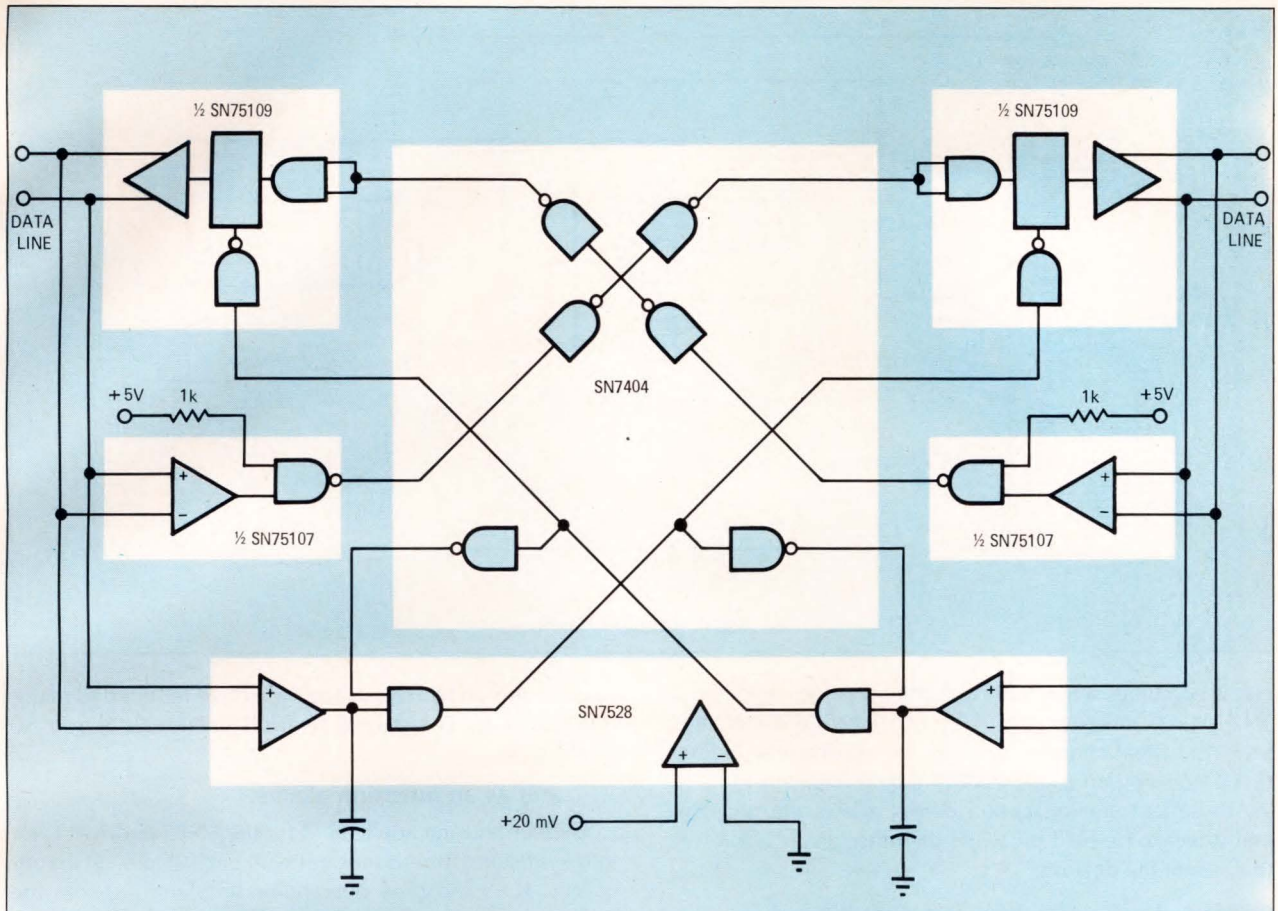


Fig. 2. Data line relay.

signed to meet special requirements for data transmission systems, have many applications. Line receivers may be used as comparators, signal detectors, oscillators and level shifters.

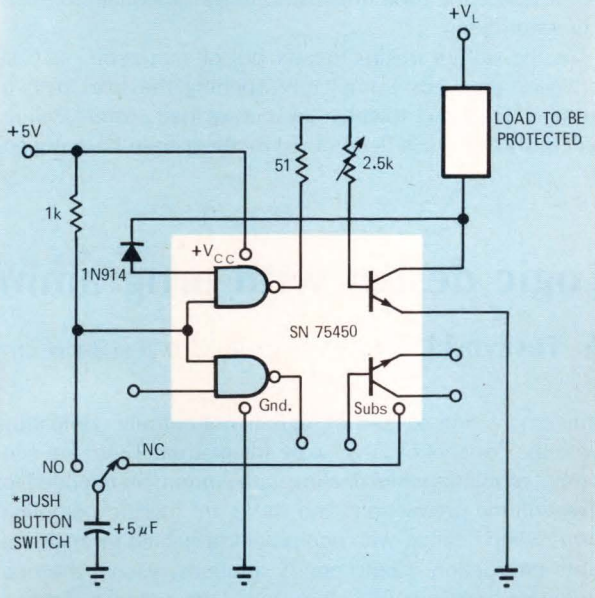
Line drivers may be used as memory drivers, level translators and lamp drivers, just to name a few of the possible applications.

Is the line busy?

One problem encountered in party-line systems is the same as that of the old telephone party lines—knowing whether a line is busy or not.

The circuit shown in **Fig. 1** monitors the transmission line and will provide an inhibit control to the local driver when the line is busy. The local driver may be enabled when no data is being received from the line. If there is no data on the line, the retriggerable one-shot releases the line driver for operation. Before data is fed to the driver input, the local enable-control input must be taken high. The line sense amplifier is then inhibited to prevent interference with the local driver. The local driver may then transmit on the line.

Data transmission between racks of equipment in the same room may be accomplished relatively easy. Long-line transmission from a building or within a building of very large size may require signal boosting. This can be accomplished simply by feeding through a receiver and driver to boost the signal. The problem becomes slightly more complex if bidirectional transmission is desired. The circuit of



*Push button switch must be actuated to turn on power to the load and also to reset if overload occurs.

Fig. 3. Electronic circuit breaker.

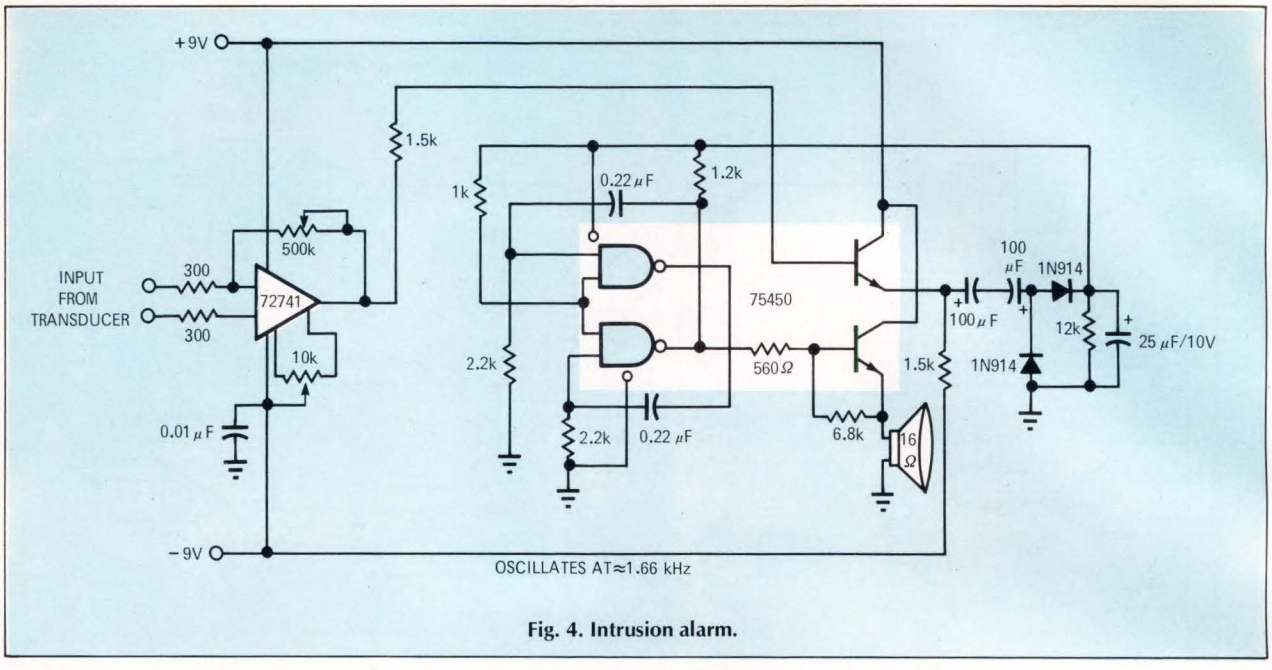


Fig. 4. Intrusion alarm.

Fig. 2 combines a SN7528 dual-channel sense amplifier, a SN7404 hex inverter, a SN75109 dual-channel driver and a SN75107 dual-channel receiver to accomplish bidirectional boosting on a single transmission line.

Adjustment of propagation delays allows the receiving end driver to be held off while the other driver is allowed to transmit the data on.

Peripheral driver doubles as a circuit breaker

A basic general-purpose driver has many applications in peripheral systems. The SN75450A operating as an instrumentation circuit breaker (**Fig. 3**) is a good example of the versatility of such a device. The output transistor saturation level locks the circuit on until the ON current increases to a point where the base drive is no longer adequate to maintain saturation.

As the output begins to pull out of saturation, its base drive is removed—completely opening the load path to ground. The limit at which the output load current will result in shut-down is determined by the gate-to-base impedance control, which limits the base drive required to maintain saturation. This may be set for limit currents of from 50 to 250 mA.

. . . and as an intrusion alarm

Another unusual application for the SN7545 driver is an intrusion alarm that sounds out with each step of an intruder (**Fig. 4**). A SN72741 operational amplifier provides the high gain required from a sensitive transducer. The transducer, similar to a very sensitive microphone, is capable of sensing even light footsteps from up to 30 feet away. The resulting pulses are amplified by the SN72741 and fed to a detector-filter circuit. The detector will develop a positive voltage, turning on a 1.5-kHz oscillator which drives a 16-ohm speaker.

Each footstep in the general area of the transducer will produce a short but sharp tone at the speaker. The output from the speaker driver can be used to operate another type of alarm or lamp, if desired. The oscillator, detector drive and output drive are provided by one SN75450 driver.

Logic design with programmable arrays

A. Tuszynski, *University of Minnesota (Consultant, Solitron Devices, Inc.)*

Implementation of custom logic is not entirely compatible with the concept of large-scale integration. There are economic problems when dealing with equipment intended for low-volume production, and there are logistic complications when dealing with equipment projected for high-volume production. Compromise solutions resolve the economic and logistic difficulties, but at the expense of device utilization efficiency or some other design criteria.

A Programmable Logic Array (PLA) affords an excellent compromise. The cost of programming is low, the turnaround time is short and device utilization is at the discretion of the system designer. It can be used as a working model of items projected for high-volume production as well as actual hardware of low-volume items.

The block diagram of a Programmable Logic Array (**Fig. 1**) comprises a bank of inverters, two logic-matrices, a set of memory elements and a block of output drivers. There is a feedback path from the output of the second matrix through the memory elements to the input of the first matrix. Sequential as well as combinatorial functions can be implemented, subject only to the dimensional limitations of the array. In a typical PLA, there may be 70 rows by 50 columns in Matrix 1, 70 rows by 35 columns in Matrix 2 and 8 flip-flops in the memory bank.

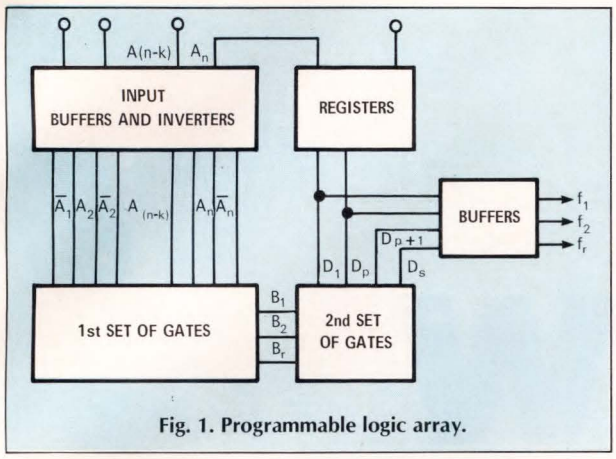


Fig. 1. Programmable logic array.

Programming a PLA

In absolute voltage notation, a MOS logic matrix is a set of NOR-gates (**Fig. 2**). Programming of the matrix is executed during the gate-oxide stage of processing. Cross-hatched gates in **Fig. 2** indicate thick-oxide gates and, therefore, inactive transistors. Regular gates represent thin-oxide gates and active transistors.

The PLA symbolism of the matrix is explained in **Fig. 3** by reference to conventional NOR-gate logic. A r x k matrix comprises r k-input gates. Going back to **Fig. 1**, both matrices have the same number of gates, since the outputs of the first matrix are also the inputs to the second matrix.

Given NOR gates as the only available hardware, any Boolean function "f" of variables A, B, C, . . . can be implemented in three stages[2]. Given the complements of A, B, C . . ., as well as the original variables A B C . . ., a Boolean function can be implemented in two stages. Thus, given a block of input inverters and two logic matrices, we can implement any Boolean function, subject only to the dimensional limitations.

To demonstrate the writing of a program, let's implement a resetable serial adder. A and B are the two inputs to be summed. C_n is the input carry term. C_{n+1} is the output carry term and R is the reset. From the truth table we get

$$\Sigma = (A + B + C)\ (A + \overline{B} + \overline{C})\ (\overline{A} + B + \overline{C})\ (\overline{A} + \overline{B} + C)\overline{R}$$

$$C_{n+1} = (A + B + C)(A + B + \overline{C})(A + \overline{B} + C)(\overline{A} + B + C)\overline{R}.$$

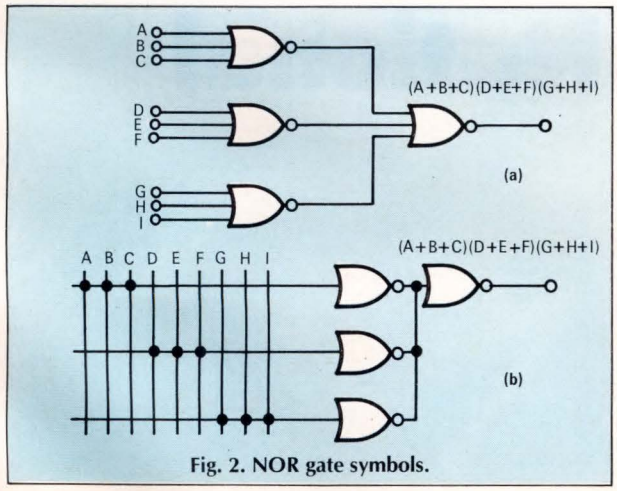


Fig. 2. NOR gate symbols.

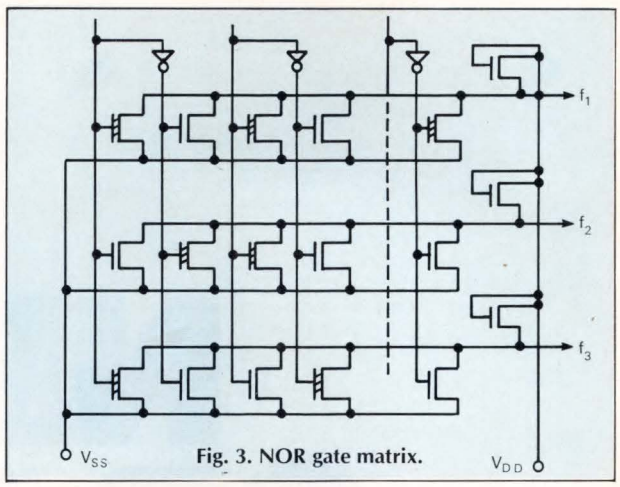


Fig. 3. NOR gate matrix.

Truth Table

A	B	C_n	R	Σ	C_{n+1}
0	0	0	0	0	0
0	0	1	0	1	0
0	1	0	0	1	0
1	0	0	0	1	0
0	1	1	0	0	1
1	0	1	0	0	1
1	1	0	0	0	1
1	1	1	0	1	1
X	X	X	1	0	0

Guided by **Fig. 3** we connect input lines ABC of **Fig. 4** to the first row of the first matrix, Lines A, B, C to the second row and so on up to input R and the fifth row of Matrix 1.

Advancing to function C_{n+1}, we note that subfunctions (A + B + C) and R are already available. We connect, therefore, lines A, B, $\overline{C}$ to row 6, $\overline{A}$, B, $\overline{C}$ to row 7 and $\overline{A}$, $\overline{B}$, C to row 8.

In the second matrix, we connect rows 1, 5, 6, 7, and 8, the elements of function C_{n+1}, to a column equipped with a memory element. Rows 1 through 5, the elements of function Σ, are connected to a direct-output column. □

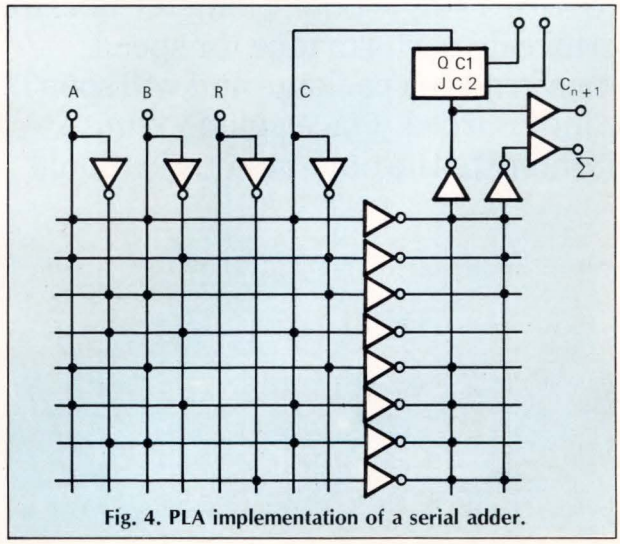


Fig. 4. PLA implementation of a serial adder.

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CIRCLE NO. 31

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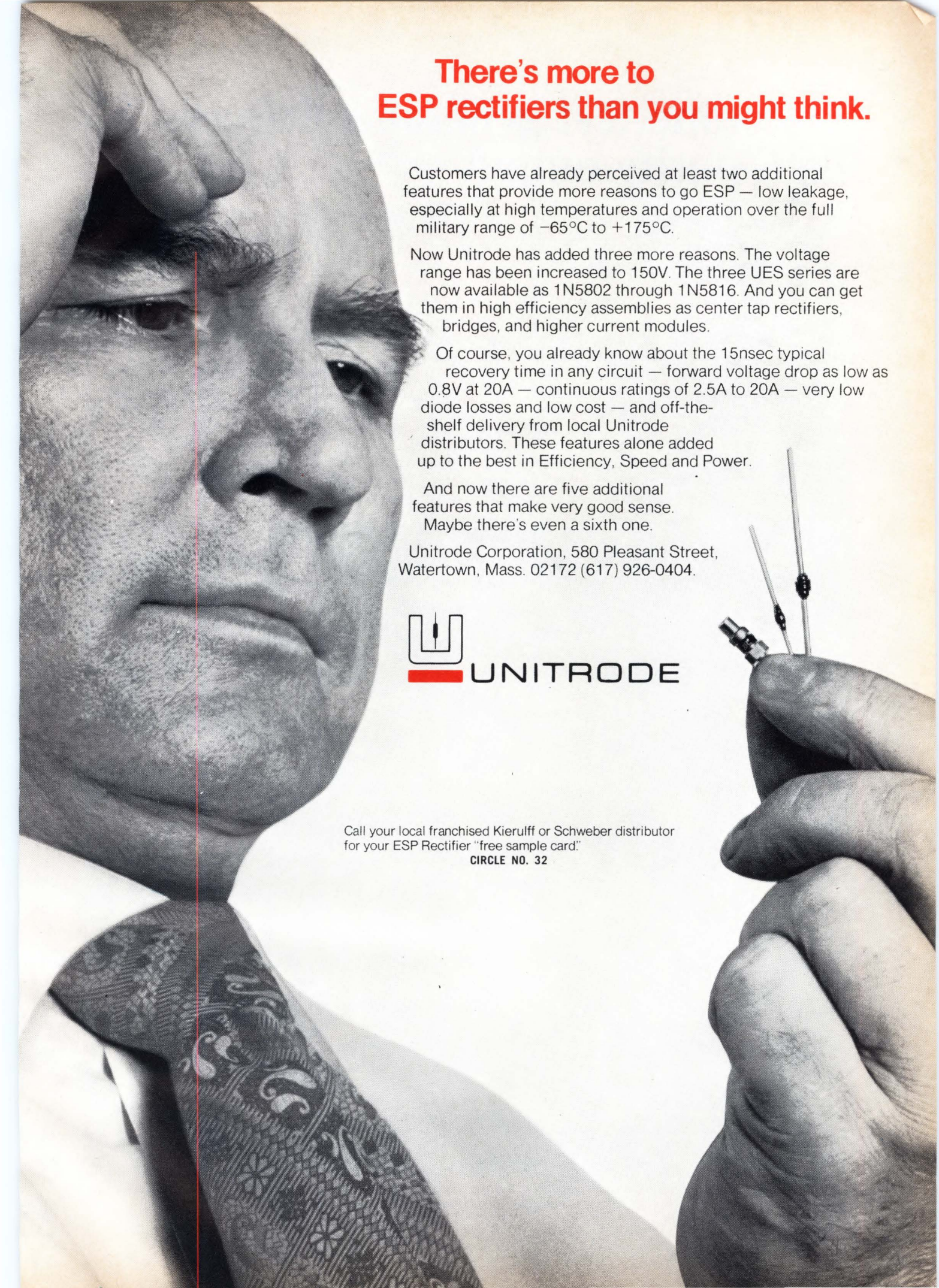

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CIRCLE NO. 32

Two-tone test generator delivers high-purity output

Here's how to design a test generator that produces two audio signals and combines them in such a way that all harmonics and cross-products are negligible.

Hank Olson, Stanford Research Institute

In the testing of single-sideband systems, it is common to use a two-tone signal as the audio input. If the results are to be meaningful, the two-tone input must itself be clean. That is, the harmonics and cross-products between the two frequencies must be small compared to the expected levels of these components caused by the device under test. When testing a system that is quite linear, this means that the two-tone input must be of high purity. Even if two high-quality laboratory oscillators are used (like the Hewlett-Packard 204C), there is still the problem of combining their output in such a way that one does not affect the other.

The generator shown in **Fig. 1** produces 800-Hz and 2000-Hz signals combined with a purity such that all harmonics and products are down more than 85 dB from the desired tones. This small degree of distortion is achieved by using two Wien bridge oscillators and then following each with an active bandpass filter. Actually, the two audio oscillators are modified versions of the classic Wien bridge circuit.

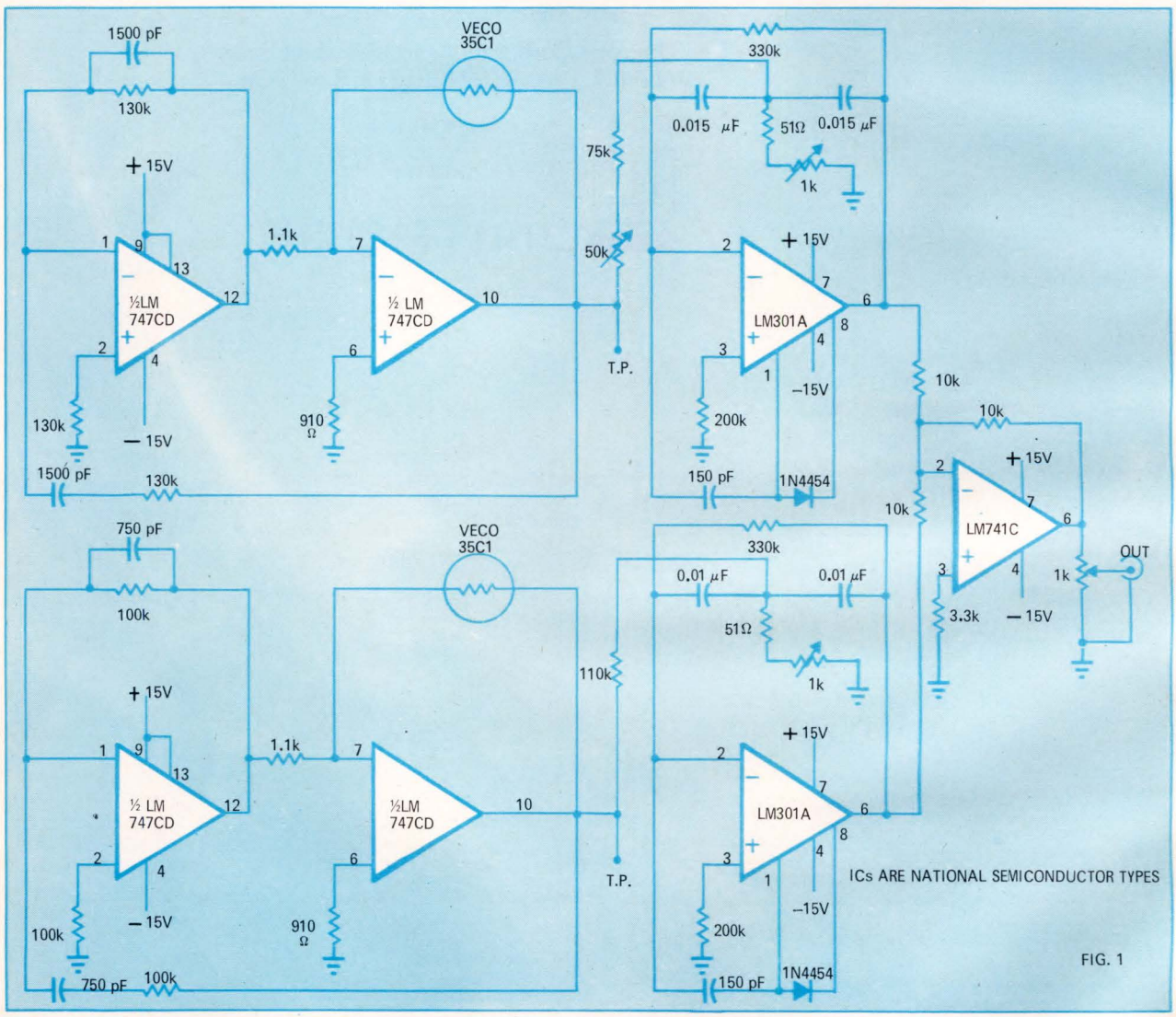

Fig. 1 — The test generator circuit consists of two Wien bridge oscillators, each followed by an active bandpass filter. The outputs from the two filters are combined in an operational adder. The generator produces 800 Hz and 2 K-Hz signals.

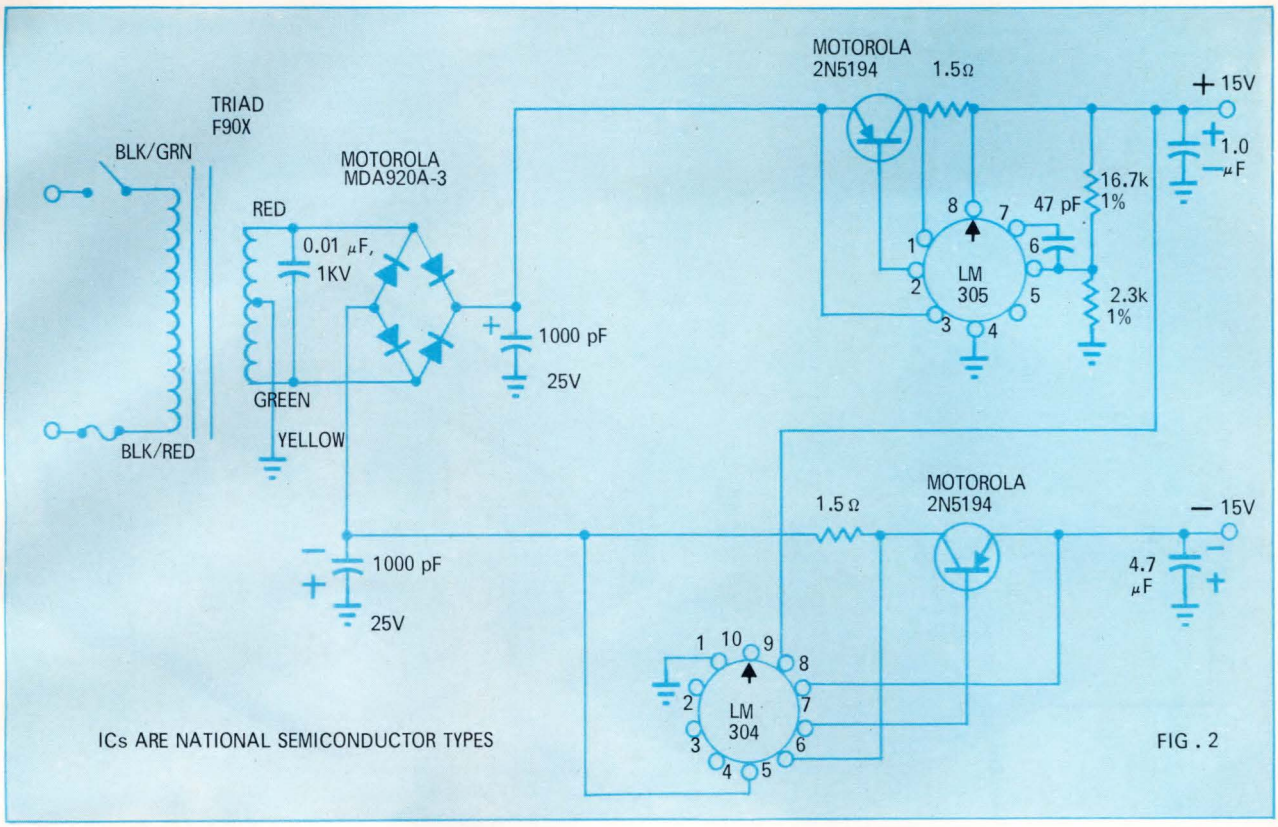

Fig. 2—A simple IC power supply can be used to provide power to the two-tone test generator.

In each oscillator circuit, the amplitude-controlling nonlinear resistance (a thermistor) is associated with one op amp, and the frequency-determining RC network is associated with another op amp. The parallel RC branch of the network is returned to the output of its op amp, instead of to ground. This makes it possible to use larger values of R (and smaller values of C) for any given frequency, since the parallel RC branch "sees" a higher impedance.

The active bandpass filters, which follow the oscillators, further reduce harmonic content. Each filter has a variable resistor which "tunes" the filter to the frequency of its associated oscillator. This particular form of active filter is discussed at some length in References 1, 2, and 3.

Finally, the two frequencies are combined in an operational adder. The fact that the inverting input appears as a "virtual ground" means that the output of each active filter effectively sees 10 kΩ to ground. But the summing point is at the virtual ground, which assures that the oscillator-filters do not affect each other.

There are four adjustments on the two-tone test oscillator. Two of these, the two filter-tuning variable resistors (1 kΩ), already have been mentioned. The third is a 50 kΩ variable resistor associated with the 800-Hz active bandpass filter. It is used to make the levels of the two tones equal. Finally, there is a front-panel control, a 1 kΩ potentiometer across the output of the operational adder, which is used to set the combined two-tone output level.

Normally, the level of each tone is about 12V peak-to-peak and the maximum combined output level is about 24V peak-to-peak. This level should be more than enough to provide two-tone signals for most systems to be tested.

A simple integrated-circuit regulated supply (**Fig. 2**) can be constructed to power the two-tone test oscillator. It uses the LM305 and LM304 positive and negative regulator ICs slaved together to provide tracking.[4] □

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3. Dobkin, R., "Easily Tuned Sine Wave Oscillators," National Semiconductor Linear Brief LB-16, March, 1971.
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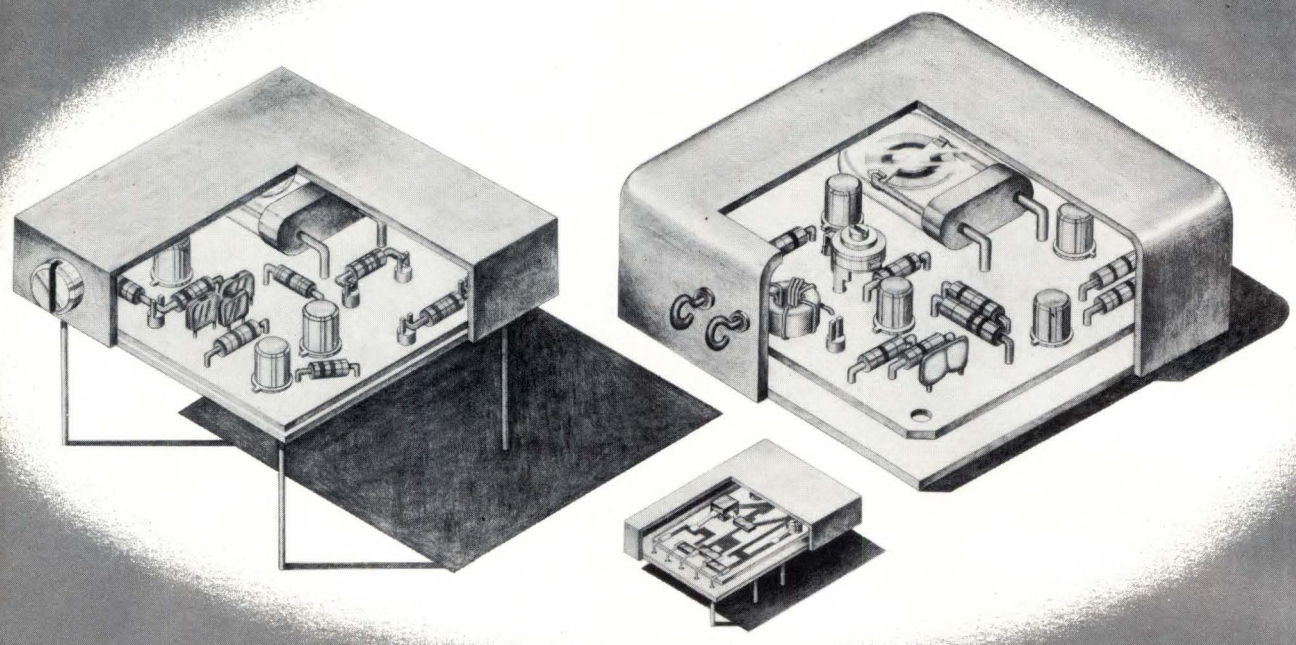
Author's biography

Hank Olson is a research engineer for Stanford Research Institute. He holds a BS and MS from Stanford University, and is a member of IEEE and APRL. Hank is an avid HAM radio operator, working under the call letters W6GXN. He lives with his wife, Jane, and daughter, Dana, in Menlo Park, CA.

Let's make it crystal clear.



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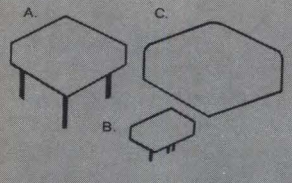

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Seal: Hermetic

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±50 PPM over		−40° to + 85°C
±50 PPM over		0° to + 75°C

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"ADVANCING CRYSTAL TECHNOLOGY FOR TWO DECADES"

CIRCLE NO. 61

Design complex active filters with these few equations

Break active filters into standard two-pole sections. You can reduce the number of design equations and therefore the design effort.

P. G. Ioannides, IBM Corp.

Synthesizing a multiple-pole, low-pass or high-pass active filter no longer needs to be a tedious job. The filter, no matter how complex and no matter how many poles, can be made up of basic filter sections which are themselves simple to design. These basic sections have only second-order transfer functions and can be designed with a minimum of equations and therefore a minimum effort. These basic sections can then be cascaded to obtain higher-order transfer functions.

Each basic section consists of a minimum number of passive elements and one active device. The active device can be any suitable amplifier that will provide the necessary unity voltage gain and high current gain. Darlington emitter followers, compound transistor followers, or operational amplifiers can be used. The circuit configurations for the low-pass and high-pass versions of the basic section, along with the design equations, are given in **Tables 1 and 2**.

Since each basic second-order section has two poles, the number of cascaded filter sections for an N-pole transfer function will be N/2. For a Butterworth frequency response, all poles of the transfer function are located on the left-hand side of a circle of radius ω_n in the S-plane, ω_n being the desired corner frequency of the filter (see reference). All the N/2 cascaded basic filter sections will have their conjugate poles located on the circle of radius ω_n at different angles, θ, from the negative real axis of the S-plane. The following equations give the location of the conjugate pair poles and the damping factor of the **k**th basic filter section for a Butterworth frequency response:

$$S_{1,2}^{k} = -\omega_n \left\{ \sin\left[\frac{(2k-1)}{2N}\pi\right] \pm j\cos\left[\frac{(2k-1)}{2N}\pi\right] \right\},$$

$$\zeta_k = \sin\left[\frac{(2k-1)}{2N}\pi\right],$$

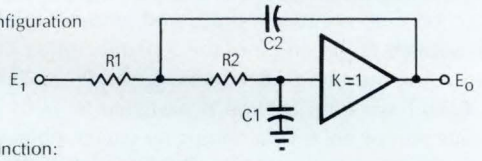
$$\theta_k = \frac{\pi}{2}\left[1 - \frac{(2k-1)}{N}\right],$$

where $k = 1,2,3 \ldots \frac{N}{2}$.

For a Chebyshev frequency response, all poles of the transfer function are located on the left-hand side of an ellipse centered at the origin of the S-plane. The minor radius of the ellipse is parallel to the real axis, σ, and the

Table 1, Design steps for two-pole, low-pass active filter

Circuit configuration



Transfer function:

$$\frac{E_0}{E_i} = \frac{\omega_n^2}{S^2 + 2\zeta\omega_n S + \omega_n^2}$$

Corner or natural resonance frequency ω_n:

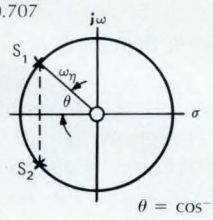
$$\omega_n = \frac{1}{\sqrt{R_1 R_2 C_1 C_2}}$$

Damping factor ζ:

$$\zeta = 1/2(R_1 + R_2)\, C_2\omega_n$$

For maximally flat response $\zeta = 0.707$

Pole location in the S-plane:



$\theta = \cos^{-1}\zeta$

Design equations for passive elements:

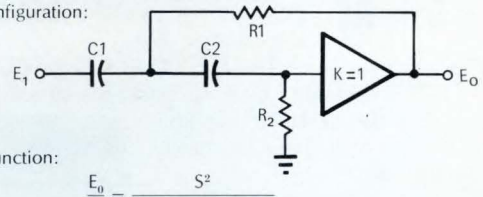
C_1 selected from stock, $M > \frac{1}{\zeta 2}$ for R_2 to be a real quantity,

$$C_2 = \frac{C_1}{M'}, \quad R_1 = \frac{M}{\omega_n^2 C_1^2 R_2}$$

$$R_2 = \frac{\zeta M}{C_1\omega_n} - \frac{1}{C_1\omega_n}\sqrt{\zeta^2 M^2 - M}$$

Table 2. Design steps for two-pole, two-zero high-pass active filter

Circuit configuration:



Transfer function:

$$\frac{E_0}{E_i} = \frac{S^2}{S^2 + 2\zeta\omega_n S + \omega_n^2}$$

Corner or natural resonance frequency ω_n:

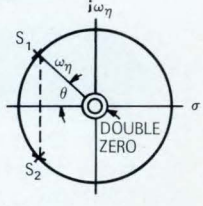
$$\omega_n = \frac{1}{\sqrt{R_1 R_2 C_1 C_2}}$$

Damping factor ζ:

$$\zeta = 1/2(C_1 + C_2)\, R_1\omega_n$$

For maximally flat response $\zeta = 0.707$

Pole zero location in S-plane:



$\theta = \cos^{-1}\zeta$

Design equations for the passive elements:
Select $C_1 = C_2 = C$ from stock

$$R_1 = \frac{\zeta}{\omega_n C} \quad R_2 = \frac{1}{C\zeta\omega_n}$$

major radius is parallel to the imaginary axis, $j\omega$. Consequently, each of the N/2 basic filter sections will have its conjugate pole at a different corner frequency ω_{nk}, as well as at a different angle θ_k from the negative real axis.

The minor and major radii of the Chebyshev ellipse are:

Minor radius $= \omega_n \sinh \beta$,
Major radius $= \omega_n \cosh \beta$, where

$$\beta = \frac{1}{N} \sin^{-1}\left(\frac{1}{\epsilon}\right), \text{ where}$$

$$\epsilon = \sqrt{10^{rip/10} - 1}$$

ω_n is the filter's corner frequency and rip is the desired ripple in db

The real and imaginary parts of each of the N poles of the transfer function are:

$$\sigma_k = -\omega_n \sinh \beta \sin\left[\frac{(2k-1)}{2N}\pi\right] \qquad k = 1,2,3 \ldots N$$

$$\omega_k = \omega_n \cosh \beta \cos\left[\frac{(2k-1)}{2N}\pi\right] \qquad k = 1,2,3 \ldots N$$

For a Chebyshev frequency response, the corner frequency and the damping factor of each of the N/2 cascaded basic filter sections are:

$$\omega_{nk} = \omega_n \left\{\left(\sinh \beta \sin\left[\frac{(2k-1)}{2N}\pi\right]\right)^2 + \left(\cosh \beta \cos\left[\frac{(2k-1)}{2N}\pi\right]\right)^2\right\}^{1/2} \qquad k = 1,2,3 \ldots \frac{N}{2}$$

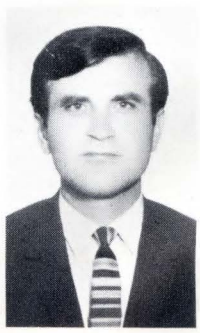
$$\zeta_k = \frac{\sinh \beta \sin\left[\frac{(2k-1)}{2N}\pi\right]}{\omega_{nk}} \qquad k = 1,2,3 \ldots \frac{N}{2}$$

To summarize: the synthesis of a high-order transfer function with conjugate poles and an even number of zeros located at the origin of the S-plane can be obtained by cascading the basic filter sections shown in Tables 1 and 2. Each basic filter section is designed to yield just a conjugate pair of poles or a conjugate pair of poles along with a double zero at the origin. The location of the conjugate pole pairs can be selected according to the proper design of the basic filter sections. □

Reference

"*Network Analysis and Synthesis,*" F. F. Kuo, John Wiley, New York, 1962. (See pages 327-340.)

Author's Biography



Panagniotis G. Ioannides is a circuit designer at IBM's Systems Development division laboratory, San Jose, Calif. He has been with IBM for two years and before that was a microwave engineer with Applied Technology Division, Itek Corp. He holds a Marine Engineering diploma, and two degrees from San Jose State College: a BSEE and MSEE.

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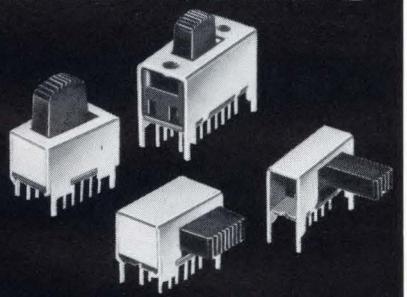

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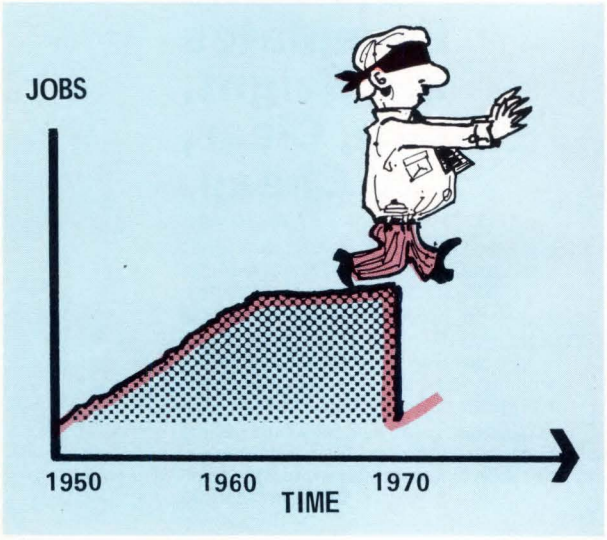
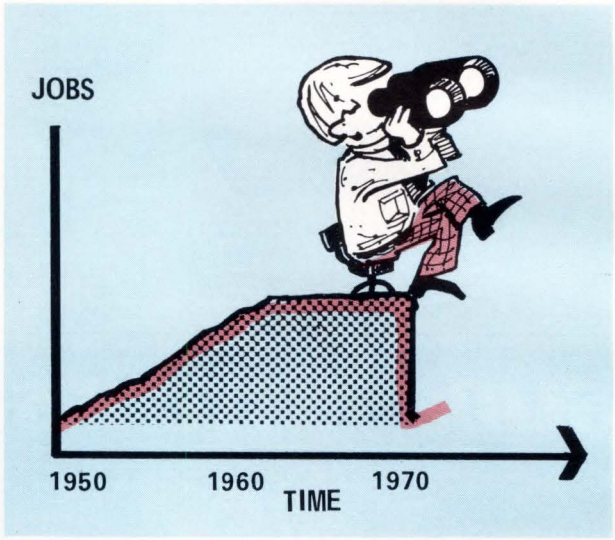
CIRCLE NO. 36

Can an EE use market forecasts to plan his career?

Design engineers owe it to themselves to forecast the markets for their services and to plan their personal careers accordingly.

Robert H. Cushman, New York Editor





The past decade has taught EE's two things: you can't trust anybody to plan your career for you, and most engineer's careers depend ultimately on government spending. The engineers who did not outguess what finally happened in 69-70 have been left with a stagnant gap in their creative careers. They have been left either with jobs that have reduced scopes of creativity or without engineering jobs at all. How, though, can engineers best chart their way out of the present catastrophe? How can they avoid getting caught the next time?

The answer is that which has been used by some of the best managed corporations: make use of market forecasts. It's easy to find fault with market forecasts because they are to some degree always wrong; but one has to admit that the larger companies that make extensive and continuous use of market forecasts—like IBM, Westinghouse, Monsanto and Foxboro—have come through the recent setback better than most engineers.

But first, let's see what's wrong with engineers.

The fault with creative EE's is that they dream of the future in terms of all the wonderful good their technology will do for the World, naturally assuming the World will meanwhile be paying them steadily. Just look back at the IEEE Proceedings for May 1962, where on the society's 50th anniversary a worthy assortment of peers predicted in rosy detail their romantic dreams for the various futures of their specialties. Their strictly technical forecasts envisioned all the usual solutions to man's needs, from computer-automated education via TV to lifetime medical aids for the handicapped.

Their dreams themselves shouldn't be ridiculed, for they were essentially sound and will eventually come true. But it is ridiculous for a profession to go on dreaming of humanitarian uses for its creative talent when historically it has only been supported (in sporadical spurts at that) by nations afraid of enemies. Look back in history (in such books as Ref. 1) and you will see that this is true.

Hard-nosed market forecasts can provide the contact with reality that in the long run will help engineers move more surely toward their dreams of usefulness.

What an SRI forecaster says

Robert Peters, industrial economist with Stanford Research Institute (SRI), Menlo Park, Calif., says: "Individual engineers can very definitely use the market predictions developed for industrial clients for their own career planning. I've used my own reports to plan my life. It is no accident that I plan to spend my career in the new communica-

tions field. My research assignments at SRI on the future of this new field—that includes both data communications and expansions of video—have thoroughly convinced me of the long-term growth, challenge, excitement and security that lie ahead. I don't see this field reaching its full bloom until the 1980's, but that's fine with me for then I'll be in my 40-50 period and in full bloom myself."

Peter's own career up to this point makes an interesting comparison to that of many aerospace engineers. Like many young men back in the early 60's, he had been pushed toward the defense industry by his work in the armed services. But, he recalls, some kind angel must have been looking out for him because he stopped himself with the thought, "Boy, this aerospace thing has a short fuse on it!"

Yet, though he saw that aerospace was risky, he did not have any clear vision of which way to head He did, however, become so interested in the problem of choosing a long-term growth industry that he ended up in market forecasting. After graduate work in business administration and a stint at Hewlett-Packard, he joined SRI.

"Being involved in market forecasting at SRI has been a lucky thing for me," says Peters, "for it has given me the answer I was groping for. I was exposed to the in-depth methodology of quantitively sizing up the present state of industries and markets and carefully extrapolating into the future, taking into account many different factors, from nuts and bolts to economic, political and social issues. So when I say I am confident that there is a long-term future in communications it is not just a casual observation, but a conviction born out of exhaustive study and analysis."

Engineers who have not seen the comprehensive reports that SRI puts out should get their hands on one. These reports often consist of several complete volumes. They are a balance between hard, quantitative data and research opinions. The logic behind the forecasts is usually sufficiently explained that the reader can evaluate their merit on his own. This is especially important for individual engineers who obtain these reports—say through the kindness of a friendly marketing department—because the reports are naturally pitched toward corporate, not individual planning.

Don't try to purchase these reports from SRI because you won't be able to afford them. They'll cost you a year's salary. SRI projects have budgets as high as a million dollars and the cost is typically shared by several dozen large corporations (quite a few of SRI's regular are in the "Fortune 500" category). Peters said he has just completed a "fairly massive" study on cable TV for 40 clients spread across the U.S., Japan and Western Europe. A current SRI study many engineers would like to get their hands on is, "World Electronics Markets." SRI's forecasts tend to go well into the future—5 to 10 years or more—so their predictions will cover a useful chunk of an engineer's career.

What advice does Peters have for EE's?

EE's should monitor the Federal Government's spending, agrees Peters. Right now, if they are doing their homework, they'll see that while DOD is remaining stagnant, HEW (Department of Health, Education and Welfare) is steadily rising (see **Fig. 1**). Peters predicts: "HEW will be ahead of DOD by mid 70's, This will be one of the first times in recorded history a nation has realized the silent enemies from within can be just as dangerous as the obvious enemies without. People are slowly comprehending that the condition of their environments, their cities, etc., are becoming as immediate a threat to their survival as the USSR and Red China.

But don't expect rapid change. The forecasters we have talked with agree that it seems to take about five years between the time that the voting public starts to become generally aware of a threat to the nation and the time the Federal Government begins to allocate significant funds. Remember it has taken 5 years to wind down our involvement

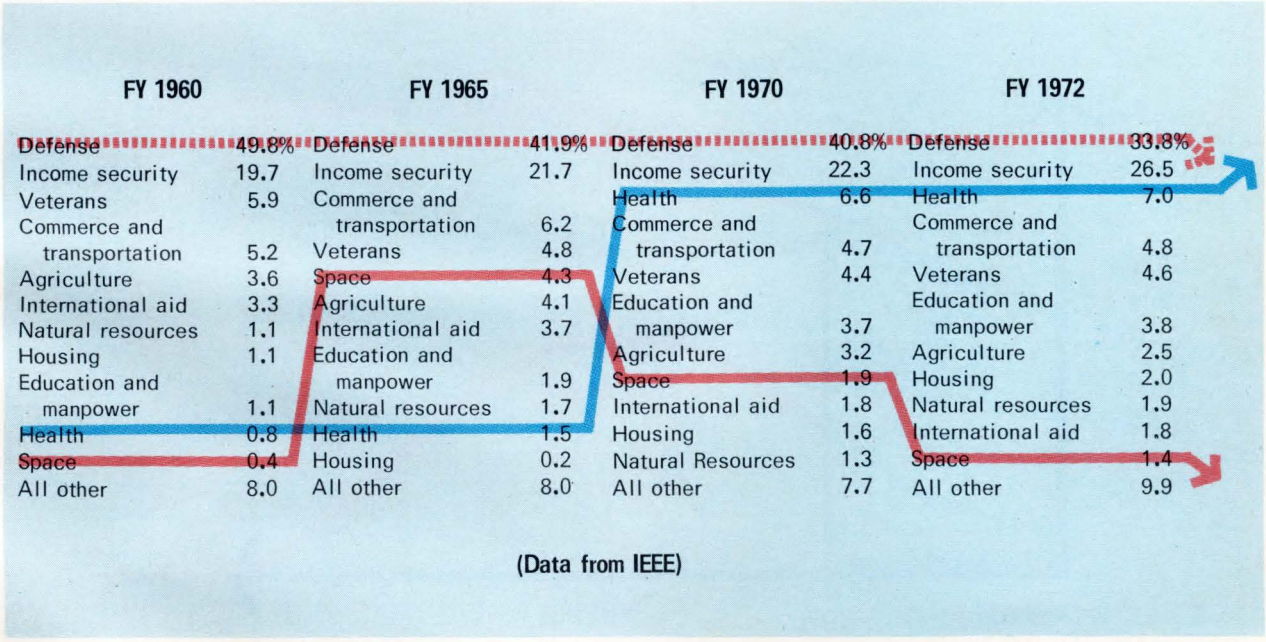


Fig. 1—Trends in government spending. If you take the budgets of the various Federal departments and see how they have varied from 1960 to the present you will begin to see what the future emphasis may be like. Look how the HEW budget has walked up through all the other budgets. An SRI researcher predicts HEW will continue to grow and will surpass the DOD budget by 1975.

in the Viet Nam "war."

Peters forecasts that the style of engineering for the new, non-DOD programs will be quite different from what engineers have been used to in the past. His surveys have indicated that the emphasis will be on a well-rounded engineer who sees hardware as but one part of the solution. This engineer will be at home in working in an interdisciplinary manner with professionals from other disciplines—such as medical doctors or educators in the case of HEW. He will contribute systems solutions in the form of combinations of hardware and software rather than just advanced gadgets. Ironically, Peters observes, the very success of the Moon mission has downgraded hardware as something that "can be bought."

Peters does not feel that many of the older aerospace engineers can be retrained for the new style. But he agrees with EDN/EEE that by the mid-1970's, when the funds finally start flowing for non-defense priorities, a new breed of EE's will be coming out of the engineering schools. This new breed is being trained right now in the interdisciplinary approach in some schools. As it was explained to EDN/EEE in a slightly tongue-in-cheek manner by one professor at the Polytechnic Institute of Brooklyn last year: "Our new 'relevant' student doesn't want to overburden himself with too many tough theory courses. He's rather go out with a tape recorder and interview the man in the street."

But these subtle changes in engineering style bring up another item for engineers to consider in their own marketing analyses. Namely, how will the supply of engineers who be completing for jobs change in the future? One thing that quite a few experts seem to agree upon right now is that because of the current slump in engineering school enrollments, there will be a possible shortage of engineers in the mid 70's. Therefore, those engineers who can "swing with the new interdisciplinary trend," may find themselves somewhat back in demand. (But as we said at the beginning, you can't trust anybody, so you'd best do your own analysis).

What a F&S forecaster says

In contrast to SRI, Frost and Sullivan, Inc. (F&S), New York, N.Y., represent a smaller (35 people) commercial forecasting service. Its projects have lower budgets and an affluent engineer could almost afford the $200-$400 they charge for each of the thirty or so reports in electronics markets they do a year.

We asked Henry Berler of F&S what he thought engineers could get out of market forecasts. Berler was also quite specific: "If an engineer had been following our reports he would know that he should be looking into public transportation (Dept. of Transportation) and into NASA earth resources satellite programs. Everything points to growth in these areas.

But Berler said that the first step in an engineer making intelligent use of market forecasts in to gain an appreciation of how these forecasts are made. As he described F&S's way of doing market projections, we noted it was really an extension of the way editors develop reports on industry trends. F&S starts with a question of direct interest to its clients. For example, a recent report F&S gave us to look over addressed itself to the question, "What will happen in the Test and Measurement Instrumentation Market up to 1980?" Then through literature searches, questionaires, phone interviews and plant visits, the F&S researchers gain a quantitative and qualitative familiarity with the field. Finally, after months of work and contacting hundreds of sources, they sit down and organize all this into a 100-200 page report. (See Refs. 3 and 4).

You might argue that you or anybody else could do this yourself if you had the time and inclination. It is nothing but data gathering and thinking. Well, it seems that fact gathering and thinking are the two things most of us never have the time to do, which is why our careers are so often poorly planned.

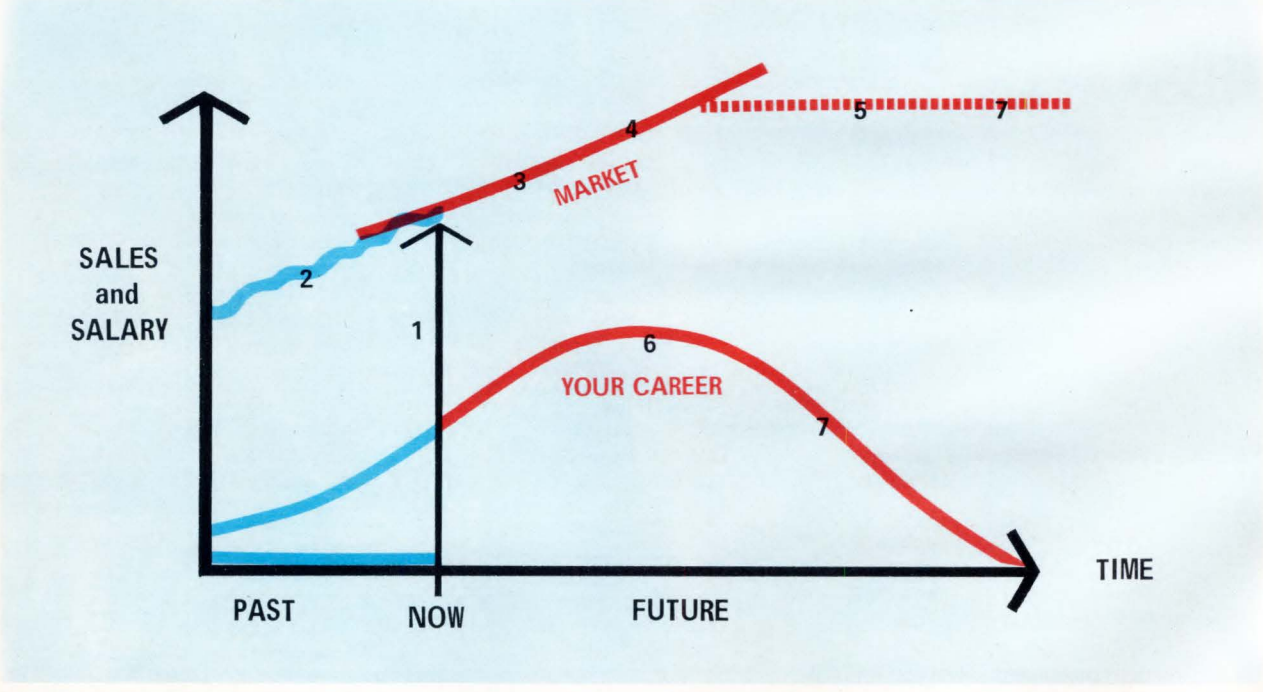


Fig. 2—The two curves that count: the market rise and fall. Both can be predicted to some degree. Graphically, most forecasting amounts to simple-minded curve extrapolation. The call-out numbers refer to the analysis steps explained in the text.

F&S's objective—like that of other forecaster's—is to extend the curve of sales in a market into the future (**Fig. 2**). As indicated by the numbers in **Fig. 2**, F&S does this in a stepwise, methodical manner, by asking and answering the following questions in turn:

1—What is the market volume at present?
2—What has been the past history of the market volume?
3—What is the best approximation of the present growth slope?
4—How should the slope be extended into the future?
5—How should the projected curve be adjusted to account for expected new influences?

F&S does this type of extrapolation for all product segments of the market they are studying and for all companies sharing the market. Though as simple as **Fig. 2** in principle, it is messy and confusing in practice. There are invariably so many overlapping products and suppliers and customers in any market that it takes considerable skill to identify the useful data and properly combine it into reasonable results.

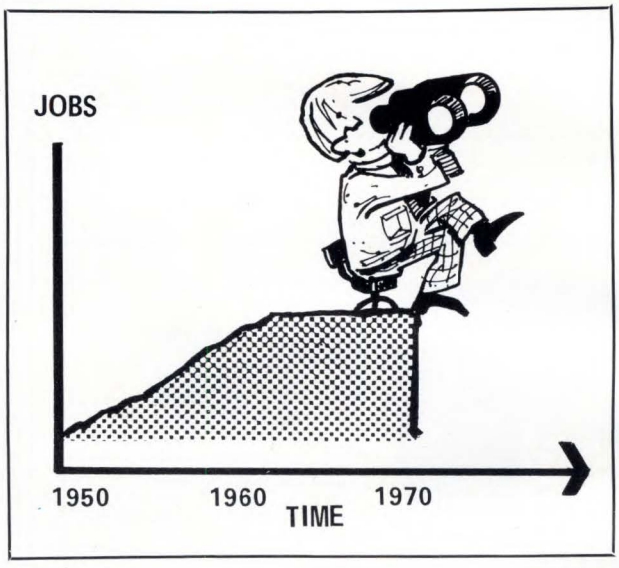
In talking with Berler about the use that engineers could make of market projections, we came to the conclusion that the engineer should add his own curve—his salary curve—to the market curve, step 6 in **Fig. 2**. The engineer should develop his personal salary projection by the same 1-5 steps that were used to develop the market curve. Then, when the engineer views the two curves plotted together on the same time scale (comparison step 7 in **Fig. 2**), a lot of things will become apparent. Either the projected market cycle will line up favorably "in phase" with the engineer's fixed-in-time career cycle, or it won't. The engineer should plot his career cycle against many different market or technology cycles to evaluate the various matches.

Will the IEEE forecast?

There is hope that the IEEE society will underwrite forecasting for the benefit of its members. Question 6a of the recent IEEE poll of members as to what services they'd like the society to perform asked: "Are you interested in IEEE engaging in forecasting for career-planning purposes?"

The IEEE could contract with market research organizations for the same large-scale studies that now only major corporations can afford. The $100,000 needed for an in-depth survey and forecast could be spread across the whole 150,000 membership. The study itself could be in terms of engineer's careers rather than in terms of markets for products. Such a study would be much easier for engineers to interpret than the marketing-oriented studies that now exist.

Another possibility is that the IEEE will encourage modelling of the whole electronics industry to determine the dynamic interactions between government spending, world attitudes, student enrollment, etc. IEEE has probably more members expert in systems modelling via computer simulations than any other society, (see Ref. 5 for one member's approach). The value of simulation is that it can spot the unexpected interactions that may upset ordinary trend-extrapolation forecasts. However, the "macro-model" tends to be less accurate than more conventional trend-extrapolation forecasts for short rum predictions. □



References

1. *"The Ancient Engineers,"* L. Sprague De Camp, Burndy Library, Norwalk, Conn., 1966. A look back at engineering in the days of Egypt and Rome shows that things haven't changed much—engineering then was the same old feast and famine in which job-hunting engineers (like Michelangelo and Leonardi da Vinci) scrambled for the same government programs while the civil servants (like Machievelli) looked coldly down.

2. Names and addresses of Market Forecasting Services that cover the electronic field:

   (a) Stanford Research Institute, Menlo Park, Ca.
   (b) Frost and Sullivan, Inc., 106 Fulton St., N.Y., N.Y. 10038
   (c) Quantum Science Corp., 245 Park Ave., N.Y., N.Y. 10017

3. *"Industrial Applications of Technological Forecasting,"* M. J. Cetron and C. A. Ralph, Wiley, 1971. A broad-brush survey of many of the techniques used in forecasting technology advances and the markets for those advances. Good for giving an outsider insight into the way facts and intuition are stirred together in this half-art, half-science field.

4. *"Econometrics,"* Wonnocott, Wiley, 1969. Introduces outsiders to the highly statistical approaches being used by economists in and out of the government to forecast economic trends like next year's G.N.P. On page 101 it briefly explains the pros and cons of using these statistical approaches vs the modelling approaches more familiar to system engineers.

5. *"Can EE Systems Engineering Solve World Problems?"* EDN/EEE Sept. 1, 1971. A description of how mathematical modelling has been applied to more general real-life problems. The Forrester techniques have been used by companies like Xerox to forecast the dynamics of their markets.

CIRCUIT DESIGN AWARDS

Low cost IR system detects intruders

Alexander Liu, Fairchild Microwave
& Optoelectronics Division, Palo Alto, CA.

This IR intruder detection system offers the following advantages: both transmitter and receiver can be packed into boxes; the IR beam path is invisible; and cost of the system is low.

The transmitter is comprised of three sections: a 500-Hz clock generator, a clock shaper, and a driver. The clock generator is made from three hex-inverter gates (μA 9016) and provides a square wave of approximately 500 Hz.

The clock shaper, consisting of two dual-input gates and one gate from the hex-inverter, is a one-shot which generates approximately 20-μs pulses triggered by the positive-going edge of the clock. This is a very simple way to generate a 500-Hz, 1% duty-cycle clock.

The driver is a Fairchild FLD 100 (a gallium arsenide infrared emitting diode), which emits an intense narrow band of radiation peaking at approximately 900 nm (non-visible). The most efficient way to operate the IR diode is with high peak current and low duty cycle pulsing. For this application, 2A peak current operation is suitable for the FLD 100. The FLD 100 is physically placed at the focal point of the transmitter lens.

The receiver consists, basically, of a Fairchild FPT 100 (a phototransistor whose spectral response peaks at 900 nm) and its associated circuitry. This phototransistor is mounted at the focus point of the receiving lens and receives a continuous stream of IR pulses. The delay time of the 9601 is 4.5 msec (0.36 R4C3) and was selected to be a little bit over the period T (2 msec) of the clock frequency. The 9601 is retriggered continuously by the incoming pulses with its output remaining at a "HIGH" level. Once the IR beam path is interrupted by an intruder for a minimum of one clock period (2msec), the 9601 times out. The result is Q;"LOW", which sets the latch (μA9936). This, in turn, triggers the SCR to activate the alarm circuit. To clear the alarm the RESET button is pressed; this clears the latch, and recycles the SCR.

To Vote For This Circuit
Circle 160

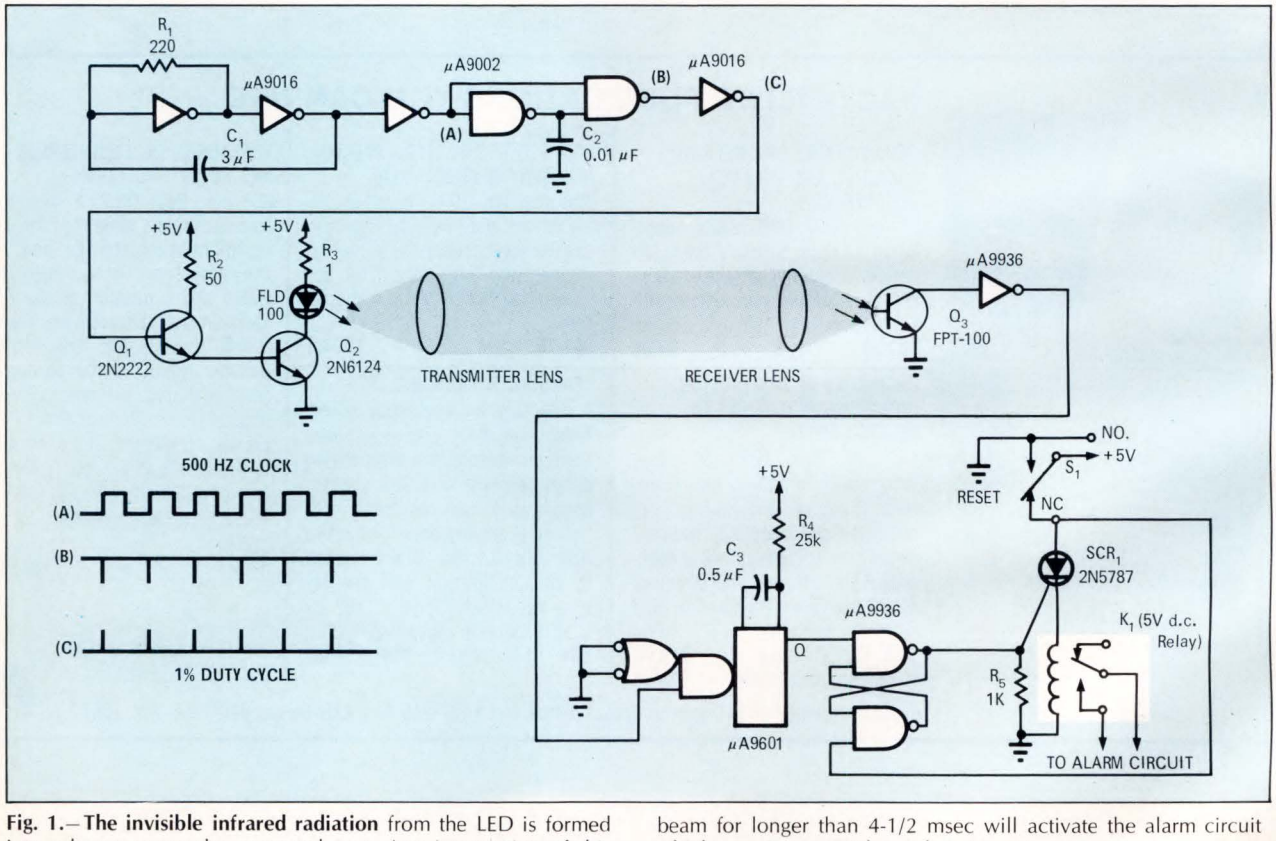


Fig. 1.—The invisible infrared radiation from the LED is formed into a beam across the protected area. Any interruption of this beam for longer than 4-1/2 msec will activate the alarm circuit which remains on until switch S_1 is reset.

Single IC makes high level logic probe

Roger F. Lyle,
Miller Printing Machinery Co., Pittsburgh, Pa.

The purpose of this logic probe is for testing systems using Motorola MC660 series or equivalent High Level logic. This logic is commonly used in industry because of its high noise immunity. The probe can be built for less than $10 and is invaluable in designing and servicing 660 logic. It draws about 3.5 mW, which in most cases will not disturb the circuit under test.

Parts location is not critical and the probe can be assembled on a small section of perforated board. The point can be made from a brass screw with an insulating sleeve covering all but the tip. The +15 and 0-V connections are miniature alligator clips. The probe is housed in a 1/2" dia. × 3" long clear plastic pill box, keeping the LED's inside but visible.

Connecting the power leads to +15 and 0-V will light LED-1 dimly. This gives you an indication of an open circuit. By touching the probe point to 0-V puts the same potential on both sides of LED-1 and the dim light goes out, indicating a logic ZERO.

Touch the point to +15 and LED-1 becomes bright. This also puts a pulse on the input to the MC667P monostable multivibrator and LED-2 will light for approximately 0.1 sec. This indicates logic ONE.

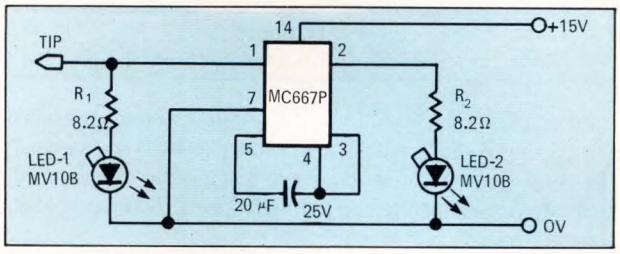


Fig. 1—High level logic states are indicated by LED-1, which will be off if a zero is probed and on when a one is probed. When a positive transition takes place LED-2 will flash on for 1/10th of a second, and then turn off.

The 667P is triggered by a positive going signal, therefore, if the circuit under test goes from ZERO to ONE for a period of 300 nsec or more, LED-2 will light for 0.1 sec. If LED-2 stays lit, the circuit under test is pulsing rapidly or oscillating.

To Vote For This Circuit
Circle 161

Phase modulator has broad bandwidth.

C. N. Charest,
Philco-Ford, Palo Alto, California

Here is a phase modulator with a bandwidth so large it can be used in multicarrier systems. As currently operated at 23.5 MHz in a communication satellite, the sensitivity is 2.38V RMS per radian, and this can be increased to a maximum of 430 mV per radian by reducing the paddling at the modulation input port. The linearity of sensitivity (with modulation drive) is within ±7 percent of a straight line—out to a modulation index of 0.5 radian.

There is no observable variation in sensitivity over modulation frequencies from 10 Hz to 100 KHz. The thermistor compensates the circuit over +5°C to +35°C to hold sensitivity changes to ±3 percent.

In addition to isolating the phase shifting portion from the modulation source, the 741 op amp sets the −0.25V varactor bias according to its offset. The 741 also serves the important function of driving the varactors from a low-impedance source, making the flat 10 Hz to 100 KHz response possible. The input resistance can also be set as desired.

The principal limitation of carrier frequency is the core material available for the transformers. Circuit gain is independent of changes in R or C, and phase shift is essentially linear with C_1, within the limits discussed above.

To Vote For This Circuit
Circle 162

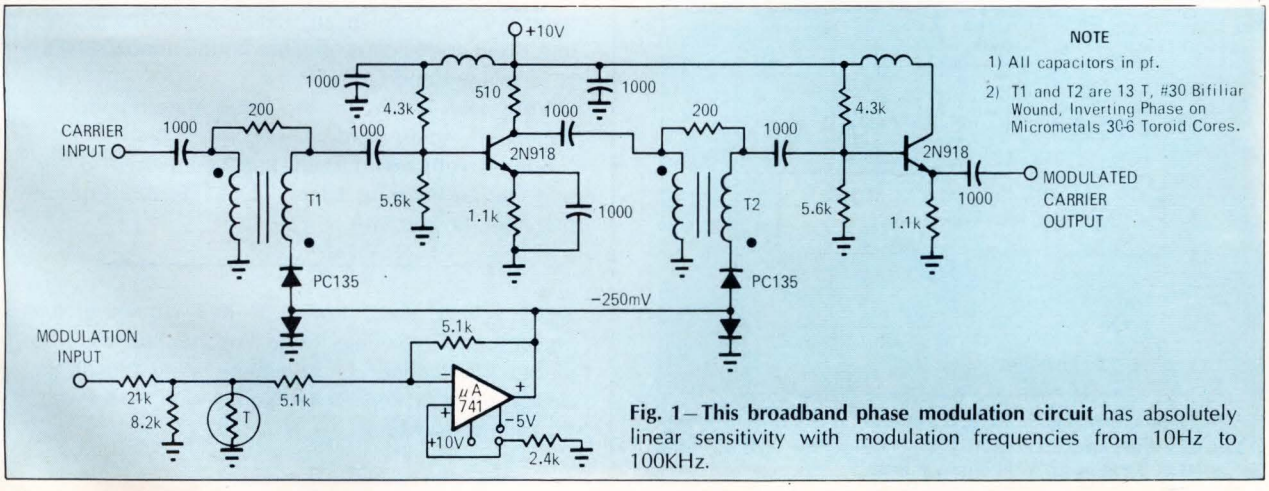


Fig. 1—This broadband phase modulation circuit has absolutely linear sensitivity with modulation frequencies from 10Hz to 100KHz.

High speed circuit converts binary to BCD

John T. Hannon,
Computer Sciences Corp., Huntsville, Alabama.

The complex logic used in today's digital systems presents a great demand for high speed binary-to-BCD converters. There are several methods presently in use but most of them are not well suited to the high speed requirements of present logic.

This circuit combines high speed, low cost and readily-available components to implement the add-three-and-shift method of binary-to-BCD conversion. **Fig. 1** presents the basic four-bit binary-to-BCD converter. The three NOR gates determine whether the number is five or greater. If it is, the gate output goes high and causes a ONE to be applied to the two least significant bits of the binary adder. This adds a binary three to the number in the adder. The outputs of the adder are the BCD equivalent of the binary number.

This method can be easily expanded to as many bits as necessary. The outputs from each detector-adder stage are hard-wire shifted to the next stage to implement the next step in the detect, add and shift cycle. **Fig. 2** illustrates the connections for a six-bit converter.

Note that NAND Gates could be used for the five-or-greater detector, but by using NOR gates, one less gate is required for each detector.

The advantages of this type of circuit are low cost and easy availability of the circuits. Since there is no clocking or shifting, as in usual add-and-shift method, there are no timing problems. The speed of the converter is limited only by the propogation delay of the circuits, consequently speeds in the megahertz range can be easily obtained.

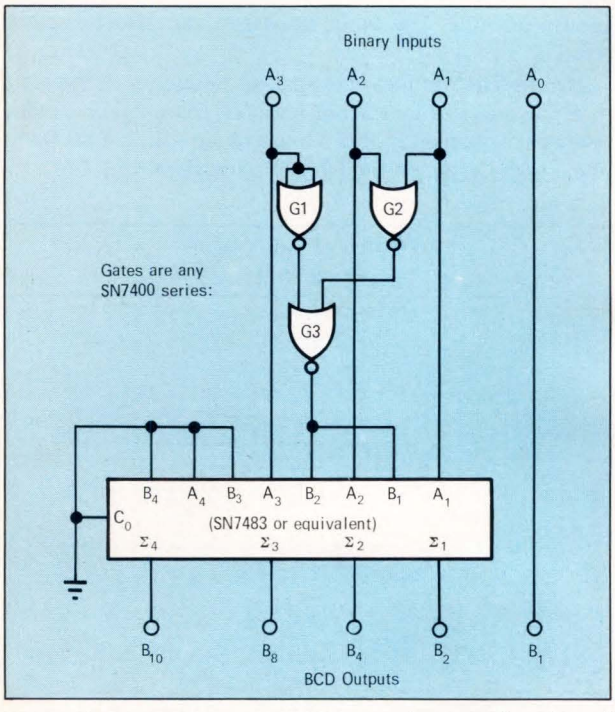


Fig. 1—High speed binary to BCD conversion is easily achieved in this add-three-and-shift method. The basic 4-bit converter uses only 3 NOR gates and a 4-bit binary adder.

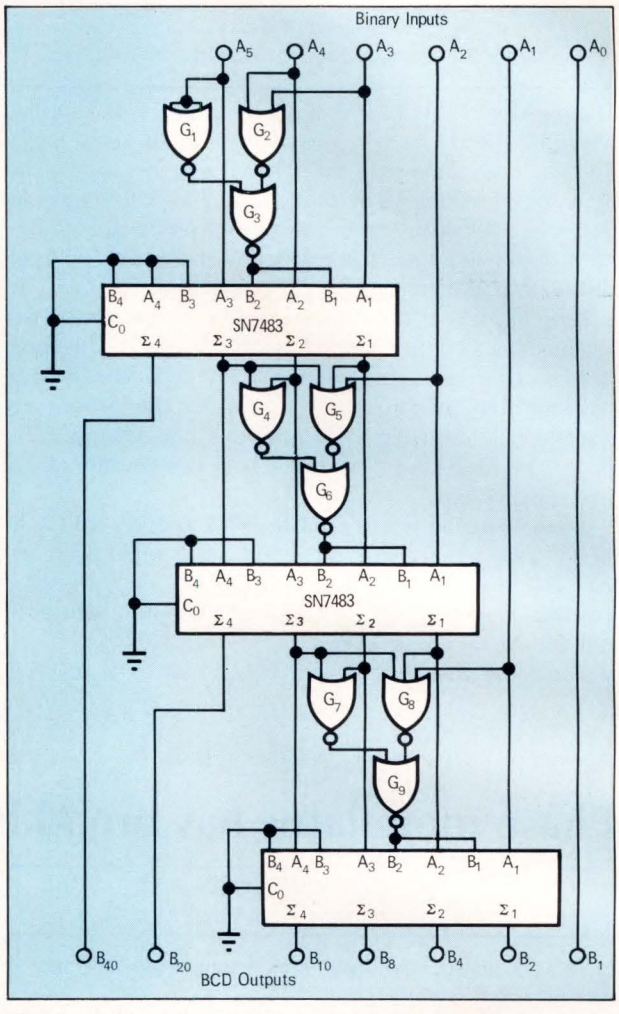


Fig. 2—Six-bit or larger converters can be assembled from the basic 4-bit circuit by hard-wire shifting the outputs from each detector/adder stage to the inputs of the next stage.

To Vote For This Circuit
Circle 163

Your vote determines this issue's winner. All circuits published win a $25 U.S. Savings Bond. All issue winners receive an additional $50 U.S. Savings Bond and become eligible for the annual $1000 U.S. Saving Bond Grand Prize.

Vote now, by circling the appropriate number on the reader inquiry card.

Submit your own circuit, too. Mail entries to Circuit Design Program Editor, EDN/EEE, 221 Columbus Ave., Boston, MA 02116.

Readers have voted Robert E. Keil winner of the November 15 Savings Bond Award. His winning circuit was called, "Automatic scaling circuit for optical measurements." Mr. Keil is with Honeywell, Inc., Hopkins, Minn.

The Model 87 switch, the Hero Maker!

It's only a half-inch in diameter. It doesn't cost very much. But it could improve your designs, save your company money, and make you a hero! Why? Because it's the most versatile little component you've ever seen. And, if you've been designing without it, you've been working too hard.

We're talking about Spectrol's Model 87 Subminiature Rotary Selector Switch. This unique low profile switch is compatible in size with other PCB components, and it may be mounted directly on printed circuit boards, thus eliminating the need for jumpers and connectors. It's available as a standard product in *single-pole, two-pole,* and *three-pole* versions with either PCB pins or solder hooks. Settings are made with a screwdriver or thumbwheel knob. If required, stand-offs can also be provided.

Some of the unit's more popular applications include:

- logic switching
- internal switching for optional equipment add-ons
- mode selection
- adapting main-frame computers to a variety of peripheral equipment
- standardizing printed circuit boards
- test-point switching
- selecting calibration resistors

We are sure that the versatility, small size, high reliability, and low cost of the Model 87 will suggest to the alert designer many new design alternatives and pave the way for his company to achieve significant new economies. But why not find out for yourself. Let the hero maker work for you!

Write to us on your company letterhead. State the application you have in mind, and ask for a FREE SAMPLE. Or, if you would like more information first, just use the reader service card.

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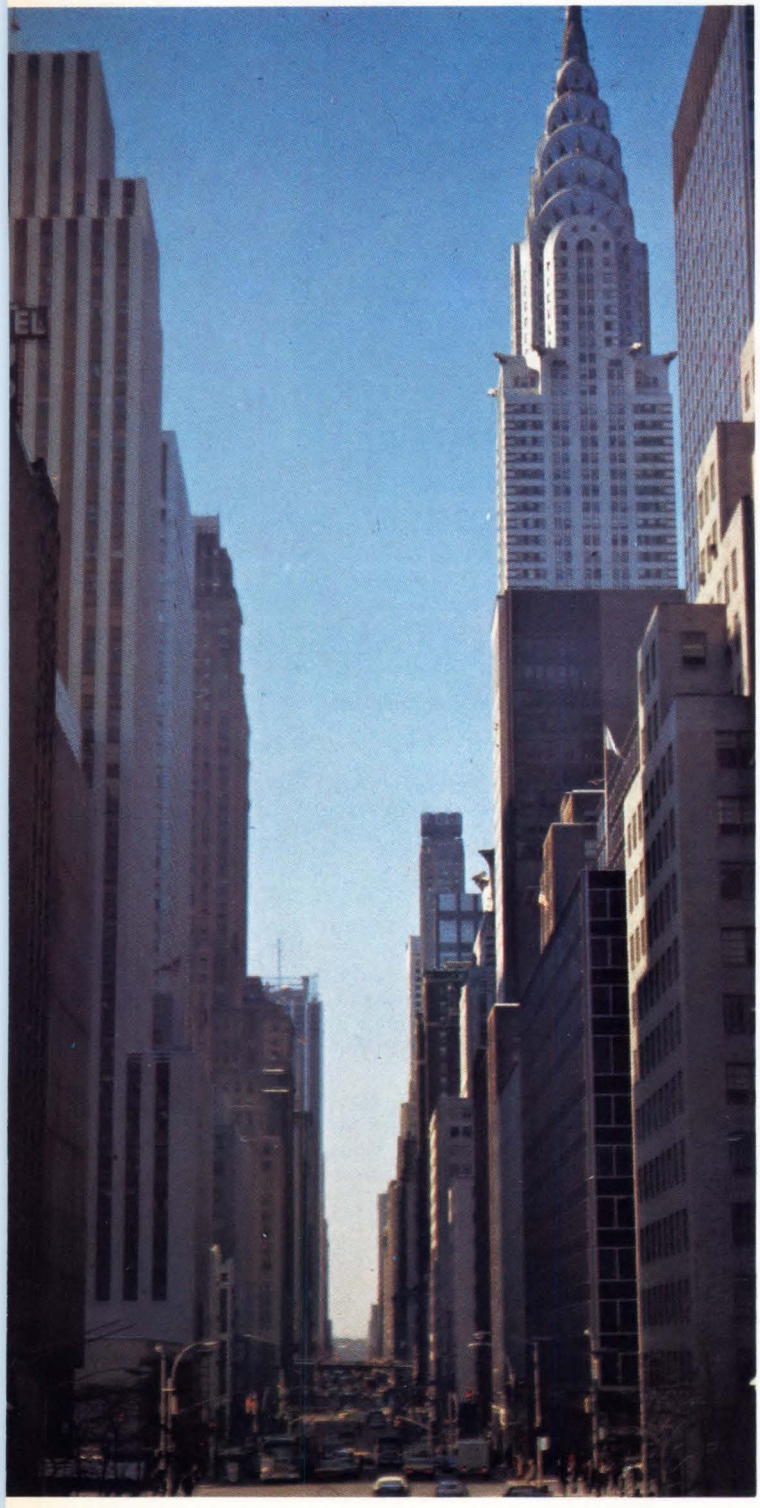
CIRCLE NO. 44

IEEE/INTERCON

The worst appears to be over



"We are cautiously optimistic." That is the most frequent answer of industry executives as we go into this year's IEEE show. Some base their optimism of reports from their salesmen that customers are starting to show interest again. A lucky few base it on actual sales growth. But most admit they are now fed up with pessimism; feel that the decline has really bottomed out, and that there is no where to go but up, even if it means going up slowly.

This ought to make this year's IEEE show a happier affair than last year's. Like last year, the actual attendees may mostly be marketing people looking each other over, trying to see if anybody has uncovered a promising new product or service area. But for those engineers who do show up, there will be one new twist: the IEEE finally is going to permit prospective employees to announce jobs on a bulletin board in the lobby and to do interviewing at the booths. Quite a change from the attitude of the early 60's! Yet according to IEEE officials and recruiting agencies, there has been little advance indication that this will turn the show into an orgy of head-hunting. As late as a month before show time, nobody had approached IEEE to take advantage of this new attitude.

On the career side

We wonder if the gathering will give any hints of the changes expected to occur in our industry in the next few years. Will there by any debates in the hallways on the results of the recent IEEE mail poll of members as to whether they wanted the society to initiate such "union-like" or "AMA-like" activities as "publishing recommendations on employment policies," and "submitting position papers to Congress and the Executive agencies."

An early report from an IEEE official who had been examining the returns indicated that there is an odd geographic split among the membership on these issues. The East and West coast members are in favor of the IEEE becoming more aggressive along these lines while the Midwest members tend to want the society to remain unchanged. However, few members have indicated they want to pay more than $5 or $10 beyond their present dues so it seems that for the immediate future the IEEE will be financially incapable of mounting anything like a true unionist offensive.

On the marketing side

Other hints of new things to come in the industry may come from the exhibits at the Coliseum. What new products and services have been developed despite the cutbacks? To assess in advance what revelations may possibly be in store, we contacted a scattered sampling of the more than 50 companies and organizations the IEEE told us were coming in new this year (or returning after an absence of

several years). Why were they coming to the IEEE this year?

North American Rockwell, Electronics Group, Anaheim, Calif., have contracted for one of the largest booths—60 ft—of any newcomer. We want to increase our mix of non-military business beyond its present too-small 10%, said the man in charge of their entry. We think the big Eastern show is still the best way to make ourself familiar to the commercial and industrial world. We'll be showing off our SOS (silicon-on-sapphire) technology with a working model of a character generator. We'll have digital communications equipment such as modems and multiplexers. We'll have POS (point-of-sale) equipment.

Magic Dot, a new company from Minneapolis, Minn., has a new thin-profile capacitance-type pushbutton switch they want to tell the industry about. The big show—which still remains one of the largest trade shows of any category in the world—has always appealed to small companies seeking to become known fast. Magic Dot thinks their little 1/2-in square wafer switches will gain a significant part of the keyboard and general man-machine input (like elevator floor selectors) market because it is moderately priced, and has no moving parts. Their optimism is based on a solid 18% response from a mailing to prospective customers.

Computers match products to company's needs

Dvorkovitz & Associates, Orlando Beach, Fla., is an example of somebody with a new service. This 35-man company with offices all over the world is a "marriage broker" for patents. They have put thousands of patents of all types on computer files and say they can readily come up with new product ideas to suit any company's needs. They are coming to the show because they have in the last year added electronic patents to their files which formerly included mainly just chemical and pharmaceutical patents. They say they will be willing to add any sellable ideas from engineers who stop by their booth but Dr. Dvorkovitz confided to EDN that as a rule he shies away from ideas from individual engineers. Engineers tend to over-estimate the value of their ideas and often don't have clear cut ownership claims because they developed the idea while at a company. This firm is quite bullish about the economy because last year they grew 50% and this year it looks like they will be growing 100%. Ironically, one of their hottest areas is in selling military patents.

Dynascan Corp., Chicago, Ill., is a $7 million annual sales company that is coming to present its new instruments—a scope and digital meters—directly to engineers. Ordinarily Dynascan sells through distributors and looks forward to having the personal contact with engineers that only a large show can provide. Besides, Dynascan found that its participation at the ISA show in Chicago, last October, actually developed business, both with new companies and with companies it had been selling to. They have high hopes for their new scope. It is one of the few dual-trace triggered scopes that sells for under $500.

Institute for Scientific Information, Philadelphia, is another example of an "outsider" company that is coming to the show for the first time to see if it can attract new business from EE's. This may seem difficult to believe in these hard times but, like Dr. Dvorkovitz's patent-clearing-house service, this 300-employee information-search company sees the tight times causing the electronics to be more appreciative of outside help.

"We don't think electronics companies can any longer afford to let their engineers waste time reinventing the wheel, just because they are not aware of what's in the world's technical literature," an ISI spokesman told EDN/EEE. "Nowadays it is not enough for an engineer to just read his favorite magazine in his own field, he should know whether subjects that concern his work might be appearing anywhere in the literature. Obviously, no single engineer could possibly read all the thousands of journals and trade magazines published just because they might occasionally have an article of interest, and that is where our computerized search comes into play. We put key descriptors of the titles of all articles in these magazines on our tapes, and by computer we scan the descriptors for relevancy. We do this on a custom basis for hundreds of engineers in the chemical, physical and life science fields. We think more EE's should avail themselves of our service and that is why we are coming to the show."

What ISI will be trying to convince Electrical engineers is: "Be more scientific about literature searches when you start a new project. Don't just see what happens to be in your private files or ask the guy down the hall, do what the engineers in the life sciences and in physics do, use our service to make a thorough search of almost all existing publications."

LogiMetrics, Inc., Greenvale, New York's marketing manager, Robert Mei, said: "I've always felt sympathic towards the show. It is still the best place for a small new company like ours—35 people—to get exposure. The show will be a bargain this year. We're only paying $900 for the floor space. The fact that there are fewer exhibits does not bother me for it only means that we will be more prominent."

Mei said that LogiMetrics will be introducing its new 9.5-520 MHz VHF/UHF signal generator. It has FM, AM and pulse modulation, a digital readout counting actual frequency, and will sell for under $3,000. He said that it ought to do well in the commercial and military communications market, including such growing markets as test equipment for police mobile radios.

As for the business climate Mei just came back from a nationwide tour of his reps, and he said things were upbeat. "Our rep in that supposedly disaster area, Seattle, said he had single handedly turned $750,000 worth of business for his 20 principle lines in the last 11 months."

Who will be missing?

The heart of our industry, the major semiconductor manufacturers, remain mostly conspicuously absent. They deserted the show in the mid-1960's and show no signs of ever returning. So also this year will be many of the foreign countries. President Nixon's surcharge came just at the time they usually make up their minds to get ready for the show, and its repeal came too late, according to an IEEE official. The uncertainty in the rate of currency exchange was another discouraging factor for the foreigners. The British however will be there in force because with their usual stuffiness their planning was so long range that the viscissitudes of international economics in the latter half of '71 made no difference, according to the same IEEE official.

For a look at the technical highlights of the show, turn to page 70. IEEE products begin on page 76. □

NOBODY ASKED YOU.

Are you going to put up with that??

There has always been a tendency for the test industry to design products, give them the "ballyhoo" treatment, then find someone to sell them to. We intend to reverse this trend by finding out what your needs are **before** we start designing. Instead of talking about our own function generators and pulsers, we're going to sit back and listen to you. We'll be at IEEE and other industry conventions, and we'll listen. You can phone in your gripes, and we'll listen. You know what you want, and we'll listen to what you have to say. The essential thing is to set us straight about what's really important to you.

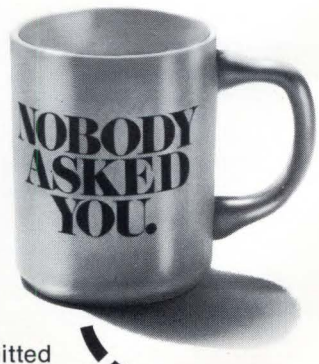
The questionnaire on the facing page was designed to let you be frank, specific, and critical. By taking time to help us build a dialog that's **going somewhere for a change,** you will be benefitting not only yourself and IEC, but the entire industry. We'll stand by our promise to get back to you with a report on the results of this communication, and what we plan to do about it.

Now it's your move — if you want what's coming to you.

TAKE A COFFEE BREAK AND FILL US IN.

It will take you 1 cup of coffee to fill out the "sound-off" sheet on the following page, and for doing so IEC will send you this FREE COFFEE MUG.* Or see IEC at IEEE, Booth 2633, and have your say. (We'll let you have the coffee mug, either way.)

*Quantities are limited! Forms will be acknowledged in the order they are received, and must be submitted by May 15, 1972. Offer limited to U.S.A.



You bet I've got something to say...

. . . about Function Generators

( ) Who needs a function generator? My RC oscillator does everything that I need to do.

( ) I'm content with the function generators available today. Models that I like best are _____

_____.

( ) **Wide Frequency range** is ( ) extremely critical ( ) important ( ) not significant for my needs. The narrowest frequency range that I would consider for my requirements is ____Hz to ____MHz.

( ) **Output Voltage** is ( ) extremely critical ( ) important ( ) not significant for my needs. The narrowest voltage range I would consider for my requirements is ____mv to ____v into a ____ohm load.

The Function Generator waveforms that are important to me (order of importance) are:

( ) Square wave ( ) Triangular wave ( ) Sine wave

( ) Pulses ( ) Ramps ( ) _____

I'm not sold on function generators. What bugs me most is _____

_____

. . . about Pulse Generators

Pulse repetition frequency range is ( ) extremely critical ( ) important ( ) not significant for my needs. The narrowest PRF range that I would consider for my requirements is _____ Hz to _____ MHz.

Rise/Fall Time is ( ) extremely critical ( ) important ( ) not significant for my needs. The slowest rise/fall time that I would consider for my requirement is _____ ns.

Pulse amplitude is ( ) extremely critical ( ) important ( ) not significant for my needs. The narrowest amplitude range that I would consider for my applications is _____ mv to _____ v into a _____ ohm load.

The other Pulse Generator capabilities that are important to me (in order of importance) are:

( ) External Trigger ( ) Baseline Offset ( ) Adjustable Pulse delay

( ) Adjustable Rise/Fall Time ( ) Gated Output ( ) _____

( ) I'm not sold on Pulse generators. What bugs me most is _____

_____

. . . about Test Instruments in general

Unique applications that have developed in my use of test instruments include: _____

_____

_____.

My biggest gripe about test instrument manufacturers and their products are: _____

_____

_____.

But once in a while, you guys **do** do something right: like _____

_____

_____.

NAME: _____

JOB TITLE: _____

COMPANY NAME: _____

ADDRESS: _____

CITY, STATE: _____

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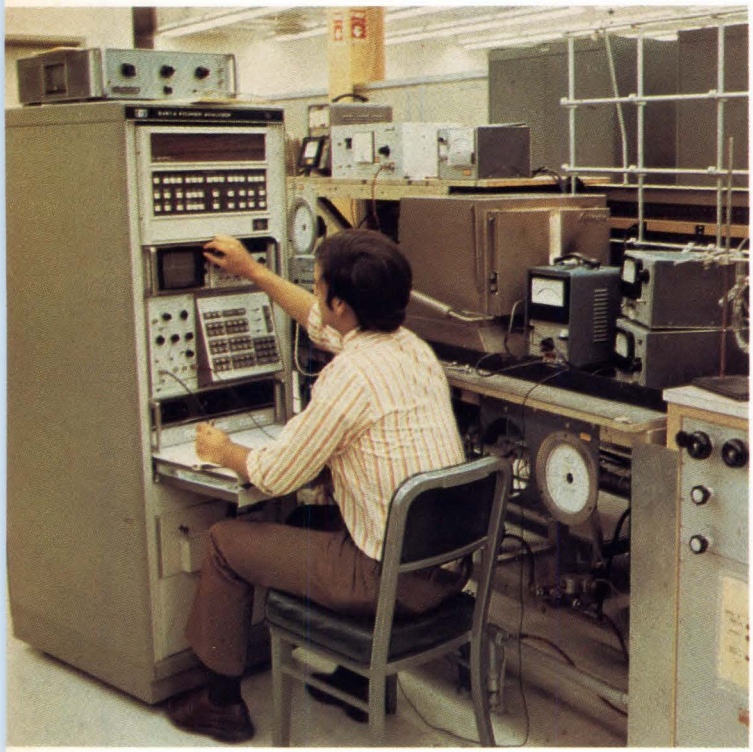
OK. NOW SEND ME MY COFFEE CUP!

CIRCLE NO. 45

Instrumentation: Automation cuts costs and opens up new fields



Hewlett-Packard's 5451A Fourier Analyzer exemplifies the economies that can result from automated, realtime testing.

No matter what the application area—be it in medicine, automobiles or electronic testing—you will find that instrumentation and automation are keeping company at INTERCON. It's not automation for its own sake, either, but automation to cut costs or to accomplish what unaided man can't do.

One area of emphasis in this year's papers is on putting electronics to work in automobiles. Four papers presented explore the automobile/electronic interface.

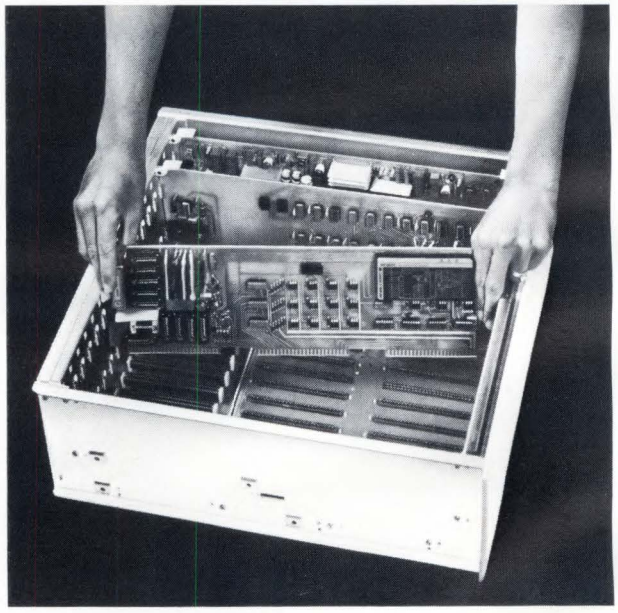
Both auto manufacturing and electronics companies are represented. General Motors (USA), Nippondeso (Japan) and the Joseph Lucas Research Group (England) air some views of the auto industry, while Texas Instruments Incorporated presents a semiconductor manufacturer's view. The General Motors paper contains some rather convincing reasons for taking a systems approach when considering the integration of electronic control systems for automotive use. This same point is also stressed by the Lucas engineers.

Nippondeso discloses a unique fault detection and monitoring system called the "OK-Meter". Its aim is twofold: One, to give the vehicle driver a continuous indication of the vehicle's operating condition. Two, at the service shop, to pinpoint individual defective functions. Status transmission is by digital signals, using 98 channels of information.

Texas Instruments, in its paper, concentrates on the use of semiconductor technologies to serve transducing or detection needs. Both the needs themselves and the devices available to fill them (such as microwave sources, optoelectronic products and silicon materials) are explored in depth.

Collectively, the papers at this auto/electronics session give a broad view of what can be expected from the application of electronics to automobiles. They also offer sobering thoughts on obstacles to be overcome, such as the fierce ambient temperature range, the economic dictation of an evolutionary replacement of existing tooling and the need to train automotive personnel to handle electronic repairs and maintenance.

Instrumentation that converts space-effort findings into biomedical aids is also explored at INTERCON. Admittedly somewhat outside of most engineer's direct sphere of interest, the content of the six papers nonetheless should prove useful and applicable in many areas. There are some good ideas for control and process engineers, partic-



Plug-in measurement module such as this is typical of boards now used in place of instruments in General Radio systems, such as the System 2200 Network/Circuit test system and the 1790 family of logic-circuit testers. This board is a resistance measurement unit. Others available are ac/dc converters and a/d converters for analog-voltage and current measurements.

ularly in a paper titled "Orthotic Control Systems" from Rancho Los Amigos Hospital. (See "What About Medical Electronics as a New Career Field?", EDN/EEE, Feb. 15)

Economics of automated testing.

Automated testing can be an economic headache to assess, so a rundown by people thoroughly familiar with the subject may well be helpful. At INTERCON, speakers from General Radio, Hewlett-Packard and RCA will discuss software considerations, the economics of dedicated vs general test systems and some hidden costs to be reckoned with. A subtle point brought out in the sessions is that until recently the programmability of instruments frequently was poorly suited for high-speed computer control. Indeed it has often been designed at least partly for human interface and convenience. □

Communications: A look at new areas and some new problems

The title of single session, "New Areas in Communication," sums up the emphasis of almost all the INTERCON sessions devoted to communications. The subjects covered in this session, 5E, namely data networks, mobile communications, solutions to urban problems and satellite systems, also forms the basis for complete sessions at INTERCON.

Hardware is not forgotten, but the trend, begun at last years sessions, is to examine the near and long term communications problems.

Interest shifts to data networks

In session 5E's lead off paper, "Digital Data Networks," Dr. Mischa Schwartz of the Polytechnic Institute of Brooklyn states that interest in the communications field has recently begun to shift to the data network and teletraffic areas. According to Schwartz, "two reasons account for this: 1. The point-to-point data transmission problem is fairly well understood now, and existing means of efficiently transmitting data have brought the costs here down well below those of combining or switching a multitude of input signals; 2. The burgeoning data transmission needs of densely-populated urban areas have made it imperative that more efficient means of managing the data flow be found."

Dr. Schwartz goes on to indicate some of the interesting theoretical and engineering problems that are arising or might be expected to arise in the design of these networks. Some of the work already carried out in this area is summarized briefly and some of the many unsolved problems that might be of interest to communication engineers are noted.

Two major problems that appear in the teletraffic area are that of combining various data sources at geographically contiguous areas, and that of optimally routing the message streams to a multiplicity of remote locations.

The data sources to be combined may have widely different statistical characteristics—message lengths, bit rate, and frequency of occurrence of messages, as well as different priorities of transmission. They might include a mix of line speeds, such as relatively low-speed teleprinter outputs and high-speed computer outputs to be switched into the same network, or they might include low-priority data for computer processing to be switched on to the same network as emergency requests for fire, police, or ambulance service.

"Much of the analysis carried out thus far is still quite primitive because of the complexity of the problems involved," says Schwartz. Simulation is used quite often to fill out the analytical gaps or to provide substantiation of assumptions made.

Problems of public policy and regulation that are of extreme importance in the design of communications networks are not considered in session 5E by Dr. Schwartz. He leaves that for the session he has organized, session 3F, "Telecommunications Policy and Society—A Case Study, Data Networks of the Future."

He and his four panelists, S. Lasher, Office of Telecommunications Policy, Executive Office of the President, Washington, D. C.; H. M. Boettinger, AT&T, New York, N.Y.; D. H. Foster, Datran, Vienna, Va.; and R. Fano, M.I.T., Cambridge, Mass., will focus upon the necessity for considering public policy and societal questions in the development of future communications systems.

Technical problems and the approaches being taken to meet the ever-increasing demands is covered in Session 4F, "Looking Ahead at Data Communications in Canada and the United States." Present and planned concepts of operation, including such topics as terminals, switching, synchronization, clocking and transmission are outlined by speakers from ATT, Bell Northern (Canada), Datran and Western Union. John E. Cox of Western Union, Mahwah, N. J. shows a comparison (**Table**) of an 1800 channel analog data transmission system to a 20 M-bits/sec digital radio system. Its interesting to note that the voice channel

COMPARISON OF TRANSMISSION CAPACITY

TYPE OF TRAFFIC	MAXIMUM NUMBER OF CHANNELS: ANALOG 1800 CH.	MAXIMUM NUMBER OF CHANNELS: DIGITAL 20 MB INITIAL
TELEX	36,000	221,000
75 bps	36,000	166,000
TWX	10,800	110,000
150 bps	14,400	83,000
2400 bps	1,800	4,600
4800 bps	1,800	2,300
Speech (Voice)	1,800	288

capacity of the analog system is very much greater than for the corresponding digital system.

Social, political and commercial issues are discussed in several other sessions. Session 2A, "CATV—What's Happening," brings together a number of experts with definite opinions on the many divergent factors influencing the Community Antenna Television (CATV) industry.

This industry is expected to grow rapidly in the near future. In a recent study, Creative Strategies Inc., Palo Alto, Calif., predicts total revenues to be $2.2 billion in 1976, derived from CATV equipment manufacturers, construction companies and systems operators.

Dean Burch, Chairman of the Federal Communications Commission (FCC), Washington, D. C., will focus on the regulatory problems while Dr. Joseph V. Charyk, President, Communications Satellite Corp. (Comsat), will describe a "CATV Network via Satellite."

Dr. Peter C. Goldmark, former President of CBS Laboratories and now President of Goldmark Communications, Norwalk, Conn., suggests cable systems as one means to a possible solution to the urban congestion problem in his paper, "the New Rural Society." "Rural life on a national scale could be attractive and provide many of the advantages of big cities," says Goldmark. "With the necessary inventions already made, broadband communications systems must now be imaginatively applied to the needs of business, government, education, health care, and cultural pursuits to stimulate the development of the New Rural Society," he continues.

Dr. Goldmark sees the expansion of existing communications facilities and the use of broadband cable systems operating on a two-way basis as going a long way towards making rural life more attractive. Similar suggestions are made by other speakers. ■

Semiconductors: Practical applications provide the focal point

Practical engineering using available technology is stressed in the semiconductor portions of the IEEE convention this year, and interest should run high among engineers in attendance.

Custom MOS designs and their pitfalls are discussed by Evelyn Berezin, President of Redactron Corp. in her paper titled, "How To Jump Into MOS Without Drowning," delivered at session 4CI. As can be seen from the photographs in **Fig. 1**, Redactron has successfully used custom MOS to shrink space and power requirements for the logic functions in their business machines. It appears that Berezin has had a great deal of experience in custom MOS design, and her presentation takes the prospective MOS designer step by step through what can be an exasperating exercise. She advocates all logic, function and layout design be done in-house, and backs up this contention with proof: delivery of the first chip in 5 to 7 months, full production within 10 months.

Ion implantation is another topic of interest to a user of custom MOS, and the advantages of this technique are well covered at session 4B with papers from Mostek Corp., KEV Electronics and Stanford University. All the papers point out that the technique is gaining popularity for lowering threshold voltages and for low impurity doping of MOS devices. In addition, much more precise geometries are possible, with ion implantation—and it's a low-temperature process.

Low-power monolithic circuits represents another area of widespread interest and some interesting papers are devoted to the subject. In one, "Monolithic Micropower Command Receiver," P. H. Hudson, of the US Army Electronics Technology and Devices Lab, and J. D. Meindl of Stanford University describe a bio-implantable telemetry system built around a monolithic receiver whose only external components are an antenna and a single 1.35V mercury cell. Total power dissipation is less than 15μW.

In another low-power paper, "A Micro-Power Phase-Locked Loop," G. Steudel of RCA details the operation of a new C/MOS monolithic phase locked loop which only consumes 600 μW of power and is designed for operation

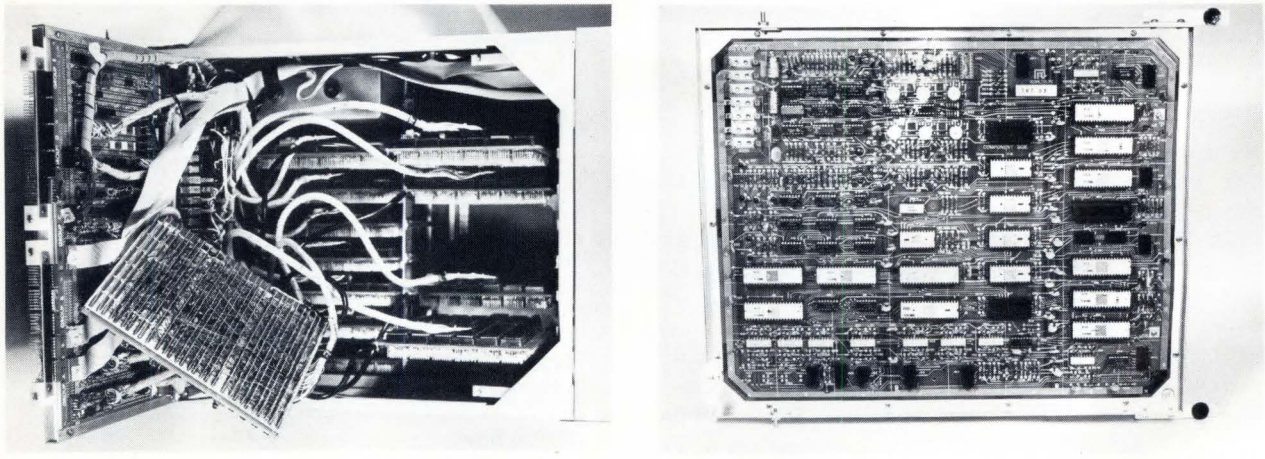


Fig. 1—The dramatic space and labor savings offered by custom MOS designs are readily apparent in these two photos from Redactron Corp. All the logic functions of their editing typewriter contained in the 13 PC boards in the left photo have been reduced to the single board shown in the picture on the right through the use of custom MOS chips.

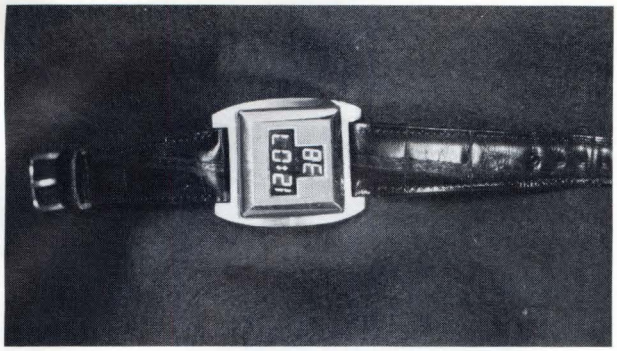


Fig. 2—A quartz-crystal oscillator wristwatch with a liquid crystal readout is representative of several new products made possible by inexpensive readout devices. Watch case courtesy of Hamilton Watch Co.

with signal processing, FM or FSK demodulation, and frequency synthesis equipment.

Liquid crystals are also of interest to the users of semiconductors because they promise to provide low cost, low power readouts that will open many new markets to the electronics industry. Gary Leffer of Optel, in a paper titled "Liquid Crystal Displays Can't Be *That* Good," covers the basics of liquid crystal operation and application. He also discusses the liquid crystal wristwatch shown in **Fig. 2**. It uses a standard 4-digit readout that can be ganged, and will be very attractive to hand-held calculator makers.

Alan Sussman and George Heilmeier of RCA's David Sarnoff Research Center present "Liquid Crystals: An Overview" at session 4C, in which they examine the requirements and capabilities of liquid crystal displays. ▭

Computers: Minis and memories are still popular topics

If one had to summarize what's happening at IEEE in the computer area, it could be boiled down to "memories, minicomputers and a touch of communications", in that order.

Memory hierarchy continues to be a favorite topic of conversation. Whereas most other conferences discuss the subject as if multi-level hierarchies are just around the corner, one speaker at session 1C puts it in proper perspective when he says, "Overall, it appears that hierarchy application to complete storage systems awaits the development of new storage devices whose structure better lends itself to the hierarchy concept. . . .Whether hardware, such as associative memory devices, is to play a dominant role in such hierarchies, remains debatable."

Two new laser memories emerge

The search continues for the most efficient mass memory to replace disc and drum and thus solve the above hierarchy problem. The "bubble" and "DOT" have already been proposed to solve this need; however session 3C papers have thrown some new contenders into the ring, namely lasers, ovonics and, believe-it-or-not, magnetic tape. Within the laser area there are two differing approaches: an optical/mechanical device and a holographic device. The former records data on 31.25 × 4.75 × 0.007 inch metalized polyester data strips with over two billion bits per strip. 450 strips would be mounted on a carousel, giving a one-trillion-bit memory. Data is written by vaporizing spots on the strip, and read by reflection.

The latter approach proposes to use laser holographic storage in which data can be written on and erased from some sort of yet unproven target material. However, such a system admittedly has many unsolved problems and is not an immediate contender as a mass-storage medium.

A third approach is an optical memory using the well-discussed ovonics principle in a disc-oriented device. This too is a proposed system whose feasibility is yet to be proved.

Of more immediate interest is a magnetic tape system called "Masstape". It uses cartridges, each with 300 feet of tape and holding 48 million 8-bit bytes. The cartridges are then mounted in Pacs and finally on a turntable in the finalized system. This system provides random access to as many as one trillion bits of data.

The fight continues amongst cores, bipolar, and MOS ICs as to which will be the dominant force in memories in the 70's. One paper in session 5A says that 14-16 mil cores will come into widespread use, that costs will continue to drop primarily due to LSI ICs and shared electronics, and that LSI decoding and drive circuitry will popularize 2-wire, 2D memories. Because of these factors and others, cores will continue to be competitive in the 70's

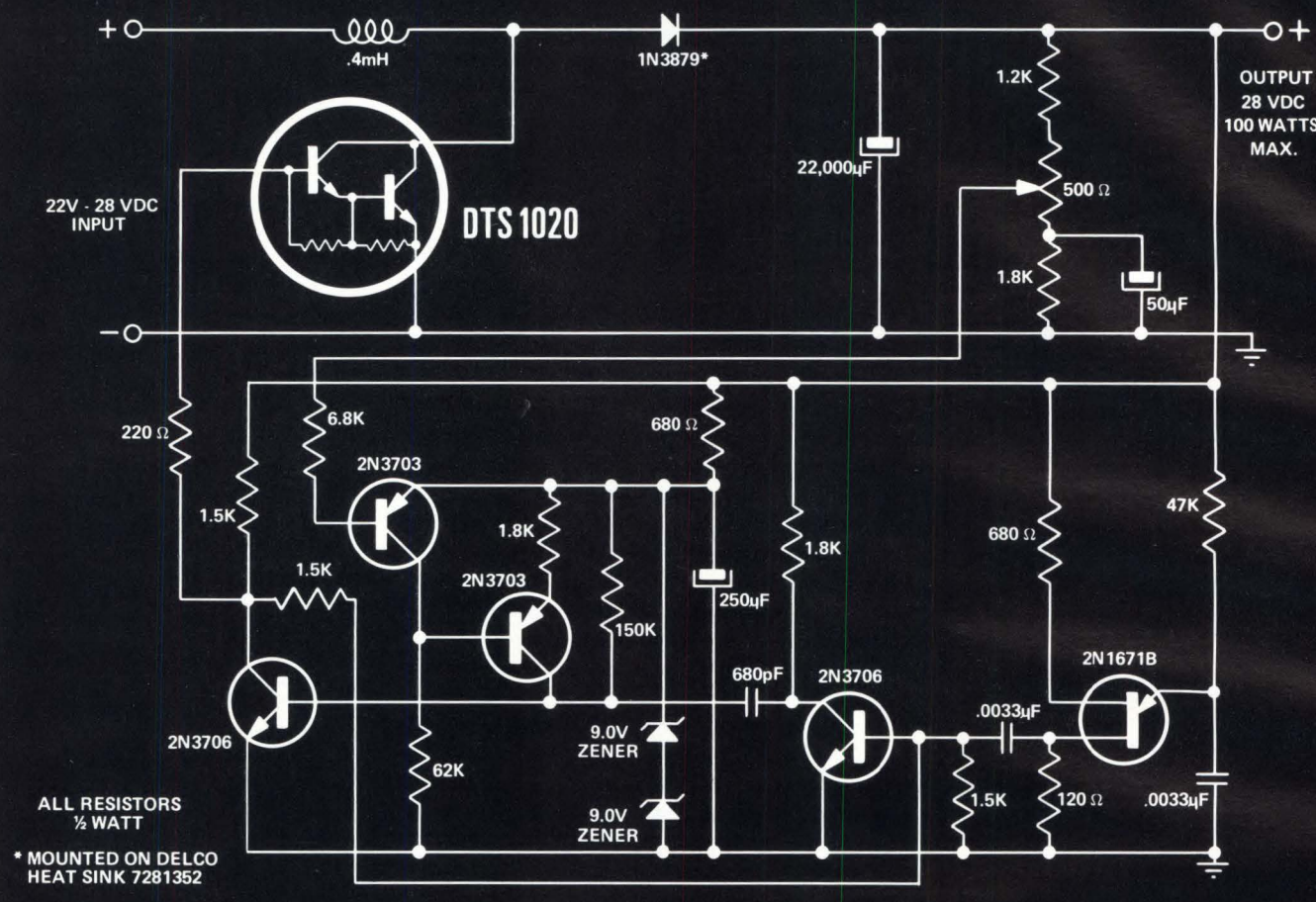
Bipolars and MOS are expected to encroach upon cores, especially in the smaller and/or higher-speed mainframes and into cache and/or control memories. By 1975, both bipolar and MOS will meet performance targets (50 nsec chip access at 5-10 sq mil/bit and 150 nsec chip access at 2 sq mils/bit), bipolar in speed and MOS in cost. By 1980, bipolar densities, including all on-chip functions, are expected to get under 2 sq mils/bit.

The MOS people foresee fast N-channel competing with bipolar in speed yet retaining MOS's low cost, high density, and low power. Costs of 0.1¢/bit are projected by 1975 and next generation's MOS devices are expected to displace other technologies. CMOS also makes a bid for fast low-power memories.

Minicomputers continue to advance both in performance and in applications. Hardware trends, like the single-chip processor examined in session 5F, will make automobile and home computers a reality. Capability of these processors is expected to double every year to the end of the decade.

One force that will continue the minicomputer's entry into new areas is microprogramming. As analyzed in session 2F, microprogramming will make computers less costly to construct and will allow them to take on much larger and more powerful architectures without significant increases in cost.

The flexibility and servicability of minis allow them to replace specialized logic in many system designs. ▭



SWITCHING REGULATOR

	V_{CEO} @ 0.1 mA	V_{EBO} @ 50 mA	$V_{CE(SUS)}$ @ 500 mA	h_{fe} @ 1 MHz (V_{CE}=10V, I_C=200 mA)	h_{FE} (V_{CE}=5V, I_C=10A)	$V_{CE(SAT)}$ @ 5.0 A	I_C	P_T @ 75°C
DTS-1010	120V	7V	80V	12	200	1.8V	10A	100W*
DTS-1020	120V	7V	80V	12	500	1.5V	10A	100W*

*100 percent tested at 2.5A, 40V.

The Kokomoans now give you Darlington Switching Power.

Use a Darlington in place of an ordinary transistor, and you'll realize an additional magnitude of gain plus increased switching power. Use a Delco silicon power Darlington (DTS-1010 or DTS-1020) and you'll also realize a gain in dependability.

Delco's Darlingtons are triple diffused mesa units housed in copper TO204MA cases and built for ruggedness. The design gives them high energy capability—the ability to handle surges of current and voltage simultaneously. They are ideal for switching inductive loads in circuits subject to transients or fault conditions.

Design a switching regulator circuit around a Delco Darlington or use it in any 60-100 volt application to reduce circuit size, weight, and cost. In addition, the Darlington space saving feature allows you more design flexibility. Unlike an ordinary transistor, it's only energy-limited, not beta-limited. You can exploit its full energy capability in your circuit.

Call your nearest Delco distributor. He has them in stock and he's got the data on high energy switching for small spaces.

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

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CIRCLE NO. 46

Low cost DMM displays data on the probe.

Keithley's new Model 167 battery-operated auto-ranging digital multimeter is not just another DMM. This one is truly unique—in price, capability as well as performance.

First let's look at the price. At $325 (single quantities), the auto-ranging 3-1/2-digit instrument has to be the lowest-cost portable digital multimeter of its type on the market. The price includes the basic instrument which measures ac and dc voltages and resistance, a probe, a four-foot ground lead and a set of six alkaline batteries.

Capability is probably the most obvious feature. The instrument's unique probe incorporates an LED display that shows not only the magnitude of the quantity being measured, but also the function being measured, i.e., ac, dc, kΩ, or MΩ, and polarity and decimal point. And that's not all. The probe slips neatly back into the instrument in an available front-panel compartment and serves as the display for a benchtop meter.

Obviously, the ability to make remote measurements without looking back at the instrument is invaluable, particularly when the user is working with cluttered and hard-to-reach circuitry. The only time he has to touch the instrument is when changing the measurement function.

The meter's probe incorporates a push-to-read switch that turns the power to the meter on as long as it is being held. If the user decides to place the proble down on a bench for example, power is automatically turned off. According to Keithley, this approach conserves battery life, with a typical lifetime for the six provided alkaline batteries of 3 months.

When used as a benchtop instrument, the 167 is always turned on once a function switch is depressed.

In the dc-voltage mode, the 167 is capable of measuring ±1 mV to ±1 kV at an accuracy of ±0.2% of reading ±1 digit. Input impedance is 55 MΩ shunted by 220 pF.

Two instruments in one. Keithley's Model 167 auto-ranging 3-1/2-digit multimeter is both a bench-top (above) and a portable (right) instrument. Its integral probe with a LED display indicates the quantity and function of measurement.

In the ac-voltage mode, it measures 1 mV to 500V rms. Accuracy for ac voltages to 200V is ±1% of reading ±2 digits (20 Hz to 10 kHz), and ±2% of reading ±4 digits (10 to 20 kHz). For the range of 200 to 500V, accuracy is a little worse at ±2% of reading ±2 digits (20 Hz to 1 kHz) and ±5% of reading ±4 digits (1 to 20 kHz).

Optional ac and dc current measurements are available with a plug-in shunt that allows measurement of 1 μA to 2A. The shunt costs $35.

Input protection on the 167 is not skimpy. It will withstand up to 1200V of overload on any voltage range. Equally important is the protection afforded the ohmmeter portion of the meter which can take the full ac-line voltage across its input without any damage.

When it comes to warming up, this instrument is extremely fast. It turns on from a cold start, sets the correct range and displays the reading within rated accuracy in just 2 sec. To protect against erroneous measurements due to low battery voltage, Keithley's engineers designed into the 167 a dc-to-dc converter that turns the instrument off once the batteries run down.

Keithley Instruments, Inc., 28775 Aurora Rd., Cleveland, OH 44139. Phone (216) 248-0400.

Booth No. 2307 **Circle No. 370**

Portable dual-trace oscilloscope has a 350-MHz bandwidth

The largest-bandwidth in a line-operated portable scope has been achieved by Tektronix with its new 485 scope that has a bandwidth of 350 MHz and sensitivity of 5 mV/div. in a 20.5-lb package. Tektronix has thus outdone itself in wideband portable scopes. In 1967 it introduced its model 454 with a 150-MHz bandwidth.

But bandwidth is not the whole story for this new scope. It includes a host of other features such as selectable input switching, trigger holdoff, trace separation, external trigger display, alternate delayed sweep, vertical scale-factor readout, auto-focus and B-channel sweep-intensity control.

To resolve the conflict over which input impedance system to use at high frequencies (50 or 75Ω), Tektronix has included both without the use of any special probes. The 350-MHz bandwidth is for 50Ω input impedance. A selectable IMΩ input is also available with a 250-MHz bandwidth.

Automatic vertical scale-factor readout for attenuating probes is provided by three LEDs located around the edge of each attenuator knob which assure the operator of the correct volts/div. on the screen anytime he is using the recommended X1, X10 or X100 probe.

Flexibility is the byword of the horizontal system. To complement the higher bandwidth, the 485 has very fast 1-ns/div. sweep speed without magnifier.

The delayed-sweep concept is expanded by a new alternate-sweep mode that allows the delayed sweep to appear alternately with the intensified main sweep. In this mode, the operator sees the intensified zone and delayed display simultaneously. He always knows exactly where in a pulse train he is making a delayed-sweep measurement. Trace separation between the main and delayed sweeps and intensity control of the delayed sweep are also additional new features.

Full-bandwidth triggering without high-frequency sync control and trigger holdoff provide stable triggering on complex waveforms. Trigger holdoff allows stable triggering on repetitive complex waveforms down to 0.2 sec/div. An optional feature allows the operator to display a signal from the external-trigger input without moving any connections.

Overall dimensions are 20-5/8 by 12 by 6-9/16 in. Cost of the 485 is $4200 and availability is 90 days. Tektronix, Inc., Box 500, Beaverton, OR 97005. Phone (503) 644-0161.

The widest-bandwidth in a portable scope is featured in Tektronix's new Model 485. The 20.5-lb. instrument has a 350-MHz response and sensitivity of 5 mV/div. Several new features, including both 50 and 75Ω inputs, highlight this scope.

Booth No. 2622 **Circle No. 371**

Modular power supplies cover 3 to 48V and 0.45 to 17A

A family of 44 modular power supplies has been introduced by the New Jersey Division of the Hewlett-Packard Co. Designated as the 62000 Series, the line offers a selection of 11 voltage steps from 3 to 48V and 29 currents ranging from 0.45 to 17A.

Three different rack sizes comprise the new power supply family—1/8, 1/4 and 1/2 rack. The 1/4-rack size is available in two version, one of which is identical to the other except that it supplies twice the output current.

The eleven voltage steps are 3, 4, 5,

A choice of 44 models are available in a new line of modular power supplies from the New Jersey Div. of Hewlett-Packard Co. The family offers a range of voltages in 11 steps from 3 to 48V and 29 currents from 0.45 to 17A.

62000 Series modular power supplies

dc voltage	Current (amperes) 1/8 rack (A module)	1/4 rack (C module)	1/4 rack (E module)	1/2 rack (G module)
3	2.0	4.25	8.5	17.0
4	2.0	4.0	8.0	16.0
5	2.0	4.0	8.0	16.0
6	1.75	3.75	7.5	15.0
10	1.5	3.25	6.5	13.0
12	1.5	3.0	6.0	12.0
15	1.25	2.5	5.0	10.0
18	1.0	2.25	4.5	9.0
24	0.75	1.75	3.75	7.5
28	0.70	1.5	3.25	6.5
48	0.45	1.0	2.0	4.0

6, 10, 12, 15, 18, 24, 28 and 48V. Each voltage step is available in four different current ratings, depending on rack size (see box). Output voltages are adjustable to ±0.5V or ±15% whichever is greater. Input rating is 104 to 127V ac, 48 to 63 Hz.

Line and load regulation of 0.01% is standard in these series-regulated supplies. Ripple and noise are less than 1 mV rms and 3 mV peak-to-peak (dc to 20 MHz). The temperature coefficient is 0.01%/°C.

Each supply has built-in overcurrent protection with 103% and 10% activation-point limits. An optional internal crowbar has an adjustable trip lever from 0.5V above the minimum rated output voltage to 2.0V above the maximum output.

Over-temperature protection is also provided though a heat-sink-mounted thermostat which opens the fused ac line should the power supply ambient temperature rise too high and cause overheating. Once the ambient drops down to a safe operating level, the thermostat automatically resets itself.

Prices are $85 for the 1/8-rack versions, $125 and $145 for the 1/4-rack supplies and $195 for the 1/2-rack units. Delivery is stock to 2 weeks.

Hewlett-Packard Co., Inc., 1501 Page Mill Rd., Pal Alto, CA 94304. Phone (415) 493-1501.

Booth No. 2400 **Circle No. 378**

Miniature 6-bit a/d converter for only $22.95

When it comes to modular a/d converters, next to performance, two things are taking on more and more importance: small size and low cost.

The smallest and least-expensive 6-bit a/d converter is one from Datel Systems, Inc. Known as the Econoverter, it has a total volume of only 1.6 cubic in. (2-in. square by 0.4-in. high) and retails for just $22.95 in single quantities. OEM quantities should make the price even lower. The unit contains its own clock generator, output counter/register, d/a converter amd a high-speed precision comparator.

In spite of the low price, performance does not take a back seat in this stocked unit. While its temperature coefficient of 100 ppm/°C and 0.1%/year stability are not earthshaking, the full-scale conversion of only 50 μs (0.5 μs for a zero input) is impressive. Since the conversion time is directly proportional to the magnitude of the input voltage, inputs less than full scale can achieve conversion times under 50 μs.

When it comes to power consumption, this converter is a miser—it dissipates only 0.7W. Input power requirements include +15V dc at 15 mA, −15V dc at 5 mA and +5V dc at 80 mA.

Linearity is specified as ±1/2 LSB and full-scale accuracy as ±1 LSB. The operating temperature range is 0 to +70°C and storage temperature range is −55 to +85°C.

Smallest and least-expensive 6-bit a/d converter is the Econoverter from Datel Systems, Inc. Measuring only 1.6 cubic inches in volume, it costs just $22.95.

Input voltage protection is afforded up to 20V. When overvoltaging, the converter simply stops converting without sustaining damage (its end-of-conversion output remains low). The input impedance is either 2.4 or 4.2 kΩ depending on the input range in use.

Any one of four input voltage ranges can be chosen from the two input terminals available by simple pin strapping: 0 to +5V, 0 to +10V, ±2.5V and ±5V.

Each output is capable of driving 6 TTL loads with output coding in straight binary (unipolar) or offset binary (bipolar), depending on the programming of the input range. Digital outputs include six-line parallel, end-of-conversion and internal clock (serial) outputs.

Booth No. 2108 **Circle No. 379**

50V 1A supply has 10-μV resolution

Incorporating a set of five 10-position switches for output-voltage selection, Trygon's Model PLS50-1 precision laboratory power supply delivers 0 to 50V dc at 0 to 1A down to a resolution of 1 mV (with the rotary switches) and to 10 μV with an available vernier dial. The $315 supply which is 4-7/8-in. high mounts in a half rack.

Three modes of remote programming include: resistance programming at 1000Ω/V at 0.02% accuracy; volt/volt programming at 200-μV accuracy; and analog-voltage programming over 0 to 5V at 1 mA and at an accuracy of 0.2%. Trygon Electronics, subs. of Systron-Donner Corp., 1200 Shames Dr., Westbury, NY 11590. Phone (516) 997-6200.

Booth No. 2532 **Circle No. 321**

Digital multimeter has 0.0001% accuracy

Linearity and accuracy of 0.001% of full scale (1 ppm) are claimed for the DM-1000 multimeter with six significant digits and a seventh one with 20% overrange. Able to measure voltage, current resistance of ratios, it is basically a 1-ppm digital ratiometer which converts measurements to the same accuracy with add-on Ratiometric options.

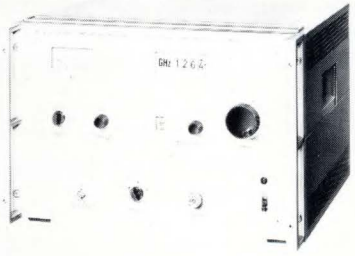
Self calibrating, the DM-1000 has TTL BCD output and can be remotely programmed. Basic price is $5995. A 0-to-12V DVM add-on costs $490. The DVM and a 1-mΩ-to-1.2-MΩ digital ohmmeter cost $990. Julie Research Laboratories, Inc., 211 W. 61st St., New York, NY 10023. Phone (212) 245-2727.

Booth No. 2313 **Circle No. 322**

6.7-to-12.7-GHz generator delivers 3W

Operating within a single tuning range of 6.7 to 12.7 GHz, Rohde and Schwarz's new SLRE power signal generator can deliver high output power ranging from 0.25 to 3W, depending on frequency. The generator's frequency tuning is linear and it can be synchronized with any standard frequency to give an unambiguous digital display.

Additional features include power indication over a 40-dB dynamic range, internal square-wave modulation at 1 kHz and external pulse-modulation capability. Price of the SLRE is $8725. Rohde and Schwarz Sales Co., Inc., 111 Lexington Ave., Passaic, NJ 07055. Phone (201) 773-8010.



Booth No. 2103 **Circle No. 323**

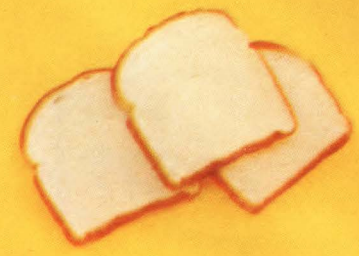
System displays 60 dB over 0.1 to 18 GHz

Swept-frequency response measurements of 60 dB amplitudes can be made with the Series 8755 test system which uses up only 10 mW of drive. It displays its results on a scope screen and can show two traces at once. Used with directional couplers, it can show insertion loss and return loss vs frequency at the same time.

The system consists of three $200 detectors (Model 11664A), a $300 modulator (Model 11655A) which is a plug-in for any of the Hewlett-Packard Series 180 scopes, and the $1350 8755A sept-amplitude analyzer plug-in. Delivery is for April, 1972. Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, CA 94304. Phone (415) 493-1501.

Booth No. 2403 **Circle 324**

SAINT LOGIC



The best thing to come along since sliced bread

The state-of-the-art has not permitted any significant break-through in DVM logic until now. In the present DVMs on the market, certain trade-offs or sacrifices are necessary. For example, accuracy is given up for speed in many cases; speed is given up for accuracy; accuracy and speed have been given up for a lower price; accuracy and speed are given up for noise rejection.

The new Cimron DMM 50 is a five digit digital multimeter and is first in a family of multimeters to be introduced by Cimron this year. The Cimron DMM 50 offers high quality, high accuracy, high noise rejection and high speed at the same time.

In order to provide such a meter Cimron has employed a logic we call "SAINT." We've taken two logics and combined them resulting in one very powerful instrument. We use Successive Approximation (SA) logic for speed and integrating (INT) logic for its inherent noise rejection.

Each reading on the Cimron DMM 50 starts with an "Automatic Set Zero," then we examine the most significant of the five decades. Any part of a digit from zero through eleven is subtracted. This is called our "subtractive digit" operation. The most significant decade can be zero through eleven. Next we integrate the four least significant decades.

The four operations of the "SAINT" technique are (1) automatic zero set; (2) subtractive digit; (3) integrate compare "one"; (4) integrate compare "two." This means the DMM 50 can operate at greater than 20 readings per second with a rejection of 60 dB at 60 Hz. An additional 60 dB of noise rejection may be switch selected.

Multimeter capabilities include: 5 ranges of DC and DC/DC ratio; 4 ranges of AC; 5 ranges of resistance; optical coupled data output and remote programming. Priced from $1200.

Other Cimron products include AC Power Sources and Line Conditioners; Data Acquisition Systems; Pulse Generators; and a complete line of high performance DVMs.

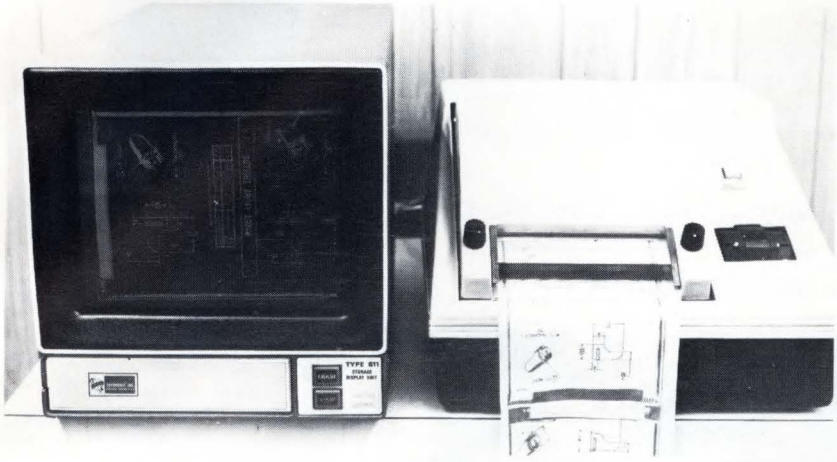
For detailed specifications and demonstration contact your local Cimron Representative or Chuck Hasley at 714-774-1010, Lear Siegler, Inc., Cimron Instruments, 714 North Brookhurst Street, Anaheim, California 92803.

LEAR SIEGLER, INC. / *CIMRON INSTRUMENTS*

IEEE Booth No. 2101

CIRCLE NO. 47

Recorders provide instant hard copy



A pair of "push-to-print" recorders provide instant hard-copy paper records of graphics, from slow-scan television, data and CRT terminals. The Model 600 is plug-to-plug compatible with and interfaces to Tektronix's 611, 612 and 162C storage display units. Model 400 interfaces with Robot Research Inc.'s Model 800 voice-band television cameras.

Both recorders utilize Alden's Flying Spot facsimile recording techniques and work at 30 lines/sec. The 600 and 400 cost $2500 to $1500. Alden Electronic & Impulse Recording Equipment Co., Inc., Westboro, MA 01581. Phone (617) 366-8851.

Booth No. 2523 **Circle No. 325**

18-GHz counter measures FM and pulsed RF

Not only does the 9-digit Model 6057 counter measure cw frequencies from 20 Hz to 18 GHz, but it also offers FM and pulse-modulated measurements over the same range. An automatic computing transfer oscillator for cw measurements is combined with a manual transfer oscillator to measure FM and pulsed RF at pulses down to 100-ns wide.

Features include an automatic decimal, an annunciator and selectable resolution as low as 1 Hz. BCD output and remote programming are optional. Cost is $5450 and delivery in 30 days. Systron-Donner Corp., Instruments Div., 888 Galindo St., Concord, CA 94520. Phone (415) 682-6161.

Booth No. 2532 **Circle No. 326**

1-GHz processor characterizes waveforms

Model 1150A programmable waveform processor is a dual-channel 1-GHz sampling-scope-like instrument that samples repetitive waveforms, digitizes the samples and sends them to an associated computer which determines such factors as pulse height, width, period, transition time and propagation delay.

The 1150A can accept 32 inputs, any two of which may be selected manually or by programmed selection. Deflection factors range from 2 mV/div. to 200 mV/div. and sweep times from 100 ps/div. to 50 μs/div. Cost is $12,000. Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, CA 94304. Phone (415) 493-1501.

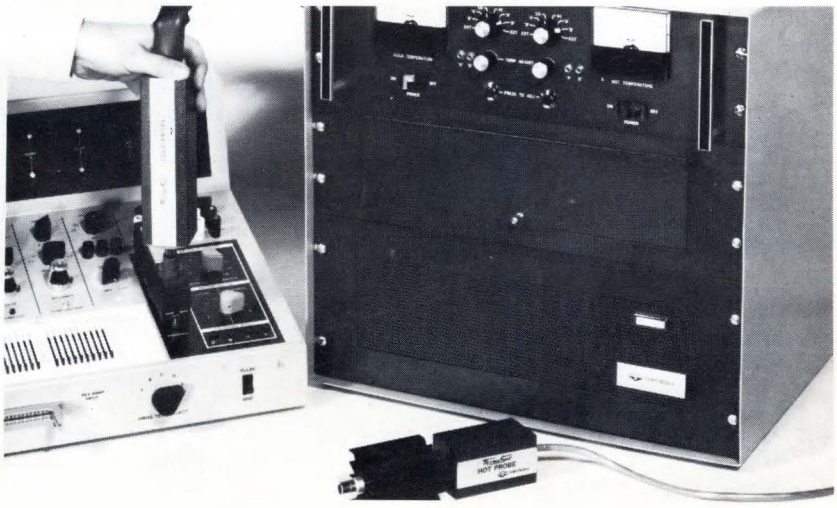
Booth No. 2403 **Circle No. 327**

Probe unit speeds up IC thermal testing

For testing and characterizing IC components on-the-spot, the TP20 Thermo-Spot can do the job in only seconds. Its probe can provide temperatures over −55 to +180°C at an accuracy of 1°C at the probe tip and stability of ±0.3°C. Any temperature value within the TP20's given range can be preset and read out in the proportional-control system.

The system can be programmed to stabilize and test even oscillation-prone IC components such as the popular 709 op amp at 10 different temperatures in 10 minutes. Delivery is from 4 to 6 weeks. Temptronix, Inc., 591 Hillside Ave., Needham, MA 02194. Phone (617) 449-3710.

Booth No. 2735 **Circle No. 328**



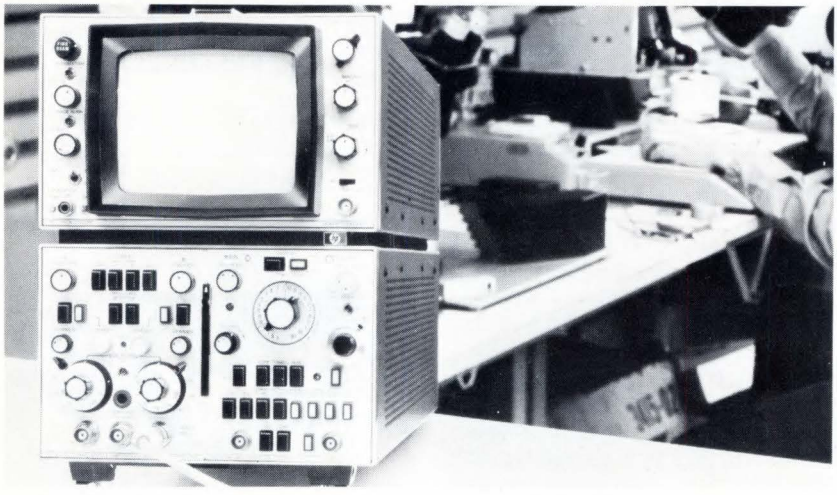
Rugged DMM runs off battery for 24 hours

Two things distinguish Hickok's Model 3300A portable 3-1/2-digit multimeter: its ruggedness and long operating time. The instrument can be dropped and will continue to operate within ratings. It runs off its own rechargeable battery for 24 consecutive hours. The Ni-Cd battery used is good for 1000 recharges minimum.

Priced at $435 (includes battery), it has 5 ac and dc voltage ranges from 100 mV to 1 kV each, 5 ac and dc current ranges from 100 μA to 1A each and 7 resistance ranges from 100Ω to 1 MΩ. Delivery is 45 days. Hickok Electrical Instrument Co., 10514 Dupont Ave., Cleveland OH 44108. Phone (216) 541-8060.

Booth No. 2442 **Circle No. 329**

100-MHz scope plug-in has 50 and 1MΩ inputs

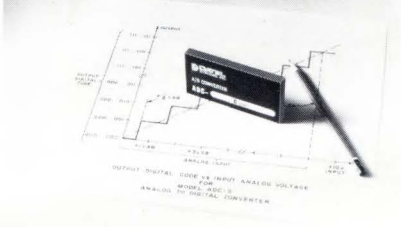


The 1805A dual-channel scope plug-in for the 180 Series scopes features switchable input impedances of 50 and 1MΩ. The 50Ω input has a VSWR of 1.35 on the most-sensitive range and a VSWR of 1.1 on all other ranges. The 1MΩ input has a shunt capacitance of 13 pF. Deflection factors of 5 mV/div. to 5V/div. are available.

Offset voltages are available on either or both channels. The voltage bucks out dc in the input signal so small deviations can be greatly magnified and brought on the screen for examination. Cost is $1400 and delivery is for March, 1972. Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, CA 94304. Phone (415) 493-1501.

Booth No. 2403 **Circle No. 330**

High-performance A/D converters from $69

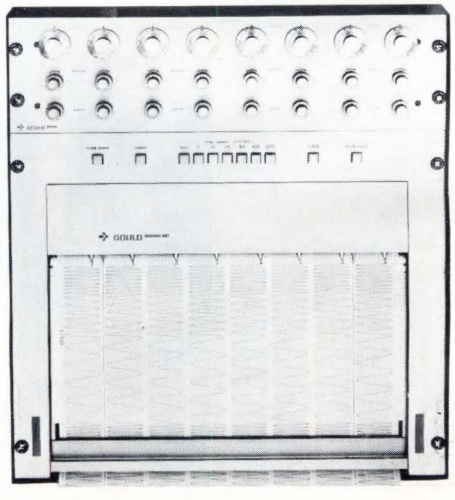


Series ADC-D A/D converters with resolutions of 8, 10 and 12 bits at prices of $69, $89, and $109, respectively, feature programmable inputs of 0 to +10V or ±5V and accuracy of ±0.05% of full scale. All models feature a conversion word rate of 100 μsec are adjustment free and exhibit temperature coefficients of ±0.005%/°C.

Digital output coding can be straight binary, offset binary or two's complement. ADC-D units measure 2 × 0.4 × 0.4 in. and can be mounted on a user's PC board. Overall linearity is ±0.0125% and operating temperature range is 0 to +70°C. Datel Systems, Inc., 1020 Turnpike St., Canton, MA 02021. Phone (617) 828-6395.

Booth No. 2108 **Circle No. 331**

8-channel recorder has 1-mV sensitivity



Using built-in preamplifiers, Brush Model 481 recorder has a measurement range from 1 mV/div. to 500V full scale (there are 50 divisions across each 40-mm-wide channel). Preamplifiers used have differential, floating and balanced-to-guard inputs that are isolated from each other, from chassis and from the output. 12 chart speeds range from 0.05 to 200 mm/sec.

Features of the 481 include pressurized ink writing, rectilinear trace presentation, 99.5% linearity, 400-Hz response at 50 divisions and electronic signal limiters to protect pens from off-scale overloads. Cost is $7900 and availability is May, 1972. Gould, Inc., 3631 Perkins Ave., Cleveland, OH 44114. Phone (216) 361-3315.

Booth No. 2509 **Circle No. 332**

THIS IS ALL WE ASK:

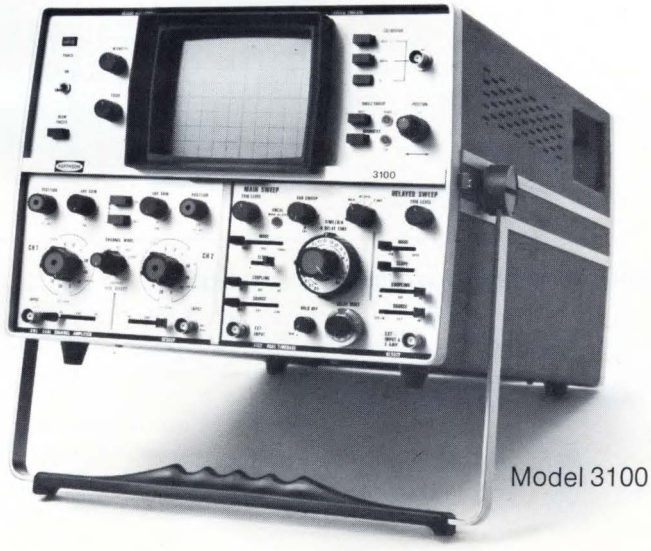
COMPARE OUR NEW OSCILLOSCOPES WITH SCOPES YOU'RE USING NOW.

	Our 3100	Your Comparable Scope	Our 4100	Your Comparable Scope
Bandwidth & sensitivity	DC-35MHz @ 5mV/div	?	DC-75MHz @ 5mV/div	?
CRT Size	8 x 10 Cm	?	8 x 10 Cm	?
Fastest Sweep	20ns/div	?	5ns/div	?
Calibrated Sweep delay	Standard	?	Standard	?
List Price	$1675.00	?	$1825.00	?

WE LET THE FACTS DO THE TALKING

For more of the facts behind these superior designs, write Raytheon Company, Instruments Operation, 175 Middlesex Turnpike, Bedford, Mass. 01730.

RAYTHEON

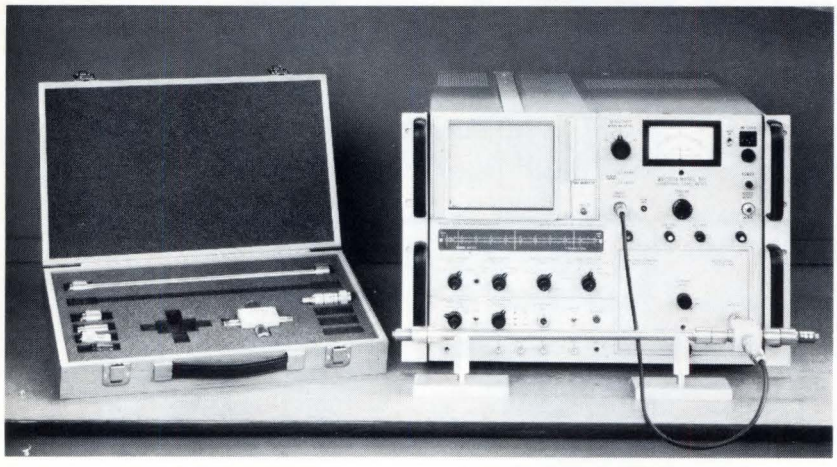


Model 3100

72 IEEE Booth 2602

CIRCLE NO. 48

RF system simplifies measurements



Model 610C rf sweeper system features wide reflection-measurement limits: 50 dB from 50 kHz to 32 MHz; 60 dB from 50 to 100 MHz; and 45 dB from 2 to 12.4 GHz. It has a 50 to 60-dB dynamic reflection and transmission range with 10 to 0.5 dB/div. displayed on a 4 × 5-in CRO and panel meter. A digitally set 60 dB offset is available.

The sweeper is externally programmable from automatic-test equipment or local built-in optional panels. The sweeper's unique sweep-intensity marker can be set anywhere in the instrument's frequency band to identify comb frequencies. Wiltron Co., 930 E. Meadow Dr., Palo Alto, CA 94303. Phone (415) 321-7428.

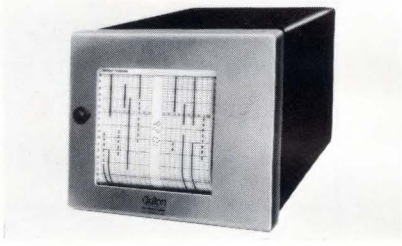
Booth No. 2115 **Circle No. 337**

20-channel recorder uses thermal head

Model 820 20-channel recorder uses a thermal print head and requires no operating stylus. It can optionally print event and numeric data simultaneously on the same chart. For event recording, the print head is positioned on the recorder time base for broken or continuous-line records. Numeric data can be printed at the same time.

Types of numeric data can be time, dates batch numbers or any other numeric data. Ten chart speeds are available from 3/4 in./hour to 12 in./minute (two are standard). Gears are color coded according to the chart speed supplied. Gulton Techni-Rite Electronics, Route #2, E. Greenwich, RI 02818. Phone (401) 884-6800.

Booth No. 2132 **Circle No. 338**



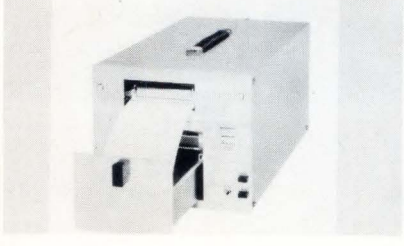
Programmable synthesizer uses built-in ROMs

Sophisticated is the word for the Model 3330B synthesizer which spans 0.1 to 13 MHz with a 0.1-Hz constant resolution and a stability of $\pm 1 \times 10^{-8}$/day ($\pm 1 \times 10^{-9}$/day optional). It uses an upward-tiltable front-panel keyboard that allows complete programming of both frequency and amplitude through the use of built-in ROMs.

The 7-digit unit has −60-dB harmonic rejection, −70 dB spurious response and a 0-to-±13.44-dBm (1.05V into 50Ω) output. The 3330B costs $6000. A less-expensive version (3330A) without keyboard entry of amplitude costs $5100. Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, CA 94394. Phone (415) 493-1501.

Booth No. 2403 **Circle No. 339**

Seven-column OEM printer for only $650



Costing only $745 (7-column model) or $650 without a power supply, a new digital printer is designed to accept 8-4-2-1 BCD inputs and prints out up to 3 lines/sec. Model 5103B can also print out 14 or 21 columns and is suitable for OEM (no power supply) or bench use. A data input-storage feature is a transfer time of only 4 μs.

Features include single-line column blanking and decimal-point and measurement-unit symbols. The 5103B uses 3-1/2-in.-wide paper, fanfold or pressure-sensitive packets. Delivery is in 30 days. Systron-Donner Corp., Instrument Div., 888 Galindo St., Concord, CA 94520. Phone (415) 682-6161.

Booth No. 2532 **Circle No. 340**

100-MHz counter can be built from a kit

Available in kit form is a 1 Hz to 100-MHz counter priced at only $269.95. Model IB1101 can be assembled in 10 hours. It accepts inputs from 50 mV to 200V and has a full-five-digit readout expandable to eight digits with overrange circuitry. It features input impedance of 1 MΩ and an automatically positioned decimal point.

The front-panel displays kHz, MHz, overrange and gating indications. A built-in variable-level source allows initial sensitivity setup while a conventional AM radio can be used as the time-base oscillator adjustment standard. Heath Co., Benton Harbor, MN 49022. Phone (616) 983-3961.

Booth No. 2214 **Circle No. 341**

Tester identifies wire leads in seconds

Tracing circuits and wires, even in complex systems involving hundreds of leads, takes only seconds with the Pathfinder—an electronic searching device. By means of a probe, an operator touches a lead and the Pathfinder identifies it with a numerical display. An additional component allows remote tester operation up to two miles.

Since the tester system is modular and permits adding components as user needs grow, it can be expanded from a basic capacity of 99 wires to 999 wires. No restrictive connection is required for common ground. W.H. Brady Co., 726 W. Glendale Ave., Milwaukee, WI 53201. Phone (414) 332-8100.

Booth No. 1413 **Circle No. 333**

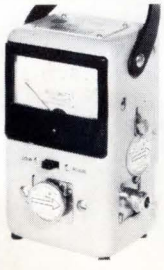
Small resistors handle high voltages

A new line of miniature metal-oxide resistors for high-voltage applications includes four types: the 1W Mini-MOX rated to 5 kV (100 ppm TC); the 2.5W Maxi-MOX rated to 7.5 kV/lineal in. (lengths of 1 to 5 in.); the 45W Power-MOX rated to 45 kV at 70°C; and the Divider-MOX with taps for output ratios up to 10^4:1 and a 37.5-kV rating.

The resistors are said to be very stable for extreme environments, with as little as 1% drift under full load at 2000 hours. Mini-MOX resistors range in value from 1 to 10,000 MΩ. Victoreen Instrument Div. of VLN Corp., 10101 Woodland Ave., Cleveland, OH 44104. Phone (216) 795-8200.

Booth No. 3506 **Circle No. 342**

Passive rf wattmeter resolves 5 mW



With a few exceptions, most bidirectional rf wattmeters measure anywhere from 5W to 250 kW. The new Thruline Model 4330 passive directional milliwattmeter measures signals in 50Ω transmission lines with plug-in elements for different frequency bands within 600 to 2300 MHz. Each element has switchable 200 and 800-mW full-scale ranges.

Ranges are available with either forward or reflected-power measurements. Insertion VSWR is a low 1.05. Price is $125 for the milliwattmeter and plug-in elements cost from $60 to $80. Delivery is 90 days. Bird Electronic Corp., 30303 Aurora Rd., Cleveland, OH 44139. Phone (216) 248-1200.

Booth No. 2243 **Circle No. 343**

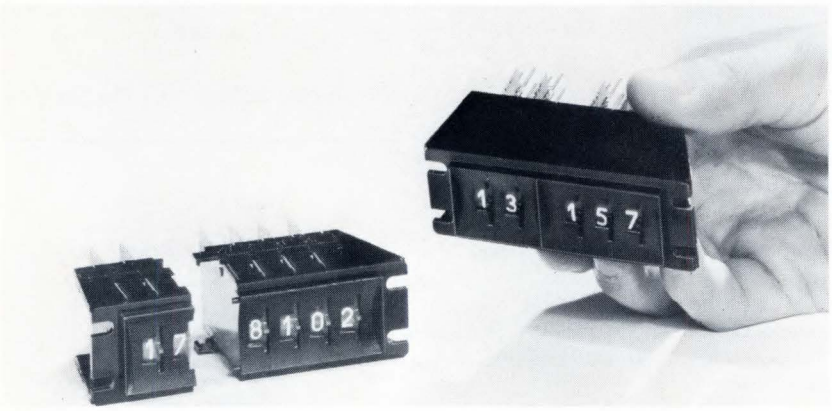
Relay cards increase switching density

As many as 21,600 switch points can be packaged into a 7-ft-high 19-in. rack using the new Series 6800 T-bar switch relays. Mounted on or between printed-circuit coards which plug directly into card-edge connectors in standard card frames, they allow common wiring by Wire-Wrap or dual-in-line solder backplane techniques.

Offered with 36 to 72 poles, they can pass pulses with risetimes of 100 ns. Contact rating is 1A at 28V dc resistive, mechanical life is 30 million cycles, through-path resistance is 200 mΩ and coil power ranges from 5.2 to 6.5W. Cost is as low as $1/pole. T-Bar, Inc., 141 Danbury Rd., Wilton, CT 06897. Phone (203) 762-8351.

Booth No. 3301 **Circle No. 344**

Thumbwheel switches form snap-on decades



Any number of desired decades can be formed with the Series 545 thumbwheel switches. These preset switches snap together on 5/16-in. centers. Any assembly of decades mounts with only four studs and end-mount brackets while spacers can be selected as required.

Switching functions include 10-position, 1 or 2-pole and binary (1-2-4-8 and 1-2-4-8 with complements). Specifications include switching capacity of 0.1A dc. Cost is as low as $2.57/digit (1000 quantities). Dialight Corp., 60 Stewart Ave., Brooklyn, NY 11237. Phone (212) 497-7600.

Booth No. 3401 **Circle No. 345**

Decade attenuators work to 50 MHz

Ten steps of attenuation are offered in a new line of rotary variable attenuators with an extremely flat response over the range of dc to 50 MHz. Standard steps include 0.5 and 1-dB increments in three different impedance values—50, 75 and 100Ω.

Each attenuator is available in a black anodized case with a 3-in. diameter and comes equipped with an engraved dial and BNC connectors. Special decade attenuators can also be built for specific requirements. Allen Avionics, Inc., 224 E. 2nd St., Mineola, NY 11501. Phone (516) 248-8080.

Booth No. 3101 **Circle No. 346**

Time-delay relay uses a calibrated panel

A new Class 218 solid state time-delay relay uses a calibrated panel and meets the rigid requirements of the National Electrical Code. The delay time is repeatible to an accuracy of ±2%. Timing is available in a variety of ranges spanning 0.05 to 600 sec. All relays are rated for 120V ac nominal inputs (dc-input versions on request).

Three output switching configurations are available: dpdt at 120V ac 60 Hz 10A resistive or 28V dc resistive (1/4 hp); spdt normally open at 50A ac or dc (1 hp); and spdt at 120V ac 60 Hz 10A resistive, or 28V dc resistive. Magnecraft Electric, 5575 N. Lynch Ave., Chicago, IL 60630. Phone (312) 282-5500.

Booth No. 3608 **Circle No. 347**

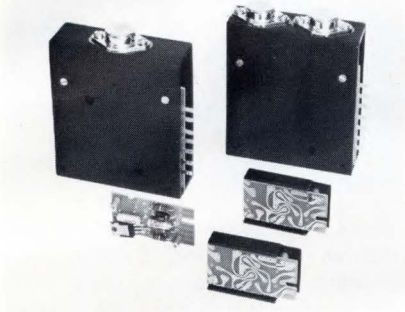
Wave analyzers with 100-dB dynamic range

Five wave analyzer models span the frequency range of 5 Hz to 60 kHz (500 MHz by additional mixing) and a dynamic range of up to 100 dB. The system includes Model FAT-1 which covers 5 Hz to 20 kHz at up to 80 dB in sweeper and sweeperless versions. The FAT-2 covers 10 Hz to 60 kHz up to 80 dB and is also in sweeper and sweeperless versions.

Rounding out the system is the new FAT-3 which has a frequency range of 5 Hz to 20 kHz and a 100-dB dynamic range. As a system, the five different models offer four selectable bandwidths from 4 to 600 Hz. Costs range from $5990 to $8150. Rohde & Schwarz, 111 Lexington Ave., Passaic, N J 07055. Phone (201) 773-8010.

Booth No. 2103 **Circle No. 351**

Power supply modules allow flexibility



A system of modular remote regulators and power supplies are available for flexibility in power supply design. The new system offers a choice of 16 basic low-cost regulators and 6 matched unregulated power centers which can be combined in a simple manner to provide an almost limitless variety of power-system combinations.

Each basic component is a complete functioning unit by itself. The power center consists of an ac operated unregulated dc power source. This matched source feeds the desired number of miniaturized remote regulators.

The regulators are four terminal designs which eliminate extra wiring and can be located at any point in the circuit or mounted directly at the basic power center. These components can be concentrated or distributed in any optimum manner desired for maximizing physical, electrical and thermal characteristics.

Regulators are available from 5 through 24V dc at 150 mA to 40A. Line and load regulation is 0.05%. The regulators are the RR Series. PC Series supplies range from 10 through 32V dc in output and 500 mA through 50A. Input is 115/230V ac 50-400 Hz. Ripple for the power centers is less than 1.5V RMS and when used in conjunction with the remote regulators results in a supply ripple of less than 0.01% or 1.5 mV. Low current regulators incorporate overvoltage protection and add-on protectors are available for high current types. ERA Transpac Corp., 67 Sand Park Rd., Cedar Grove, N J 07009. Phone (201) 239-3000.

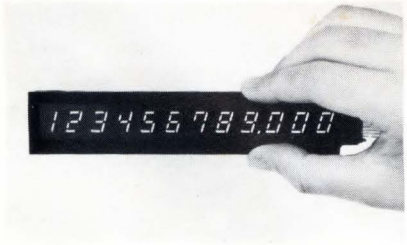
Booth No. 2610 **Circle No. 352**

12-digit display panels at $1.12/digit

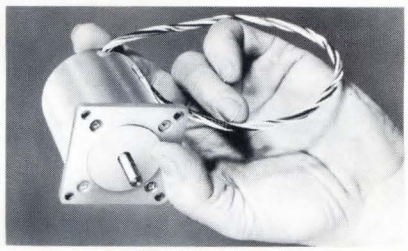
When purchased in 50,000 quantities, Utovue 12-digit display panels can be bought at $1.12 per digit. Model LD-8026 7-segment panel indicates numerals 0 through 9 and a decimal point. Its gas-discharge displays have character heights of 10 mm (0.394 in.) and widths of 6 mm (0.236 in.). Only 24 connections are needed per panel.

Designed to be multiplexed, each 157.5-mm long (6.2 in.) by 30-mm wide (1.18 in.) by 5-mm thick (0.197 in.) 12-digit panel dissipates 0.1 mW per digit at a driving voltage of 160V. Brightness is 70 ft-L. NEC America, Inc., 200 Park Ave., New York, NY 10017. Phone (212) 661-3420.

Booth No. 3112 **Circle No. 348**



Stepping motors increase in torque



New M Series Slo-Syn stepping motors can be driven to speeds above 10,000 steps per sec with a minimum of input power. Each stepping increment is 1.8° using a 4-step input sequence, and is 0.9° using an 8-step sequence. Each step is accurate within ±5% noncumulative for conventional types and ±3% noncumulative for precision types.

All M Series motors have permanent-magnet rotors and 8-pole stators. Torque ratings range from 35 to 840 oz-in. No brushes, gears, ratchets or detents are used. The motors operate over −40 to +65°C ambient temperatures. Superior Electric Co., 383 Middle St., Bristol, CT 06010. Phone (203) 582-9561.

Booth No. 1102 **Circle No. 349**

Automatic Circuit Tester Speeds Checkout

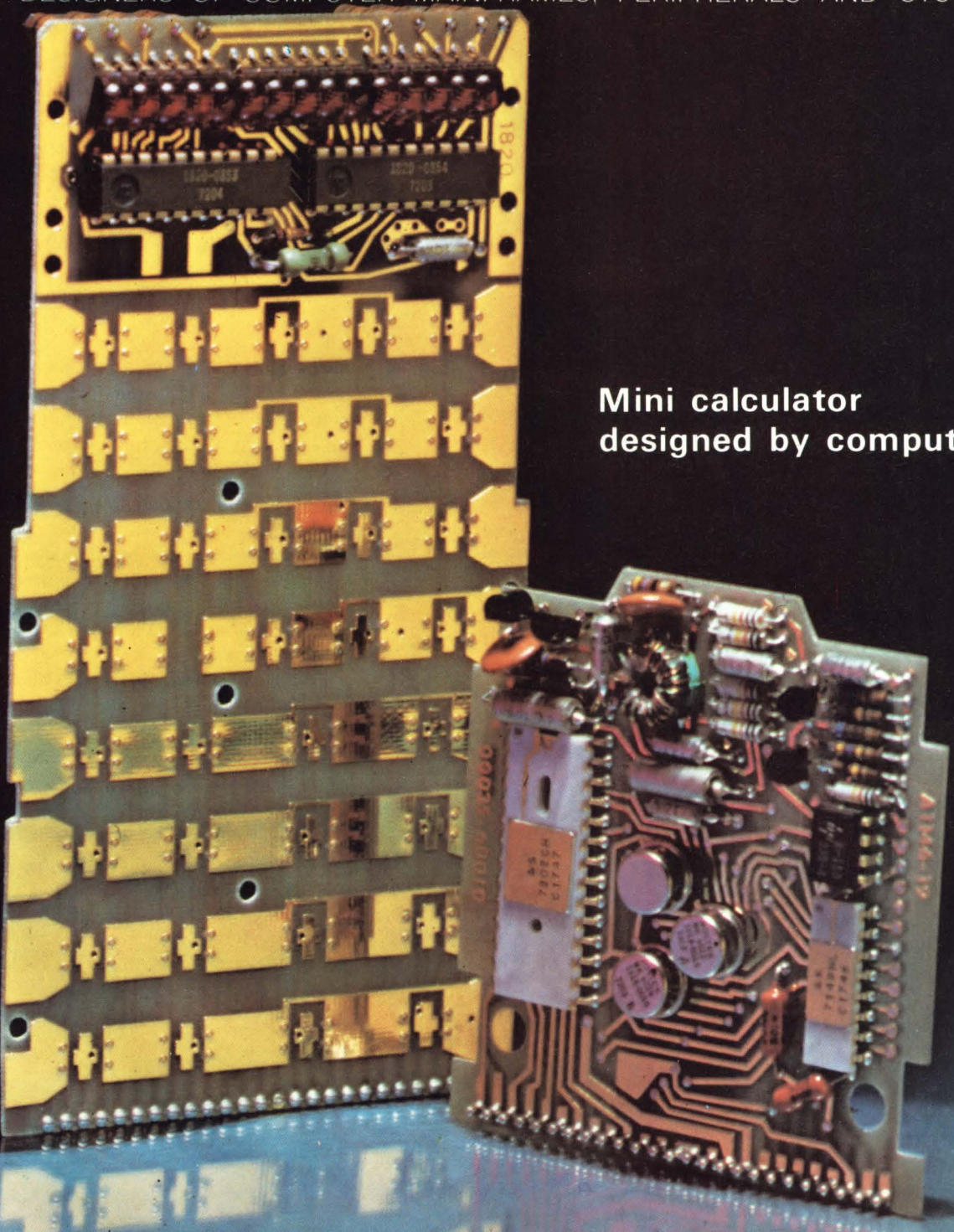
A new automatic circuit tester, the Testmatic TM61, is a portable instrument with a simple and flexible programming arrangement. It can be used by unskilled operators to make a series of quick and accurate functional tests on completed electronic assemblies. Up to 61 tests can be made in only 5 seconds. The time taken for each test can be extended if required. Assemblies under test are placed on the instrument's test panel, which is pre-drilled to provide a convenient type of locating jig.

Programming is carried out simply by inserting diodes into a double-sided printed-circuit matrix board. The Wayne Kerr Co., Ltd, Surrey, England. U.S. Agent: Mechanical Technology, Inc., 968 Albany Shaker Rd., Latham, NY 12110. Phone (518) 785-2323.

Booth No. 2112 **Circle No. 350**

computer hardware

FOR DESIGNERS OF COMPUTER MAINFRAMES, PERIPHERALS AND SYSTEMS

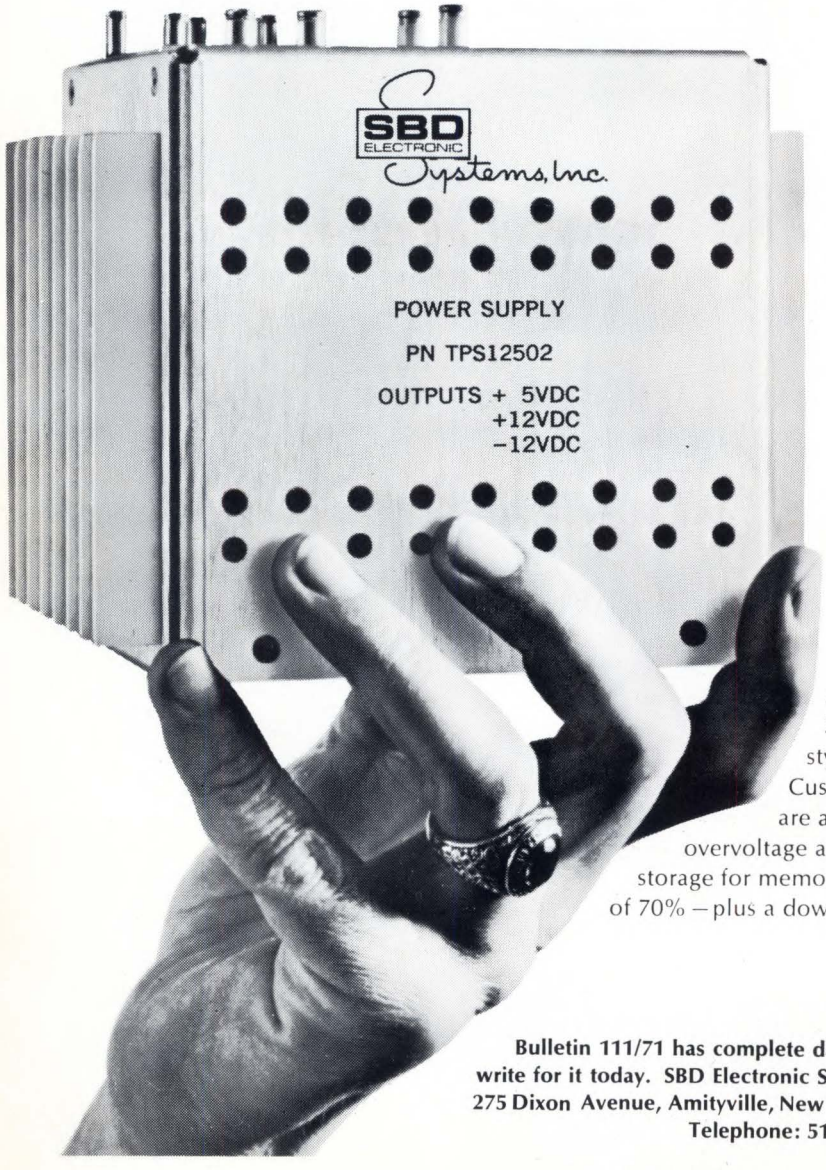


Mini calculator designed by computer

A CAHNERS PUBLICATION/MARCH 15, 1972

YES, WE SAID

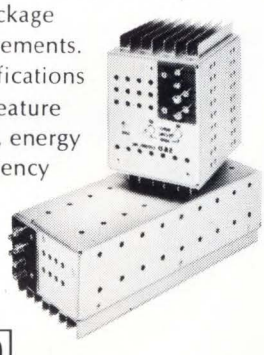
MIX-MATCH LOADING



That's right—Series TPS125 Computer Terminal Power Supplies can accommodate a virtually infinite combination of mixed loads with one cool-running, multi-output unit small enough to hold in your hand!

Choose any combination of these outputs: +5V, ±12 or ±15V, −5 and +28V. SBD's unique mix-match loading design automatically delivers the load currents your circuits demand—up to 25 amperes at +5V, up to 2 amperes at other outputs, right up to the total rated power of 125 watts. You get performance that previously required multiple supplies—in 1/5 the space of a conventional unit.

System-engineered specifically for computer terminals, Series TPS125 Power Supplies are available off-the-shelf in 10 models, with up to 5 standard outputs, in 2 package styles to meet specific requirements. Custom voltages to your specifications are also available. All models feature overvoltage and short circuit protection, energy storage for memory protection, typical efficiency of 70%—plus a down-to-earth price tag.

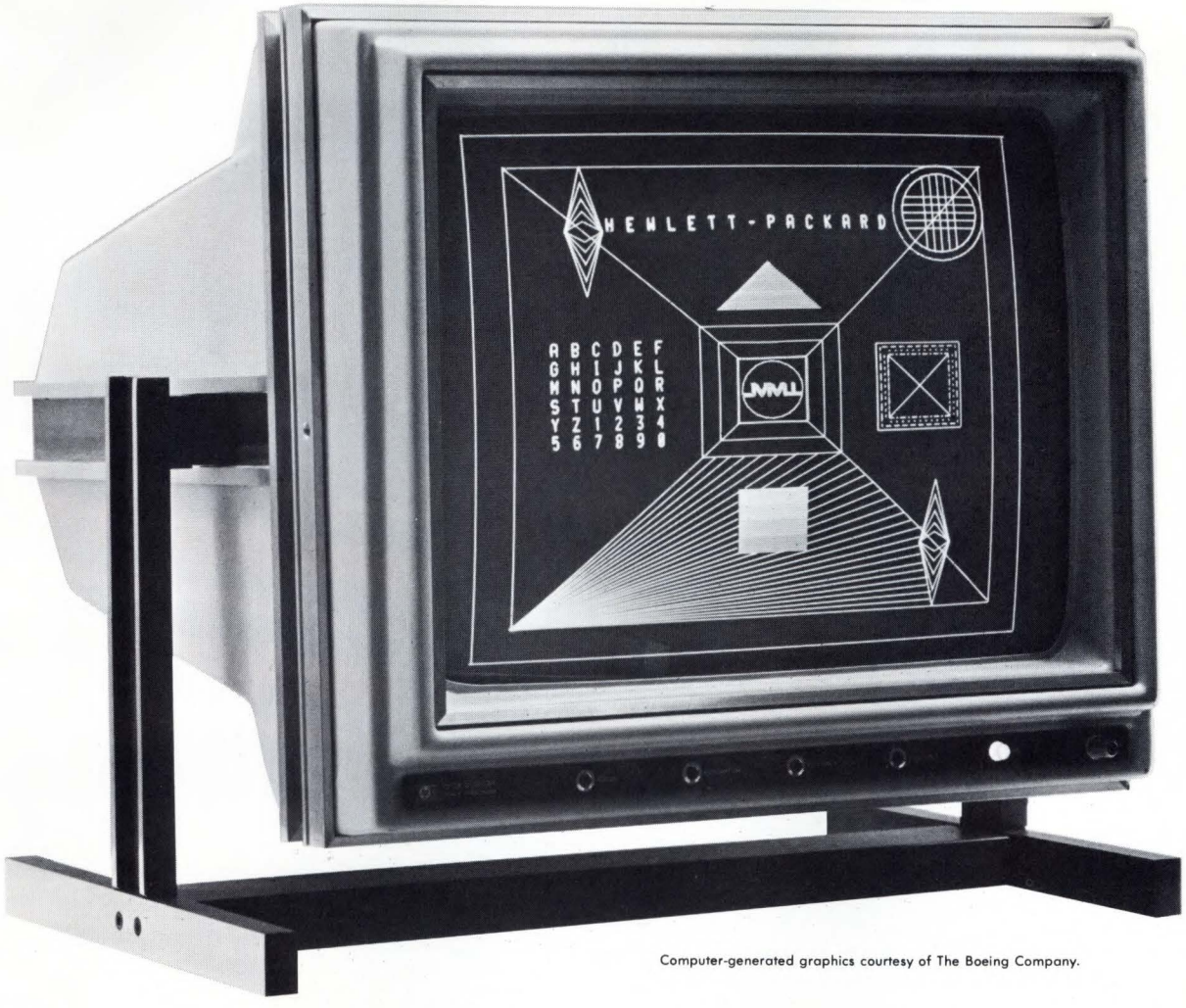


Bulletin 111/71 has complete data. Call or write for it today. SBD Electronic Systems, Inc. 275 Dixon Avenue, Amityville, New York 11701. Telephone: 516-842-2000.

SBD ELECTRONIC Systems, Inc.

CIRCLE NO. 401

This display writes as fast as your computer can talk.



Computer-generated graphics courtesy of The Boeing Company.

HP's new 1310A 19-inch-diagonal X-Y display is the answer to many an OEM's prayer... because it's the **first display ever that can keep up with the graphic information output of today's high-speed computers.**

The 1310A has a **writing speed of 10 inches per microsecond** – 10 times faster than any other display's. Its slew rate is 100 inches per microsecond. And its large-step jump and settle time is 1 microsecond. Thus, the 1310A gives you the ability to display information as fast as your computer puts it out – in any desired sequence of locations, without "smearing." No longer must you program outputs in a manner imposed by display limitations.

The key to the 1310A's outstanding performance is its **unique, advanced cathode ray tube** which uses electrostatic deflection to control its electron beam.

Also as a result of using electrostatic deflection, the 1310A is smaller, lighter, and **requires less power** than any competitive graphic display – only 100 watts. Because it uses the latest, highly rectangular CRT face glass, its display area is equal to that of many 21-inch units. And its **0.020-inch spot size** gives you a crisp, clear image over that entire area.

And performance is only the beginning! With the 1310A, you also get plug-in-board construction for fast, easy servicing. Replacement boards are available from any of HP's service centers around the world, on an exchange basis, within 48 hours. And it takes only minutes to remove or insert any board.

Yet, despite all these advantages, the **1310A costs only $3000**—far less than competitive displays (covers and stand, $100 extra). Or, for $2875, you can get all the features of the 1310A, in the new 14-inch-diagonal 1311A. **OEM price schedules are available on both the 1310A and 1311A.**

For further information on both of these new displays, contact your local HP field engineer. Or write Hewlett-Packard, Palo Alto, California, 94304. In Europe: 1217 Meyrin-Geneva, Switzerland.

081/14A

HEWLETT hp PACKARD

OSCILLOSCOPE SYSTEMS

CIRCLE NO. 402

Your EDP cable jam is TRW/Holyoke's bread and butter.

We *like* the tough jobs . . . and we tackle many assignments that others have turned down or classified as too difficult. Manufacturing EDP wire and cable is a science, which requires experience, expertise and equipment. But it is also an art, which requires imagination, ingenuity, and an attitude of *willingness.*

That's what sets us apart—the willingness to handle the difficult designs—combined with the ability to closely control the production process to provide high volume output of precision cables.

For example, the 32 pair .363″ diameter cable illustrated upper right is a redesign of an existing cable that maintained equivalent flexibility, crush resistance, abrasive resistance and cable diameter, held impedance to closer tolerances yet costs less than the original!

In another case, a minimum diameter 90 ohm coaxial cable was needed by a major computer manufacturer. Other cable sources stated that a 30 ga. center conductor was the minimum they would consider, resulting in a .125″ OD cable. TRW/Holyoke designed it with a 32 ga. center conductor producing a .086″ OD cable that met all mechanical and electrical parameters—and shipped it a week ahead of schedule!

Our comprehensive service to the EDP industry also includes harnesses and cable assemblies with PC board, molded connectors, terminals, plugs, sockets and other hardware.

Your cable jam is our bread and butter—so call us at (413) 533-3961 when you need help, or write for more information to TRW/Holyoke Wire & Cable, an Operation of TRW Electronic Components, 720 Main Street, Holyoke, Massachusetts 01040. CH-7250

TRW®
HOLYOKE WIRE & CABLE

CIRCLE NO. 403

computer hardware

EXCLUSIVELY FOR DESIGNERS OF COMPUTER MAINFRAMES, PERIPHERALS AND SYSTEMS

COVER

Cover photo courtesy of Hewlitt-Packard Co., Palo Alto, CA shows the entire set of electronics for the HP-35 pocket calculator. For the complete story of how the electronics was designed by computer simulation, see "Baby calculator is sired by big daddy computer" on p CH

DIRECTIONS

FEATURES

Baby calculator is sired by big daddy computer

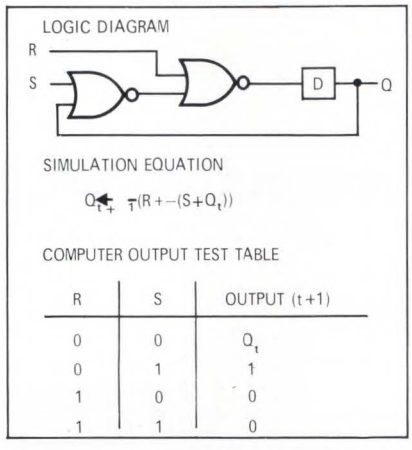
The designers of the HP-35 calculator faced many problems in building the powerful pocket-sized machine, but perhaps the most critical was the time factor. No one had ever tried to pack so much computational power into such a small (1 × 6 × 3 inch) box, let alone do it in the ten months allotted to bring the project from concept to working prototype. The approach taken was to design the machine from the outside in. HP laboratories specs called for a calculator that would fit into a man's shirt pocket and also have all trigonometric, logarithmic and exponential functions, even x to the y. It had to be battery-powered, and the speed of the longest function had to be less than one second. And, the final cost was critical.

The heart of a calculator of this nature is obviously the integrated circuits that serve as memories, contain data paths, and provide control, synchronization, timing and data manipulation. MOS/LSI technology was deemed the only feasible method of achieving the high packing density, low power and low cost required.

When the logic diagrams and partitioning had been completed, only about six months remained before working prototypes were due. It would have taken several months to build a hardware breadboard, which would probably still give incomplete answers on the feasibility of the MOS/LSI design (because of the 1-to-1 simulation of MOS circuits).

HP didn't have time to build a breadboard that might, in the end, not work properly. So the designers took the unusual step of designing the electronics with computer simulation. In the process, they saved three months, which amounted to one quarter of total development time.

The logic diagrams were converted to algebraic equations and then into computer simulation language (see



R	S	OUTPUT (t+1)
0	0	Q_t
0	1	1
1	0	0
1	1	0

diagrams). Each of the five MOS/LSI chips was built up piece by piece and checked out. Then each chip was checked with the others, and finally all were exercised with the simulated display and keyboard interface.

In the simulation, each algebraic gate was defined in general-purpose simulation languages, and they were debugged in that form. They were then put into cells which could be used in a larger expression. All of the registers were defined in this way, including all clock times. Although there was a million-to-one slowdown from real-time in this part of the simulation, it had the advantage of providing a precise computer printout of the condition of every flip-flop, every gate, every bit in a shift register, and every signal—and these could be called up at any selected time.

After the system was checked out, the designers tried a few simple algorithms, such as add or subtract. When these worked, the longer algorithms such as trig and exponential functions were tried using a higher level simulation language in order to come closer to real-time operation. Otherwise a trig function would take ten days to be processed. Thus, instead of specifying all the gates in the logic equations, only the through-put functions were specified. This became a type of macroprogramming, rather than microprogramming. Finally, the entire operation of the calculator was completely debugged with the higher level simulation language.

In a hardware simulation, special test apparatus would have had to be built in order to step and stop the program at any point. The computer printout did away with this and also with the necessity of having a scope probe at a specific point at a specific time. In order to watch what happened in the middle of a multiply with hardware, perhaps at the point where the fifth digit was multiplying, the probe would have to be at the right output at exactly that time.

The computer did this automatically. All that was necessary to make changes was to input new cards, rather than soldering in new parts. This factor gave a significant savings in time and an important increase in accuracy.

During the design of the actual chips with Mostek and AMI, Hewlett-Packard was able to save additional time. If any problems cropped up, new cards could easily be made and run through the simulation to provide rapid answers.

The most crucial test after chips were delivered came when the first prototype was assembled (see photo). With chips, display, keyboard, etc. all in place, the calculator worked the first time the switch was turned on . . . the difficult functions and all.

There still remained the normal amount of cleanup work associated with turning a prototype into a production machine, but computer simulation had proven its worth. □

For more information circle . . . 354

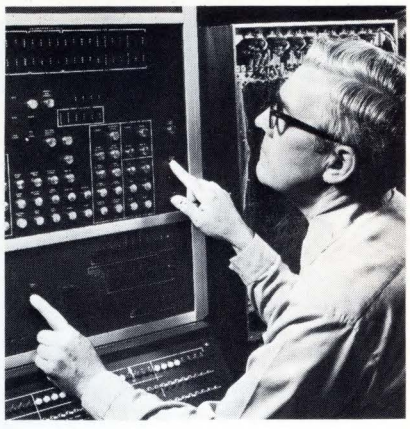
RCA continues in military and aerospace computer business

Although RCA has shut down its commercial computer manufacturing operations, it still remains in the computer business as evidenced by two recently announced computers.

Model R-100 is a real-time communications processor able to control 2500 voice and data circuits at the same time. It's main memory cycle time is one msec, it's ROM is 240 nsec and it can perform 220,000 operations per sec. Main memory consists of 16K bytes expandable to 262K bytes. Optional expansion goes up to 16 million bytes.

Model 195 is the first computer in RCA's new Series 200 line. It has a main memory cycle time of 1.5 msec, a ROM cycle time of 300 nsec, and performs 290,000 operations per sec. Main memory can accommodate up to one million bytes. Model 195 can be expanded to the soon-to-be-announced Model 215 multiprocessor configuration.

Model R-100's instruction format is compatible with Spectra 70 and IBM 360, and Model 195 is compatible with computers already in military and aerospace applications. ▭



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Free system design for do-it-yourself OEMS

United Telecontrol Electronics, Inc. (UTE), Asbury Park, N. J., is offering to provide free design and manufacturing drawings to OEM designers of minicomputers and intelligent terminals. The drawings are for UTE's MESA 900 memory system, a 4K by 18 expandable core memory system.

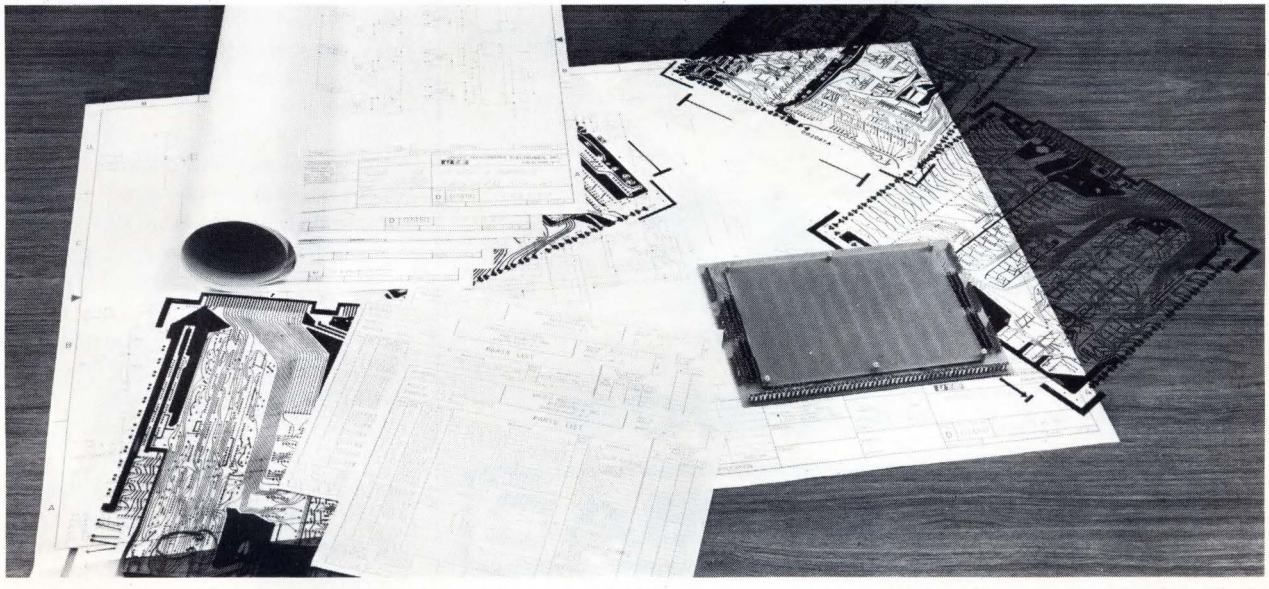
"The only requirement is that if they use the drawings, they have to buy the first 100 core stacks from UTE," says Warren Fee, UTE's general manager of memory products. "Of course they don't have to buy 100 stacks if they plan on building less than 100 systems, only the number of stacks they actually need," he adds.

The offer is aimed at companies that want to keep as much of the manufacturing work in-house as possible. With more of the fabrication kept in-house, these firms can realize a large share of the profits from their systems sales. The offer is particularly attractive to fledgling firms who need to husband their venture capital. Mature firms starting on new products can save $50,000 to $100,000 in designing and proving out their memory systems or in buying designs from memory consulting houses.

UTE makes both complete memory systems and the basic core stacks. The company decided that the standard memory system is only good for places like universities that buy only one or two memory systems. The larger business, according to Fee, is in custom systems or stacks. "We are trying to sell our expertise in memory stacks," says Fee.

If a company is building a large number of systems (typically more than 100, says Fee) it wants a customized memory to interface with the rest of its system. A standard memory will contain many components and circuits that are not needed by all its users. These components are required to make the memory as universal as possible.

For those customers who want the



Printed circuit board artwork, mechanical drawings and parts lists are representative of the memory system manufacturing aids available free to purchasers of United Telecontrol Electronics' memory stacks. Shown is the memory stack for UTE's MESSA 900.

memory system customized, UTE will provide design modifications and drawings at cost. Fee indicates the cost is usually under $10,000. A recent order cost $7500 for the modification while two others were quoted in the $2500 to $5000 range. Most of this cost is paying for drafting time for changing board size. No matter how it is redesigned, UTE uses the same core stack for each system.

The UTE MESA 900 memory system consists of a control board and one or more plug-in storage boards, each with 4K words by 18 bit capacity. Up to eight storage boards may be used with each control board, making a 32K by 18 system. The system has a 325 nsec access time and 900 nsec full cycle time. The unit quantity price for a 4K by 18 system is $1490. One of the companies taking advantage of UTE's free license estimates its cost at under .8 cents per bit for 500 systems in a 4K by 16 configuration. □

For more information circle ... 356

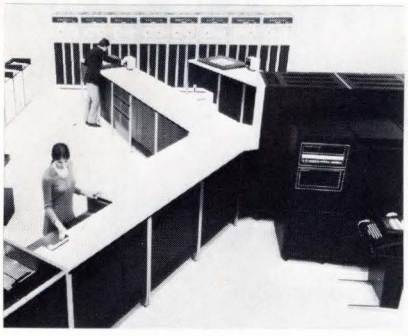
Communications featured in new computer family.

Recognizing the growing communications needs for computer systems, Honeywell Inc. has announced its new Series 2000 medium-scale computer systems, designed to operate in a heavy communications oriented environment.

Series 2000 is not just a set of hardware. It includes five different central processors, a communications processor, a data-base operating system and a control console. However, the key to the new series is the DATANET 2000 communications processor, which places all communications in the front end of the system, thus relieving the CPUs of such tasks.

Series 2000 is the outgrowth of a Honeywell-run study among its users. In the study, Honeywell found that by 1974 communications hardware costs are expected to be about 39% of total hardware costs.

This reflects an increase from 10% in 1964. On the other hand, CPU



hardware is expected to drop from 54% to 22% over the same period.

The Datanet 2000 data communications processor contains a minicomputer with 24K bytes of memory, an interface to the main computer, a network interface for one to 120 full-duplex communications lines, a control console, and real-time clock.

Stored programs poll and handle line speeds from 45.5 bits to 10,800 bits/sec, translate ANSI code to and from the 6-bit code of Series 200/2000 computers, queue messages in core or on the fixed-head disk file, handle main processor coupling, provide recovery and error handling, initialize the system, load the system and permit operator intervention.

The basic memory of the communications processor consists of 24K bytes and can be expanded in modules of 8K to 65K bytes. Effective cycle time is 385 nsec/byte.

The CPUs in Series 2000 are made up of four single-processor models and one dual-processor. They range from model 2040 on the low end which has a 49K-131K 6-bit character memory and a cycle time of 1.6 msec per character, up to model 2088 on the high end. Model 2088 is a dual-processor computer with a combined main memory of 524K-1M characters. Cycle time is 750 nsec for four characters per processor. The 2088 has a shared data file so that while one processor is performing real-time operations the other can perform batch processing of local jobs and also serve as a back-up for the real-time system.

Shown in the photo is the Y-configuration of model 2060. To the right is the Datanet 2000 communications processor and on the left is the visual information control console. □

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Combinations of established techniques result in new MOS RAM

When the advantages accrued with this new MOS RAM are utilized in building large memory systems, gains in cost/performance result.

D. C. Bapat and **D. Mrazek**, National Semiconductor Corp.

Unlike earlier advances in MOS memories, the improvements in this new 1K MOS random-access memory (RAM) do not stem from a new process. Instead, a new combination of operating techniques has solved system cost/performance problems. They include a three-state I/O structure at a common I/O bus terminal, precharge decoding, and true bi-polar-compatibility. Improvements realized on the system level are very low average power dissipation, simplified timing control, fewer and faster interfaces with the external system, reduced cooling requirements and elimination of high-level MOS supplies. Specifically, power dissipation is reduced by two-thirds, overhead circuits are cut in half, and overhead cost reduced by 200% with no attendant loss of speed.

Comparisons in a system environment will be made with another MOS RAM design having slightly faster access and cycle time at the individual device level in order to illustrate the results attained.

Storage cells are TTL compatible

The RAM's internal design (**Fig. 1**) is fairly standard except for its bipolar compatibility and I/O structure. There are 1024 storage cells in a 32 × 32 array accessed by a 10-bit address, which is X-Y decoded on the chip.

Bipolar compatibility means that all data and address inputs sense bipolar data levels and that data is read out at the original data levels. For example, a TTL "1" is stored as an MOS "0" but read out as a TTL "1". This eliminates need for external level translators at inputs, and sense amplifiers at outputs, all of which required as many as 51 interface circuits in a typical memory module. In addition, two standard supplies (+5 and −12V) are used instead of the three original high-level supplies.

The cells are dynamic, meaning that stored charges leak from the storage transistors and must be refreshed periodically. For this design, each cell is refreshed every 2 msec. Since accesses are made every 600 nsec (which also re-

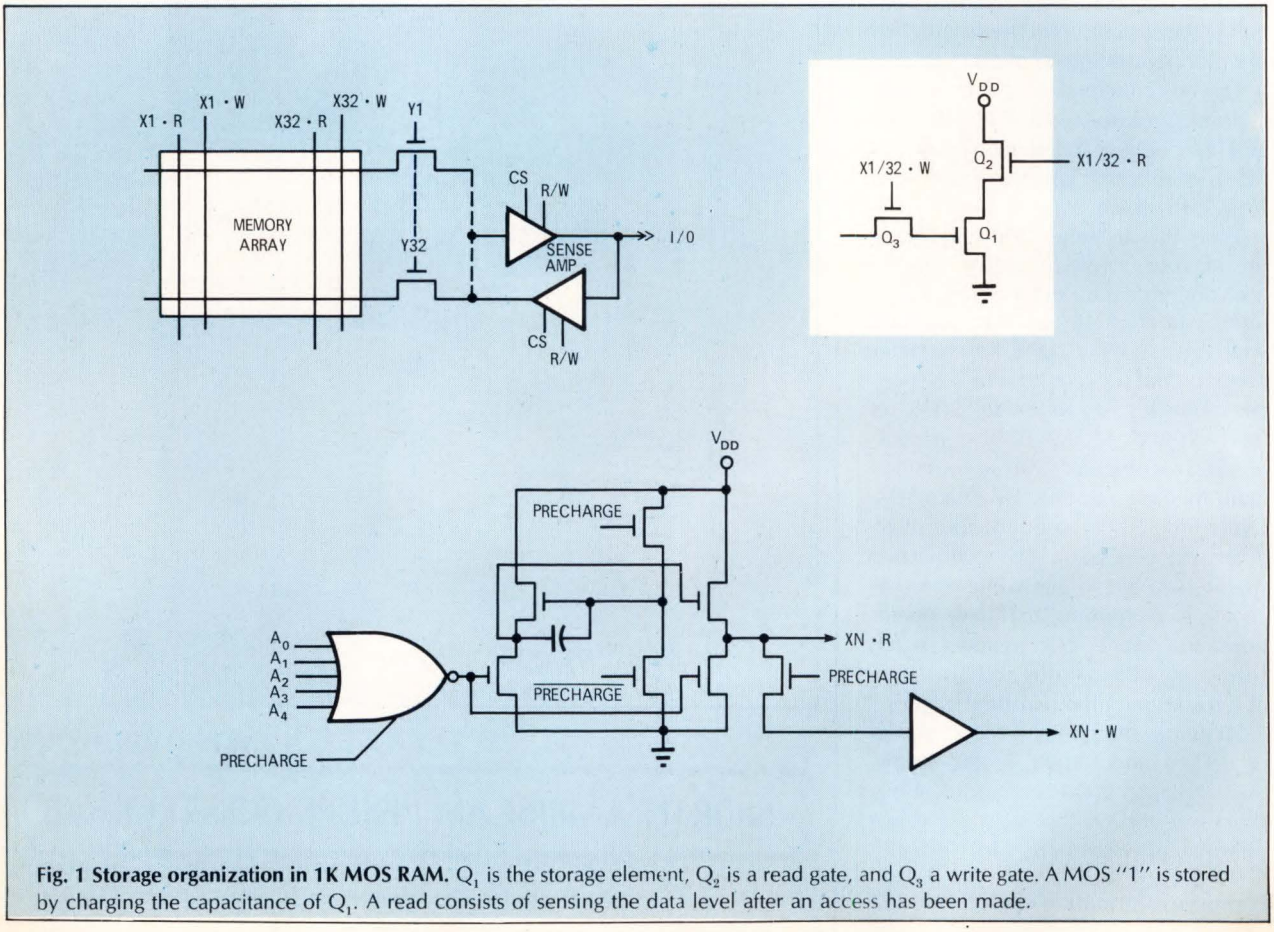


Fig. 1 Storage organization in 1K MOS RAM. Q_1 is the storage element, Q_2 is a read gate, and Q_3 a write gate. A MOS "1" is stored by charging the capacitance of Q_1. A read consists of sensing the data level after an access has been made.

freshes all other cells in a column), refresh overhead is less than 1%, and does not significantly affect system efficiency. Refresh signals are always given precedence over addresses in the system control logic.

Tri-State outputs allow common busses

The I/O structure in **Fig. 1** allows a common I/O terminal on the final RAM. This is made possible by using Tri-State MOS for the I/O gating and sensing elements. (Tri-State is a trademark of National Semiconductor Corp.)

As the name implies, each element has three operating states. Two are the bipolar-compatible "1" and "0" states. The third is a high-impedance state that effectively disables that element. In this third state, only a small leakage current flows and it has no definable logic level.

A feature such as this gives several advantages. For example, the third state prevents data transfer, allows one element to look into the other, and permits outputs of several packages to be bus-connected with no significant change in memory cycle time. One pin can be used for I/O because the read element is in the third state when write is enabled, and vice-versa. Read speed when these outputs are bus-connected is high because the disabled elements on the bus present a very light load to the enabled output.

Without this third state, a conventional MOS input could not share a common terminal with an output, and separate data-in and data-out terminals would be required. Although several outputs may be bus-connected (wire-OR'ed), it multiplies their capacitive loading, causing a proportional increase in output transition times. As a result, system cycle times must be increased. In order to gain maximum speed, each conventional MOS output should look directly into a low-level sense amplifier.

Precharge decoding minimizes power dissipation

During standby, each MOS RAM circuit will dissipate about 75mW. To achieve memory access, a more powerful clock pulse, called the "precharge," is applied to set up the decoders and other I/O functions. The use of precharge minimizes system power dissipation by making it unneces-

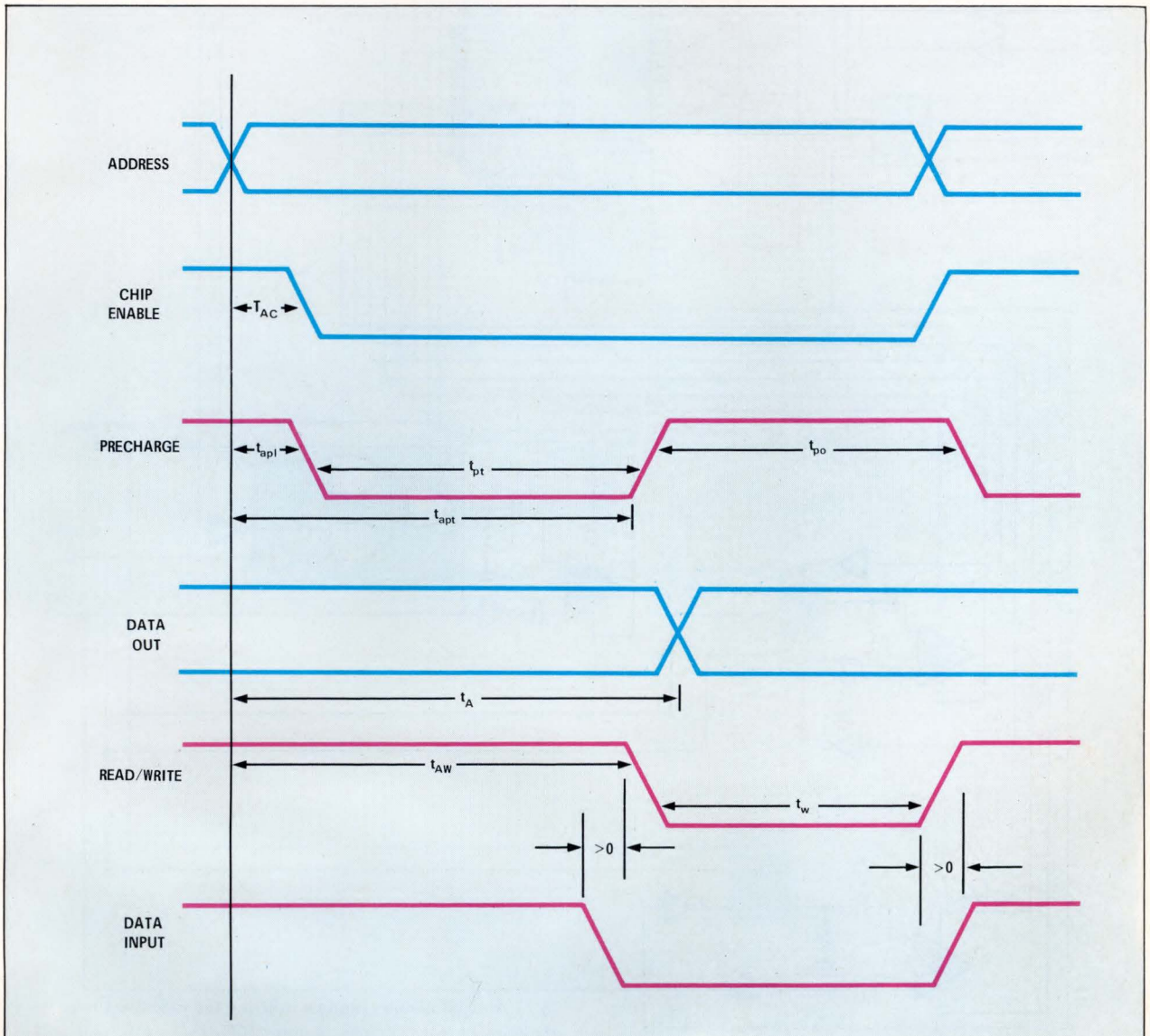


Fig. 2 Timing diagram for the 1K RAM shows how "precharge decoding" is applied.

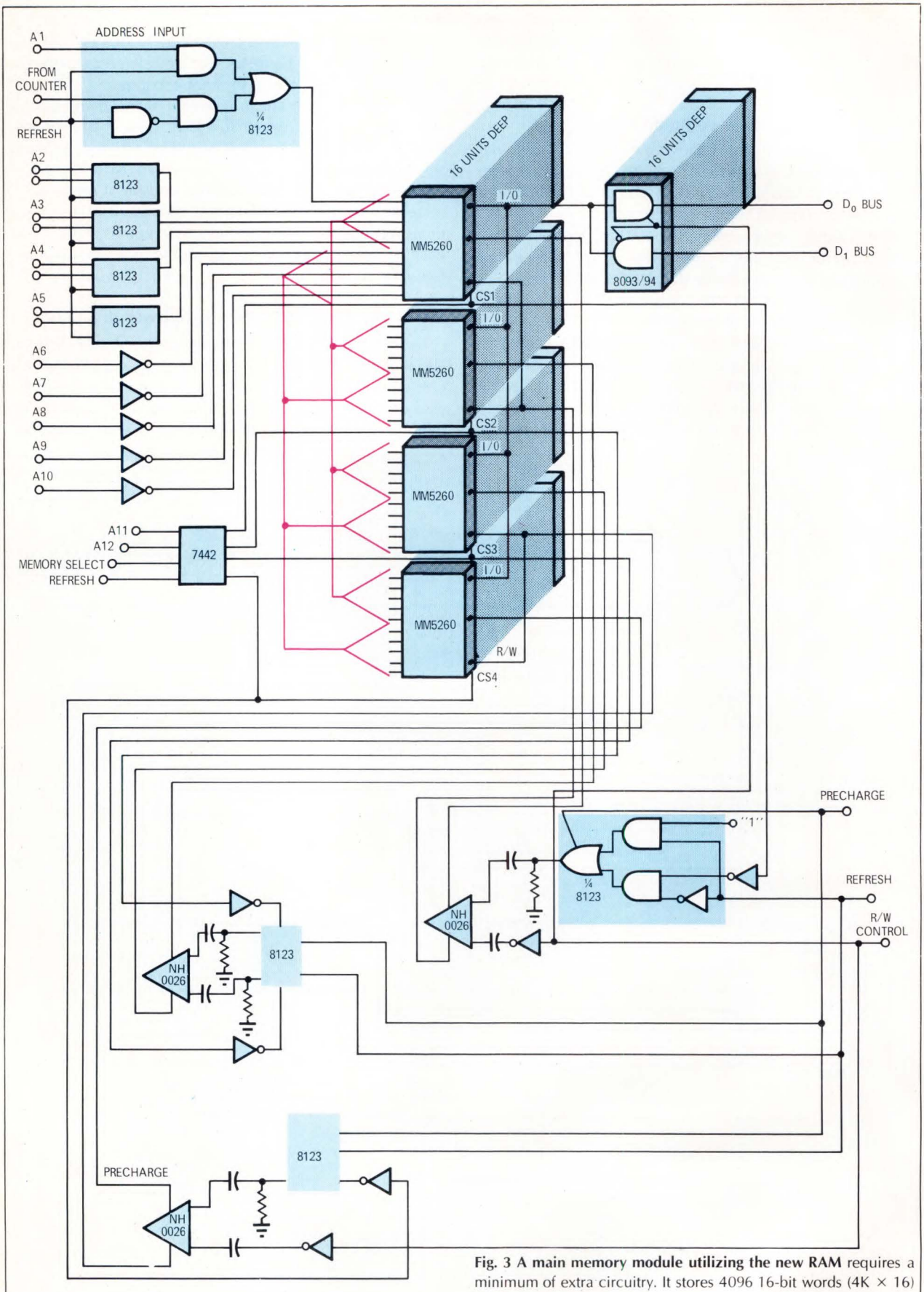


Fig. 3 A main memory module utilizing the new RAM requires a minimum of extra circuitry. It stores 4096 16-bit words (4K × 16) in four 1K × 16 submodules. One submodule is selected at a time by two bits of the DM7442 TTL decoder address. The same decoder could access eight submodules with a 3-bit address.

sary to energize decoding logic in between selects. During a 600 nsec access, the RAM's power dissipation will increase up to 400 mW.

It is important to keep as many of the RAM circuits on standby as possible in order to minimize average power dissipation. If excessive dissipation occurs in a high-density system without adequate cooling, it would overheat the semiconductor junctions and cause device failure. The only way of preventing overheating, should the average dissipation be high, is to reduce speed and subsequently lower performance, reduce packing density, or increase system cooling hardware. All of these options are unfavorable for optimum system design. Average power supply and clock-driving requirements are also reduced by use of either precharge modulation or by reducing the precharge pulse rate.

Fig. 2 and 4 illustrate the most effective way yet developed to decrease precharge power dissipation. It is called "precharge decoding", which means applying precharge to a submodule, only when that module is selected. This can be implemented by having the chip-enable output of the decoder gate the precharge clock by way of the Tri-State TTL data selectors in the clock circuitry. Thus, this simultaneously controls the I/O directions.

Memory timing is simplified

Timing control is quite simple because of the precharge decoding technique and arrangement of the I/O structure. As indicated in **Fig. 2**, maximum cycle time is 600 nsec. A delay of 100 nsec (t_{apl}) is allowed before precharge for address settling and decoder operation. Precharge goes low for 250 nsec (t_{pl}) to set up the decoders, and then it returns to conserve power.

If read is commanded, the read gates are enabled and the write gates disabled at the outputs. Stored data is available at the output within 400 nsec (t_A) of the start of the access. Write may be commanded just prior to the precharge transition and is completed by the end of the 600 nsec cycle.

A skew of about 50 nsec between address timing by the CPU and leading and trailing edges of chip-select and precharge will not affect access time, cycle time, or memory speed. Thus, the RAMs timing is not critical.

A practical implementation

The advantages of the new 1K MOS RAM can be seen when it is used to construct a memory system like the one in **Fig. 3**. The external data selectors (DM8123) and read/write bus buffers (DM8092 and DM8094) are Tri-State TTL devices. These have high-speed, active-pullup outputs when enabled. The two types of buffers operate in parallel with the internal MOS read/write gates. One control line gates both gates in complementary fashion, since one is enabled by a "0" and the other by a "1". The data selectors hold off accesses during a submodule's refresh intervals. The TTL clock-forming and timing control circuit for the module is illustrated in **Fig. 4**.

Having 10 address inputs, the MM5260 is effectively a memory of 1024 1-bit words. Lengthening the bits per word merely requires parallel access of several devices, such as nine for 1024 9-bit words. A chip-select input, enabled by decoding additional address bits, allows expansion of word capacity.

How does the new memory stack up?

For evaluation purposes, the new MOS RAM, designated MM5260, will be compared with National Semiconductor's original type 1103 MOS RAM, which is the closest of previous MOS RAM designs to the MM5260 in performance and organization. It is also a 1024-bit device with chip-select and on-chip decoding of 10-bit word addresses. The package has two additional pins, one for the extra power supply and one because data outputs and inputs must be separate.

One significant difference is in the power requirements. Not only does the 1103 use two high-level supplies, but also the 1103 module dissipates about three times as much power as the MM5260 module. Total dissipation in the MOS RAMs and by the circuitry outside the 1103 is around 30 watts; while that of the MM5260 module is about 10 watts. As a benchmark, core memories with the same capacity dissipate about 25 watts.

Power dissipation factors to consider are standby power—the same 75 mW for both devices, precharge dissipation, and external dissipation.

A quick calculation shows that the new RAM has precharge dissipation in only 16 out of 64 devices as a result of clock decoding. Counting the standby dissipation in the other 48 devices, total internal dissipation is about 10 watts. Dissipation in the logic devices won't be counted since it is not large in either module, and is approximately equal in both.

Precharge dissipation in the 1103 is 300 mW—100 mW less than the new design. However, precharge is used in the 1103 to reduce access time as well as average dissipation, which compromises precharge power savings. Using precharge to save time precludes precharge decoding. In the 1103 precharge sets up the decoders to receive the addresses; therefore, it must be applied to all 64 RAM circuits since the chip-enable portion of the address is not decoded until after precharge begins. After chip-enable decoding, precharge may be turned off at the unselected submodules. By then, these 49 circuits will have been precharged for some 100 nsec, thereby consuming an extra 6 watts. A total of about 14 watts is dissipated in precharge, and standby power in the 1103 module is about 30% higher than in the new RAM.

The extra amplifying devices account for the remainder of the increase. Address, chip-enable and data inputs must be pulled up to +20V, and these level translators must drive heavy capacitive loads. For example, each address input capacitance is 7 pF, a total of 450 pF for 64 in parallel. To avoid making input delays very long, high-power transistor drivers must be used. In addition, the low-level outputs must be detected with sense amplifiers to drive the processor logic. And lastly, losses in the high-level power supplies increase dissipation elsewhere in the system.

There are some tradeoffs with regard to access and cycle times. The 1103's access time is 300 nsec if the precharge time is anticipated. If address and precharge occur together, access time is 390 nsec.

Good bipolar drivers at the inputs, say a monolithic translator like the NH0027, will hold input delays to 40 to 60 nsec. However, these add to memory system cost. A low-cost alternative, namely open-collector TTL devices with passive pullup, would stretch input delay to about 225 nsec (due to the RC time constant of a 450 pF load

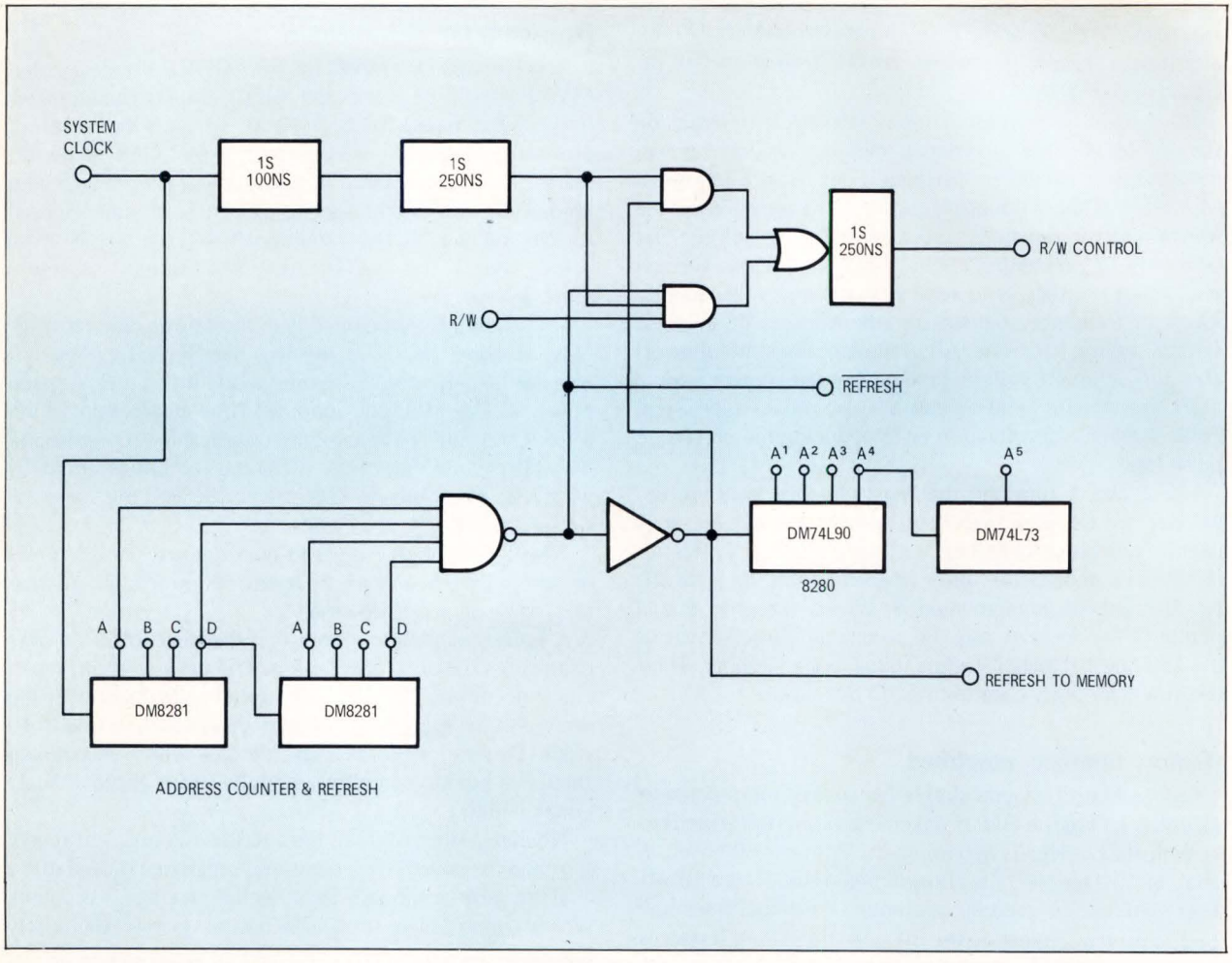


Fig. 4 Memory system clock timing and control circuitry needed to implement read/write precharge and pulse generation.

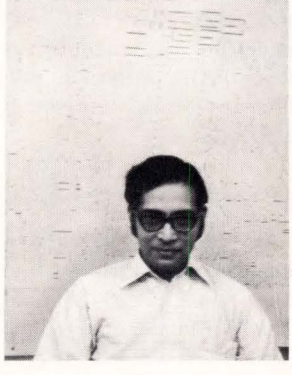
and 500 ohm pullup resistor). Unfortunately the passive pullup devices would about double power dissipation. Delays in the sense amplifiers are 30 to 40 nsec. Good sense amplifiers are essential because of the short read time and because the MOS outputs are wire- OR'ed for practical reasons. But this also delays output transitions.

In sum, a minimum increase of 70 nsec in 1103 access or cycle times offsets the extra propagation delays (50 nsec) in the MM5260 which result from the delay in the Tri-State sense amplifier on the MOS chip. This is a worthwhile tradeoff to achieve the benefits already cited for the new I/O technique. Furthermore, the Tri-State TTL bus buffers will drive long buses at high speed with high noise immunity, so the common I/O bus can extend well into the system structure.

Savings in system costs are accounted for by elimination of 17 interface and control circuits, 8 dual sense amplifiers, 14 resistors, 1 power supply, and the need for a high-level supply. Proportional savings can also be added for printed circuit board costs, cooling hardware, assembly, component test and inventory control.

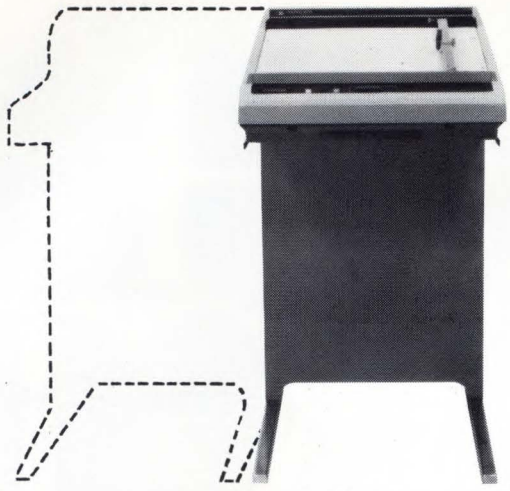
Effective packing density is high, since the new RAM has two fewer package pins (common I/O and one less supply) and less stringent cooling requirements. More RAM circuits can be packed into the same volume, or more can be used on bigger boards if system designers want to increase word length or module word capacity. □

Author's Biography



Dilip Bapat has been a design engineer at National Semiconductor Corp. for 2-1/2 years. His main responsibility is designing MOS ROMs and RAMs. Prior to this he was employed at Signetics Corp. Bapat received his MSEE from Stanford University.

Dale Mrazek, manager of digital systems applications for National Semiconductor Corp., is the originator of the "Tri-State" concept for which there is a patent application pending. Mrazek has been with National Semiconductor for 3 years, has been granted two patents with two more pending, and holds a BSEE from Denver University.



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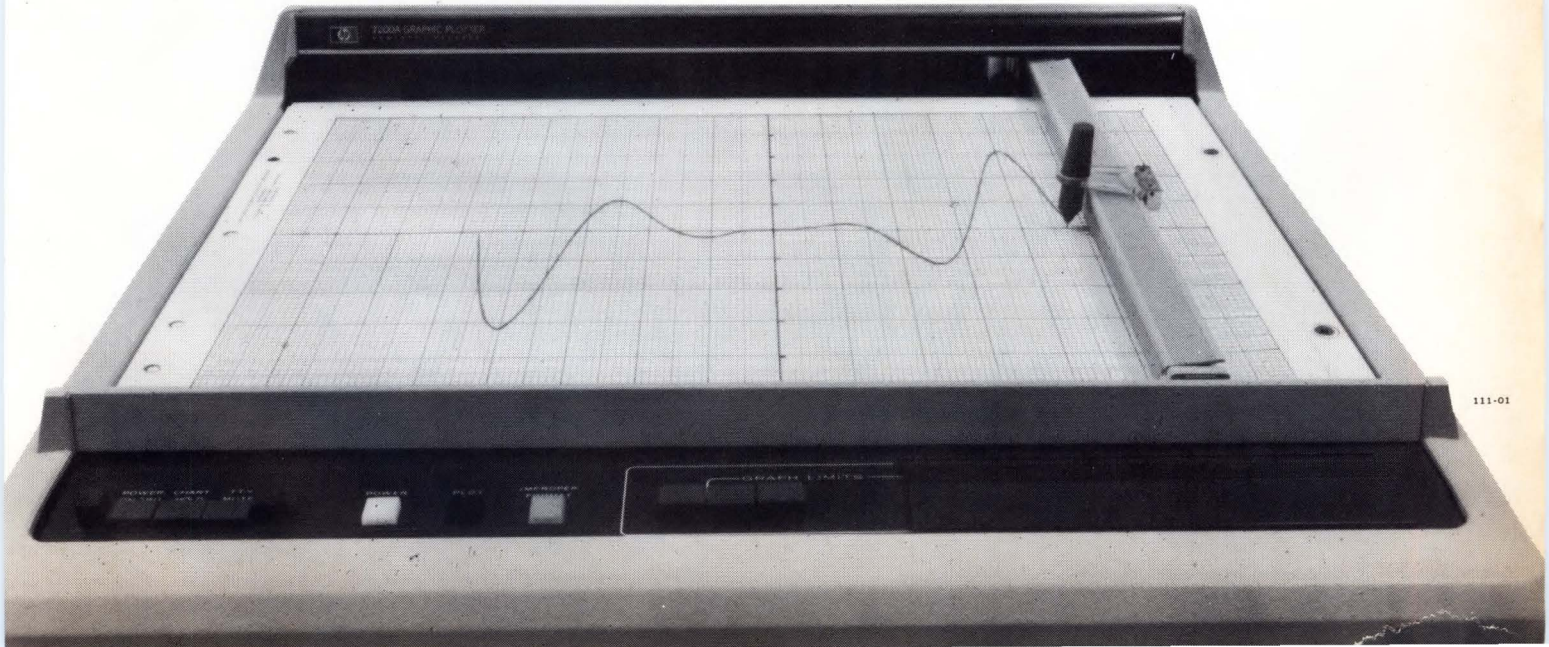

111-01

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CIRCLE NO. 407

Build a keyboard code converter with off-the-shelf parts

One approach is to use a custom ROM. Here is an easier and faster way that uses a standard converter with external logic to generate the missing codes.

Herman E. Sheffield Jr., Data Technology, Inc.

Standard IC read-only memory code converters often come close to meeting user requirements except for a limited number of special functions. For example, an off-the-shelf converter is almost certain to meet 95% of the requirements for EBCDIC to ASCII conversion because the upper case letters, numbers and the commonly used special symbols ($,#,etc) have standard EBCDIC codes and standard ASCII codes. They are converted from the one standard code to the other and all conversions are unique. That is, a given EBCDIC code generates a given ASCII code, and no other EBCDIC code will generate that same ASCII code.

However some of the following problems could crop up with certain symbols and control functions:

- Some ASCII control and character codes do not have EBCDIC equivalents. The symbol [is one such code. With most off-the-shelf EBCDIC to ASCII code converters, there is no way to generate an ASCII [.
- Some EBCDIC control and character codes do not have ASCII equivalents. ¢ is one such character.
- The EBCDIC set is not completely standard in the allocation of control codes. For example, the EBCDIC sets used by IBM and SDS are different in the assignment of some control codes.
- Off-the-shelf converters commonly convert more than one input to the same output. For example, an ASCII to EBCDIC converter may output the EBCDIC code for (space when an ASCII coded [or (or { is called for.

One or more of the above may be a problem depending on the particular application. In the system shown in **Fig. 1**, displays are constructed on the CRT and stored in the computer for future use. This system can be implemented with off-the-shelf converters, but some of the ASCII characters won't be converted properly. If the CRT uses only the upper case character set, there will be problems with ASCII characters [/] and maybe ~. One of three things can be done to correct this: don't use these characters, add logic to cause the proper conversion of the codes, or order specially designed (custom) code converters.

The first alternative may be possible, depending on the application. However, if the CRT uses some of these characters for control functions, there would be a problem if these characters were eliminated. There are also disadvantages in using the third alternative, such as: cost of an IC masking charge, long delivery times, and possible mistakes in specifying the mask, as well as expenditures of engineering time in specifying and testing the special converters. Thus, the second alternative is the most practical and is discussed in more detail.

What needs to be done?

Implementation depends on the exact application. The method described however, will be general and work for many applications. The system in **Fig. 1** could be designed

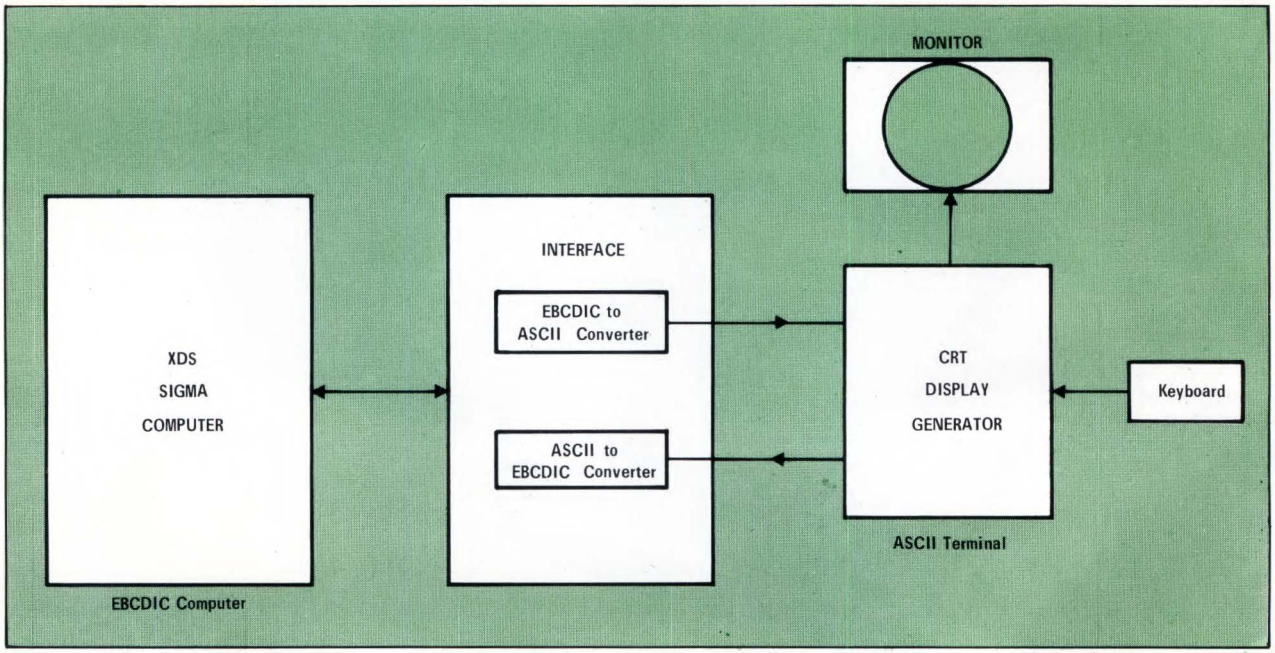


Fig. 1. Computer system requiring conversion from one code to another is shown here in block form. In this case it is EBCDIC to

Table 1. Code assignments for brute force conversion approach.

ASCII TO EBCDIC					EBCDIC TO ASCII				
Convert			To		Convert		To		
Symbol	Hex	Binary	Hex	Binary	Hex	Binary	Hex	Binary	Symbol
[	5B	1011011	BB	10111011	BB	10111011	5B	1011011	[
\	5C	1011100	BC	10111100	BC	10111100	5C	1011100	\
]	5D	1011101	BD	10111101	BD	10111101	5D	1011101	]
∩	5E	1011110	BE	10111110	BE	10111110	5E	1011110	∩

in the following manner;

- Assign some unused EBCDIC codes to the problem ASCII codes
- Add logic to cause problem ASCII codes to convert to one of these EBCDIC codes
- Add logic to cause these same EBCDIC codes to be reconverted back to the proper ASCII codes.

If the system in **Fig. 1** is to be designed to properly handle the ASCII code [\], logic must be added to cause the ASCII to EBCDIC circuit to output an unused EBCDIC code whenever the ASCII codes for [\] are inputed. Logic would also have to be added to cause the EBCDIC to ASCII circuit to output the ASCII code for [\] when the assigned EBCDIC code is inputed. **Table 1** shows how codes for these operations might be assigned. It shows several facets of the problem including: (1) that ASCII is a 7-bit code while EBCDIC is an 8-bit code and (2) that the codes may be conveniently represented by hexadecimal (base 16) notation.

How to do it

A brute force approach, shown in **Fig. 2**, requires considerable logic. Needed with the unmodified code converter are level conversion circuitry on its input and output if the ROM is an MOS circuit, and additional logic represented by the "special code detect", the "special output code gen" and the output "multiplexer." The use of some finesse, however, including the judicious selection of the EBCDIC codes to be used, will allow a logic implementation with only a few gates.

In the worst case, the "special code detect" could require detection of each special code, and then the generation of an output for the special codes in order to switch the multiplexer to the "special output code gen" input. Since the "special output code gen" could require generation of an output for each of the special codes, the multiplexer might have to be an 8-bit × 2 multiplexer.

An easier way

The same functions shown in **Fig. 2** can be performed in a simplified manner as shown in **Fig. 3**. When a special code is detected, the converter *input* is modified so that the converter generates an output close to the desired one (only one bit different if possible). Then the converter output is changed only as required to give the actual desired code. **Fig. 3** shows the actual logic required to solve the previously discussed problem of providing for the ASCII codes [\] for EBCDIC to ASCII conversion. The exclusive ORs are available at 4 per 14-pin chip. Thus, the entire modification is implemented with one full exclusive-OR chip, two additional gates and one inverter. **Table 2** gives the codes at points A B C & D in **Fig. 3**.

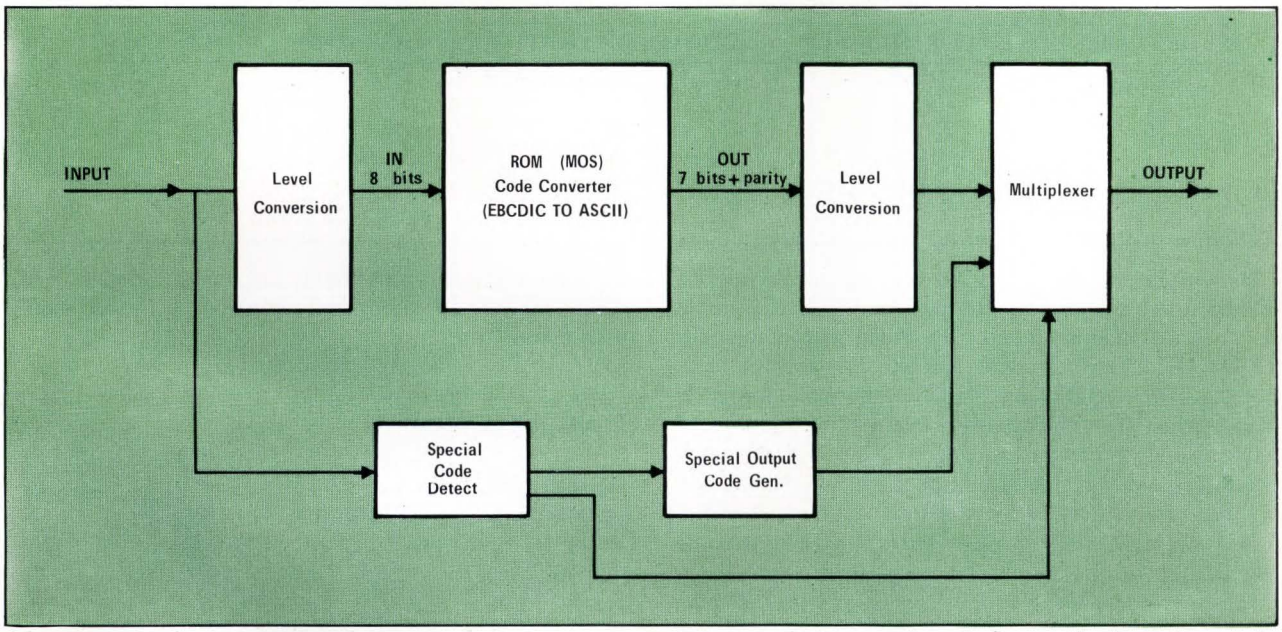


Fig. 2. Brute force method of code conversion is as follows: When one of the special EBCDIC codes from Table 1 (BB, BC, BD, BE) appears at the input, the "special code detect" block generates the appropriate output to the "special output code gen" telling it which of the special codes is present. In addition, a line to the "mux" causes it to switch to the "special output code gen." The "special output code gen" generates the required code, and the proper ASCII code would then appear on the output.

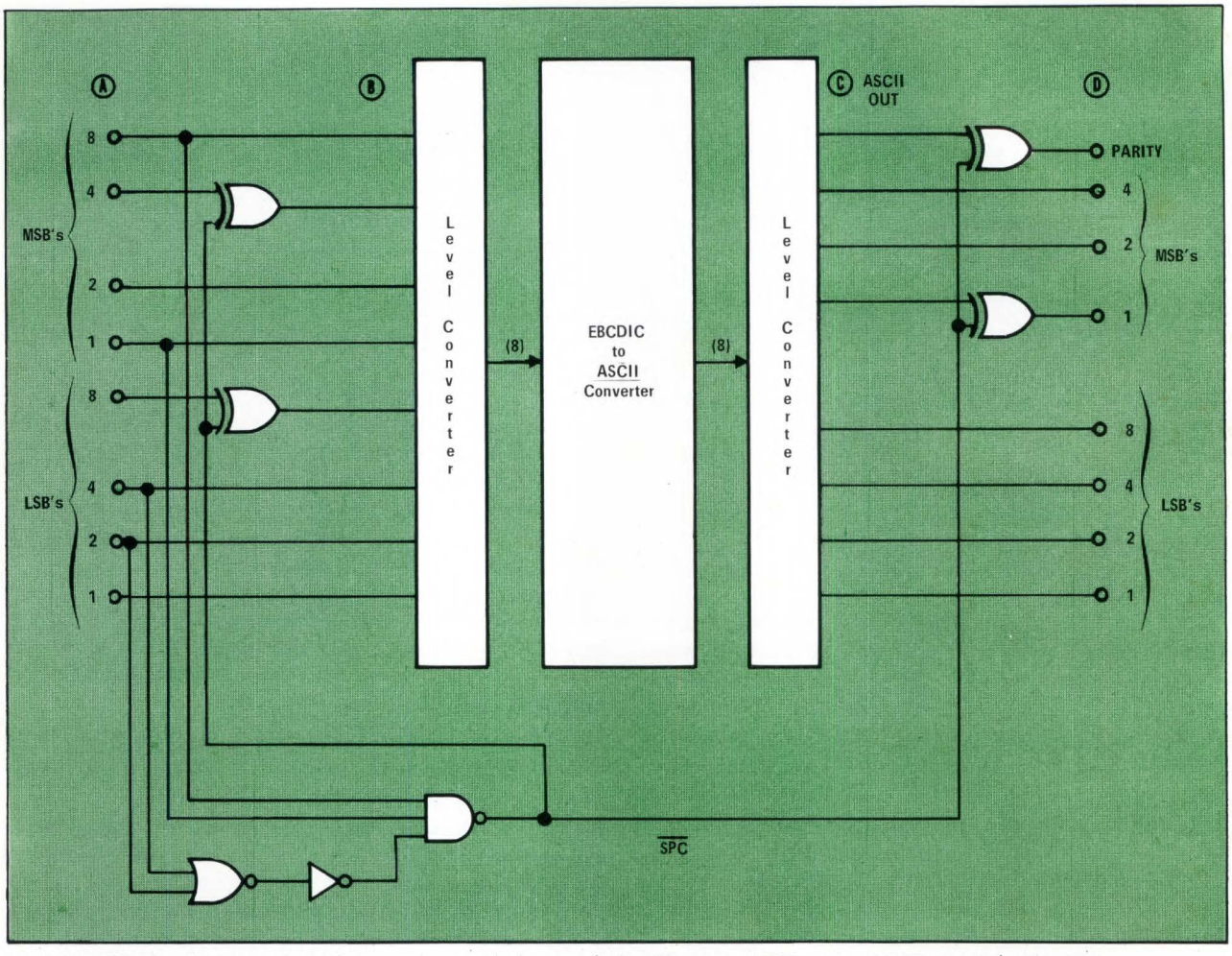


Fig. 3. Simplified code conversion scheme requires only four exclusive OR gates, a NOR gate, a NAND gate and an inverter.

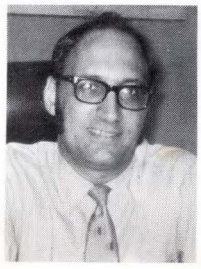
TABLE 2

A	B	C	D	
EBCDIC CODE	CONVERTER INPUT	CONVERTER OUTPUT	ASCII CODE	ASCII SYMBOL
9A	D2	4B	5B	[
9B	D3	4C	5C	\
9C	D4	4D	5D	]
9D	D5	4E	5E	∩

The unused EBCDIC codes are selected as 9A, 9B, 9C, 9D. These are selected by trial and error to give a simple logic implementation and are changed at point B to codes D2, D3, D4, D5, which are the EBCDIC codes for K,L,M,N. Only 2 exclusive-ORs are required to make the code changes since in each case, the same two bits must be inverted. The code converter changes EBCDIC K,L,M, and N to ASCII K,L,M,N which are, respectively, 4B,4C,4D, and 4E. Then one bit must be inverted to give the required outputs at point D. Since the converters normally generate ASCII parity, the output parity bit must also be inverted.

Thus, whenever $\overline{SPC}$ goes low, indicating a special code, the exclusive-ORs cause the two input and the two output bits to be inverted. $\overline{SPC}$ is the decode of an unused area of the EBCDIC code map, which includes 9A, 9B, 9C, and 9D. Since there are 256 possible EBCDIC codes, about half of which are normally used, there are plenty of available unused codes. □

Author's Biography



Herman E. Sheffield, Jr. is president of Data Technology, Inc., Houston, Texas. He received his BSEE and MSEE from the University of Houston and is a member of IEEE, SEG, SID, and NSPE. Mr. Sheffield has had one patent granted, three pending and is a registered professional engineer.

FOR A FREE COPY OF THIS ARTICLE, **CIRCLE RS 479**

High-voltage monolithic technology Permits 200V gas display drivers

Up until now it has been thought impractical to extend monolithic IC technology over 100V because it has been impossible to form junctions with breakdowns much higher than this. Now, however, Dionics, a small company in Westbury, L.I., N.Y., has developed a process for forming junctions of both polarities in monolithic structures that have breakdowns as high as 600V.

The first application Dionics has tackled with its new process is a pair of complementary 200V drivers for gas discharge displays, such as those made by Burroughs and Sperry. The NPN and PNP versions are mirror-images of each other. They incorporate dielectric isolation, as the transistors must be separated from each other when running at these high voltages.

The Dionics drivers provide seven current sources suitable for uniformly lighting the seven segments or cells of the gas-discharge readouts. Each source has its own control switch that can be driven by TTL or MOS logic-level signals.

The $3.00 price (100K level) that Dionics has put on these devices should make them competitive with present discrete component drive circuits, according to Burroughs display-system circuit designer, William Harmon.

One resistor programs currents

The seven current sources are all programmed by one external resistor, R_1 in **Fig. 1**. How this is done is shown in the insert at the left of **Fig. 1**.

Transistor Q_1 is connected with its base to its collector so that it is always turned on and operating in its active region. Therefore, by far the greatest part of the supply voltage is dropped across R_1 and the current through R_1 is essentially equal to V_{sup}/R_1.

Most of the current in the Q_1 leg will flow through Q_1's collector. Q_1's base will only take a small part of the current because all these transistors have gains of 100 or so. What is significant is that the base of Q_2 will also "accept" the same amount of base drive as Q_1 and will therefore try to set up the same current flow out of its collector. Q_2 will imitate Q_1 in this manner, because Q_2 is identical in construction to Q_1 and has the same emitter-base bias conditions.

Returning to the main circuit diagram in **Fig. 1**, it can be seen that all the seven current sources, Q_2 to Q_8, will try to imitate the current flow of Q_1. In EDN/EEE's experiments with some of the early devices from Dionics, we were impressed with how faithful this imitation would be despite rather wide variations in the individual loads in the collectors of the current sources. We found that we could vary the collector loads over a range from dead short to 1MΩ and yet they would hold within a percent or so of the current commanded by the choice of R_1, at least for our room-temperature tests.

Fig. 2 explains the constant-current behavior in terms of various load lines plotted against the I-V characteristics of one of the current-source transistors. The programming results in a fixed base drive, such as the 5 μA for 0.5 mA shown.

The slope of the load resistor determines the operating point.

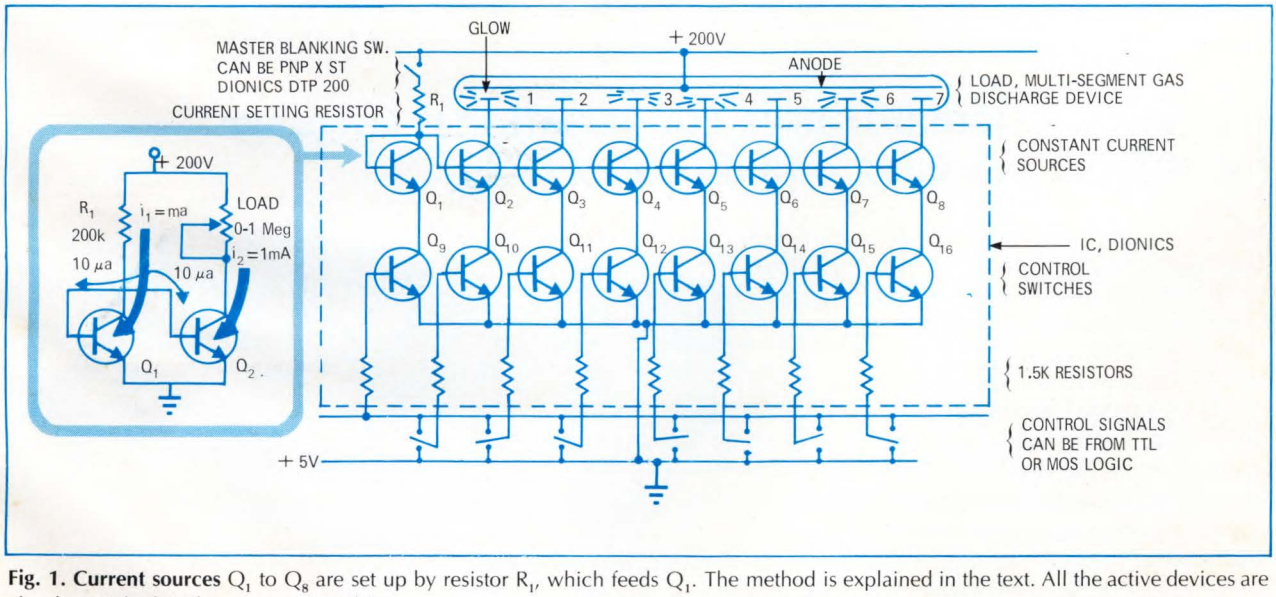


Fig. 1. Current sources Q_1 to Q_8 are set up by resistor R_1, which feeds Q_1. The method is explained in the text. All the active devices are closely matched as they are on one chip.

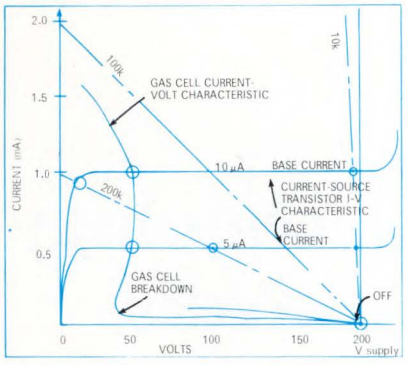


Fig. 2. The load lines for nonlinear gas-discharge cells are ideal for the current sources, as they intersect the current-source base drives at right angles. But the devices will also work with linear loads, as long as they fall within the allowed 200 mW power dissipation and useful gain regions of the source transistors.

Note that it is the flatness of the constant base-drive curves in this region that allows the source transistor to hold the output current constant despite the variations in load.

For 1 mA currents, or less, the outputs can be safely shorted, for each will absorb 200 mW dissipation, and the whole unit will absorb the seven times this value, or 1.4 W, if all the sources are on and shorted at the same time, according to Dionics.

The bottom row of switches Q_{10}-Q_{16} provide the means for turning the current sources on and off. They also have to be matched in characteristics to prevent upsetting the balances achieved along the top row. Dionics adds a dummy switch, Q_9, in the current-programming leg of Q_1 to make this balance consistent all the way across the device. These switches can be driven by TTL or MOS logic.

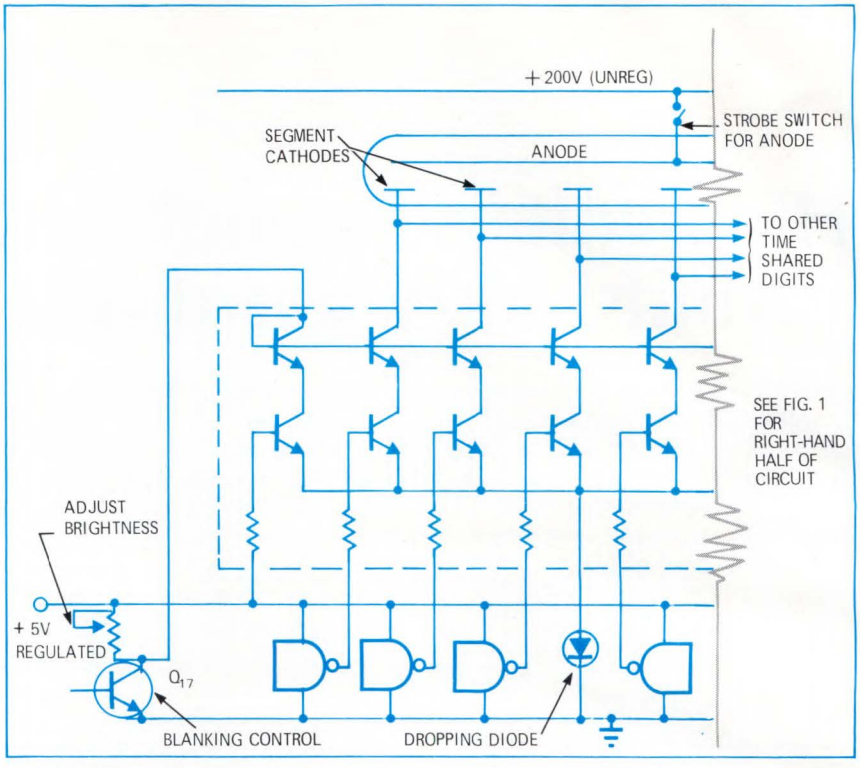


Fig. 3. Practical arrangement for driving gas-discharge displays with the high-voltage IC is as shown. The current-programming resistor, R_1, is tied to the logic supply, which is easily regulated, and it is made variable so that the brightness for all seven segments can be adjusted simultaneously. Strobbing to turn individual numerals on when many are time shared, as shown, can be either by the anode switch or by the Q_{17} blanking control.

Application circuit for driver

A practical approach to driving a seven-segment numeric display like the Sperry line is shown in **Fig. 3**. The current sources are driving the cathodes that define the segments, while the anodes are connected to an unregulated 200V supply.

The PNP version of the driver has been successfully applied to Burroughs' fully alpha-numeric dot-matrix "Self-Scan" panel. Here it can replace 8 discrete transistors and 14 discrete resistors. Neither of these drivers is, however, capable of driving the large Owens-Corning XY-addressed "flat CRT."

Dionics, Inc., 65 Rushmore St.,
Westbury, L.I., N.Y. 11590
Phone (516) 997-7474

389

Algebraic calculator uses conversational language for solving complex equations

How would you like to enter your design equations directly into a calculator, in the same form that you would write them on paper, and then with a single keystroke execute that equation? You can with the Hewlett-Packard Model 9820A desktop calculator.

The unit uses a natural algebraic language for problems from simple arithmetic to complex equations. No artificial machine rules, procedures or languages are required.

The Model 9820A comes with 173

A 16-character, alphanumeric LED display is featured on the 9820A calculator.

registers, and can be expanded to 429 registers internally. As an example of its computing power, the basic unit can solve 17 simultaneous linear equations. Fully expanded, the calculator solves as many as 36 simultaneous equations with 36 unknowns. It easily handles equations with unlimited nested parentheses and performs implied multiplication (the multiplication sign need not be used).

Three banks of keys on the Model 9820A keyboard are associated with plug-in function blocks. Up to three-read-only-memory (ROM) plug-in blocks may be used simultaneously for maximum flexibility. Plug-ins now available include: mathematics, user definable and peripheral control. Mathematics includes common trig and log functions; user definable enables the user to "personalize" from 5 to 25 keys for his unique programs; and peripheral control is used to interface certain of the peripherals.

Full editing capability includes deleting, changing or inserting characters, lines or statements.

Complete alphanumeric display and printout is included in the basic Model 9820A. A thermal printer provides a hard copy output.

A 16-character, solid-state, LED alphanumeric display shows the expression keyed into the machine, and the computation results. Line length is not limited to 16 characters, however. Overflow characters simply move off to the left and can be recalled.

Programs and data can be entered into the calculator with magnetic cards or from the keyboard. I/O slots on the rear panel of the calculator accommodate peripherals, including a plotter, marked-card reader, typewriter, digitizer, paper-tape reader, tape-cassette unit, and others to be introduced later. All peripherals can be used simultaneously.

Price of the basic Model 9820A with 173 registers, built-in thermal printer and magnetic-card reader is $5475. Option 001 adds 256 registers for a total of 429 registers, at $1450 additional.

The Model 11221A Mathematics Function block is $485; Model 11220A Peripheral Control I block is $485; and Model 1122A User Definable Functions block is $485. Delivery is from stock.

Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, CA 94304. Phone (415) 493-1501. **390**

Active filters come in custom varieties with almost off-the-shelf delivery

Custom active filters are now available with delivery times that rival those of off-the-shelf units. Pricing, too, has become much more attractive. The key to these advances is modularization and prefabrication.

By reducing active filters to two-pole modules and stocking PC boards for commonly-used circuits, De Coursey Engineering Laboratory, Culver City, Calif. is able to assemble the modules in a short time.

Standard computerized design programs for each filter type speed up design and assembly. Orders of 25 units can be completed in less than three weeks.

Prices range from $18.50 for 3-pole Butterworth or Chebyshev low or highpass filters, to $92.50 for 8-pole filters, in single quantity. Bandpass filters are twice the price.

Kinetics Technology Inc. of Santa Clara, Calif. calls their standard active-filter modules "Universal active filters." They consist of a single-pole-pair per module which can be used singly or combined by the user.

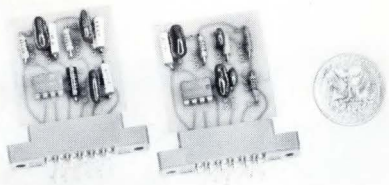
Three new standard units have just been introduced. They are the FS-30, which operates up to 100 kHz and carries a price tag of $52.00, and two low-cost units, the FS-50 and FD-200. The FS-50 is a lower-performance version of the Universal line with a price of $26.00 in single quantity. The FD-200 is a dual, active filter using only one op amp per pole pair. Minimum order for the FD-200 is 100 units at a price of $19.00 ea.

Burr-Brown Research Corp., in Phoenix, Arizona, a long time supplier of active circuits, stocks units which are about 85% complete. Upon receipt of performance requirements, a computer run determines component values, and the filters are then completed. Delivery time is less than 2 weeks, and a broad choice of active filters is available; Chebyshev, Butterworth or Bessel. Prices begin at $25.00 each in small quantities.

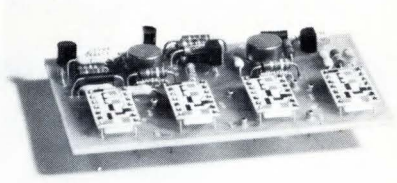
De Coursey Engineering Lab
11828 West Jefferson Blvd.
Culver City, Calif. 90230
Phone (213) 397-9668. **391**

Kinetic Technology, Inc.
3393 De La Cruz Blvd.
Santa Clara, Calif. 95050
Phone (408) 296-9305 **392**

Burr-Brown Research Corp.
International Airport Industrial Park
Tuscon, Arizona 85706
Phone (602) 294-1431. **393**

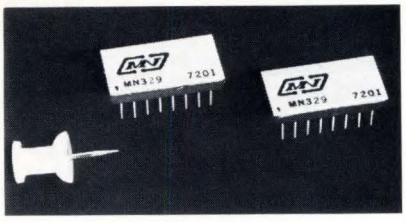


Pole-pair modules are stocked by De Coursey for quick assembly into custom filter units, allowing fast reaction to customer requirements.

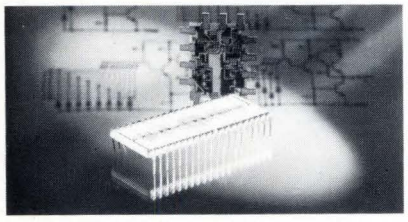


Burr-Brown stocks active filters that are 85% fabricated. Final fabrication and delivery of most custom filters can be accomplished within 2 weeks.

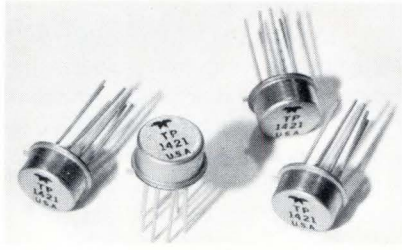
Universal active filters from KTI consist of a single-pole pair per module, which can be combined by KTI or their customer into any required configuration.



BIPOLAR DAC IN DIP PACKAGE, Model MN329, is a complete 10 bit D-to-A converter specified for ±1/2 accuracy bit over its operating range of 0 to 70°C. Model MN329R has 1-bit linearity over the operating range of ±15 to 55°C. The 329 is priced at $35.00 and the 329R at $23.00 each in orders of over 250 units. Micro Networks Corp., 5 Barbara Lane, Worcester, MA 01610. Phone (617) 756-4635. **171**



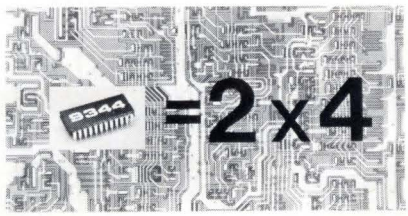
BEAM-LEAD LOW-POWER TTL CHIPS and custom assemblies are offered both as catalog products and in custom complex-logic LSI assemblies. These Series 54L/74L chips feature the same electrical characteristics as their standard Series 54L/74L counterparts. Typical power dissipation per gate is 1 milliwatt at a 50% duty cycle; propagation delay is 33 nsecs; and fan-out is 10 Series 54L/74L loads. Texas Instruments Inc., 13500 North Central Expressway, Dallas, TX. Phone (214) 238-3741. **172**



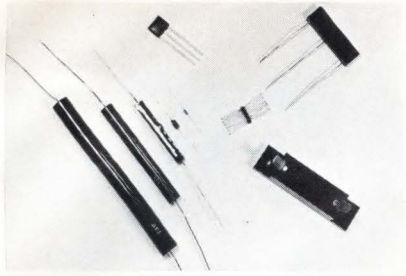
HIGH PERFORMANCE FET OP-AMP, the 142T, is directly interchangeable with the 741, is "latch-up" proof, and incorporates output short-circuit protection. Guaranteed specifications for the basic 1421 include I_{bias} of 50 pA and CMRR of 4000. The higher performance 01 and 02 versions have bias currents of 15 and 10 pA, and CMRRs of 4000 and 1000, respectively. Prices range from $8.50 to $14.00 each in orders of 100. Teledyne Philbrick, Allied Drive at Route 128, Dedham, MA 02026. Phone (617) 329-1600. **173**

ULTRA-LOW DRIFT MONOLITHIC OP-AMP, the Model 3500E has a maximum voltage drift of 1.0μV/°C. The unit is internally compensated, and the low drift is achieved without nulling the initial offset voltage of 500 μV. Maximum input offset current is 30 nA. Price is $20.00 each in quantities of 100 or more. Burr-Brown Research Corp., International Airport Industrial Park, Tuscon, AZ 85706. Phone (602) 294-1431. **174**

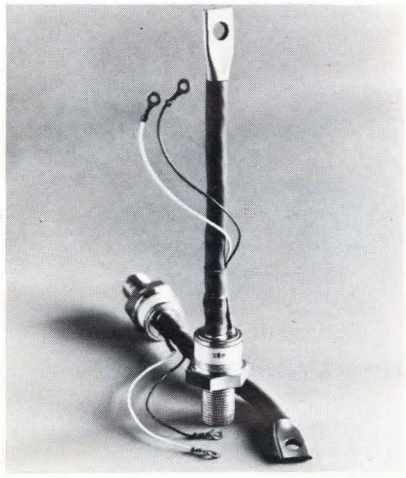
WORLD'S LARGEST SEMICONDUCTORS are a line of pressure mounted diodes with current ratings form 475 to 3800A avg. The 3800A unit comes with a 102 mm wafer, and its surge current is over 45,000A. The unit is presently offered in voltage ratings as high as 600V. Voltages as high as 2500V are available in the 52 mm, 1600A "Astropack," as well as the smaller 33 mm and 28 mm diodes. Power Semiconductors, Inc., 90 Munson St., Devon, CT 06460 U.S.A. Phone (203) 874-6747. **175**



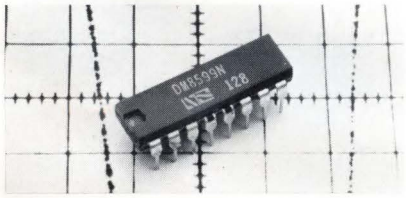
IMPROVED LSI MULTIPLIER, the 9344, has been redesigned for general-purpose and low-cost applications. It is a 2 × 4 bit combinatorial multiplier using internal carry lookahead and has sufficient carry inputs to combine all equal weight outputs. This permits the design of iterative multiplication arrays without using any other components. Price in 100-999 quantities is $17.50 for the industrial version. Fairchild Corp., Semiconductor Components Group, 464 Ellis St., Mountain View, CA 94040. Phone (415) 962-3816. **176**



HIGH VOLTAGE RECTIFIERS are rated from 1000 to 50,000V PRV and are available in standard and fast recovery (200 nsec typical) versions. Designated the 3 NV, MR, 7S, 35ST and FRR Series, they have current ratings up to 3A. Prices range from $0.45 to $15.00 for 100-999 quantity, depending upon voltage and current. Arthur Fallon Industries, 400 Warburton Place, Long Branch, N J 07740. Phone (201) 229-8300. **177**

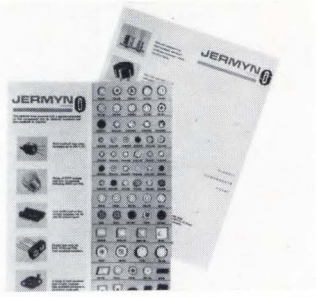


HIGH SPEED SCR handles 600V, 235A rms. Type 151RF has maximum turn-off time or 20 μsec; dv/dt is 200 volts per μsec and di/dt is 300A per μsec. The SCRs are suitable for applications at higher frequencies, up to 10 kHz. Package conforms to JEDEC outline TO-93. Price is $63.10 in 100-999 quantities. Semiconductor Div., International Rectifier Corp., 233 Kansas St., El Segundo, CA 90245. Phone (213) 678-6281. **178**

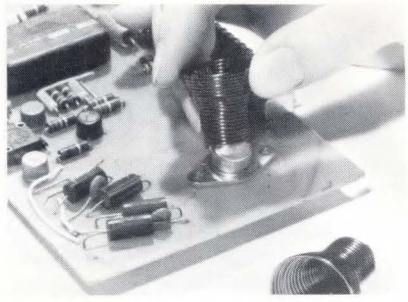


TTL READ/WRITE MEMORY has high-speed tri-state outputs. The 64-bit random-access memory stores 16 4-bit words and is fully decoded. It can be expanded to 2048 words without pullup resistors. Access time is typically 20 nsecs. from chip enable and 30 nsecs from address input (50 nsecs max.). Price is $7.20 each, in 100-up lots. National Semiconductor Corp., 2900 Semiconductor Drive, Santa Clara, CA 95051. Phone (408) 732-5000. **179**

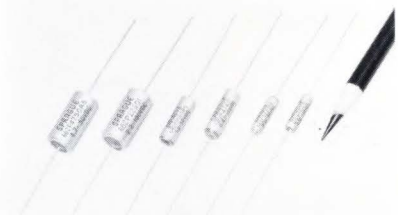
COMPONENTS/MATERIALS



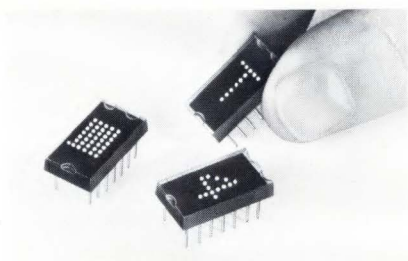
SEMICONDUCTOR HARDWARE SAMPLE CARD includes two sizes of anti-vibration clips suitable for small capacitors, together with mounting pads designed for transistors and integrated circuits. Sixty-seven samples are FREE, attached to a card which has been treated to allow components to be removed and then replaced. Jermyn, 712 Montgomery St., San Francisco, CA 94111. Phone (415) 362-7431. **190**



FREE SAMPLES of a newly designed spiral wound heat dissipator are available for evaluation. A simple twisting motion secures the Kooler-Koil to the component. The spring configuration grips the case firmly over its entire circular area and the copper coils effectively dissipate the heat. Unitrack, 8738 West Chester Pike, Upper Darby, PA 19082. Phone (215) 789-3820. **193**

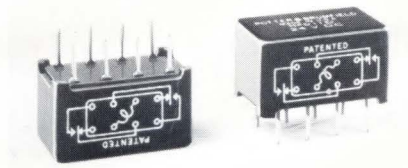


METALLIZED FILM CAPACITOR is low-cost, ultra-small and metal-encased. Type 682P Metfilm 'A' Capacitors offer high transient voltage ratings of 4 times rated working voltage. Capacitance ranges from 0.1 μF to 10μF with tolerances of ±20% ±10%, and ±5%. Voltage ratings are 50 and 100V dc. Operating temperature range is −40 to ±85°C. Sprague Electric Co., Marshall St., North Adams, MA 01247. Phone (413) 664-4411. **191**

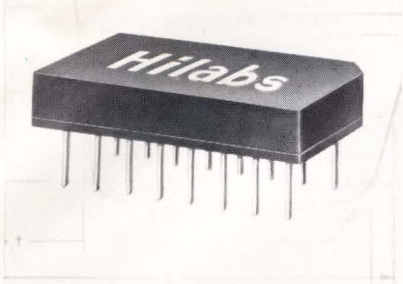


LED 5 × 7-DOT MATRIX has total alphanumeric display capability. This 35-dot array (series 745-0005) has X-Y select and decimal in a 0.300-inch character height. The display is made of GaAsP mounted on a 14-pin dual in-line substrate and cast within an electrically nonconductive transparent epoxy. In quantities of 250 the price for each unit is $11.80. Dialight Corp., 60 Stewart Ave., Brooklyn, NY 11237. Phone (212) 889-7767. **194**

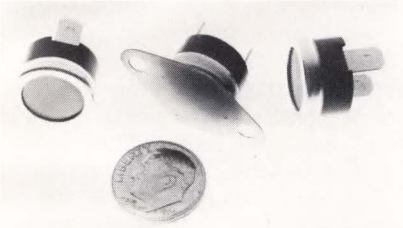
MINIATURE READOUT features lowest cost. The readout packs 11 positions (with character height up to 0.37 inch), in a 2-inch case. The Series 0345 employs a film mask. Anything photographically reproducible may be displayed. Cost in 1000 quantity including driver/decoder is $24.33. Industrial Electonic Engineers, Inc., 7720-40 Lemona Ave., Van Nuys, CA 91405. Phone (213) 787-0311. **192**



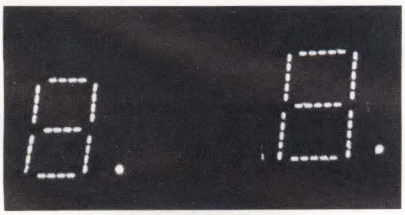
MINIATURE RELAYS, HPD series are half-crystal size. Gold-plated silver contacts are rated 0.3 to 2A at 28V dc, resistive; 0.1 to 0.5A at 120V. Coil voltages are 6V, 12V, 24V, 36V and 48V. The price is $8.35 for a DPDT. Potter & Brumfield, 1200 E. Broadway, Princeton, IN 47670. **195**



PRECISION NANOSECOND DELAY LINES feature low insertion loss. The Hilabs 50-ohm series offers nine different standard delay lines in epoxy DIPs, ranging from HI-1050 (delay-10 nsec, rise time 1 nsec) to HI-20050 (delay 200 nsec, rise time 12 nsec). Prices, in 1000 quantity, are: HI-1050—$7.50, HI-20050—$15.80. Hilabs Inc., P.O. Box 282, Fort Washington, PA 19034. Phone (215) OL9-1100. **196**



THERMAL SWITCH provides a snap-action disc switch for use in a wide range of appliance and industrial applications. It is calibrated for consistent 100,000 cycle operation under a 10A, 120V load, and is designed for precise temperature control from −20° to +350°F. Its trip temperature range is ±5°F with a reset temperature range of ±10°F. GTE Sylvania Inc., Rt. 35, Standish, ME 04084. **197**



SEVEN-SEGMENT LED DISPLAY, Model MAN-3M, features a 32% larger digit than the MAN-3. The display is packaged to permit mounting of five per inch and has a brightness of 200 ftL at 5mA forward current. The MAN-3M sells for $5.00 each in quantities from 1 to 9, $3.30 each for 100 and $2.95 each for 1000. Monsanto Commercial Products Co., 10131 Bubb Rd., Cupertino, CA 95014. Phone (408) 257-2140. **198**

COMPONENTS/MATERIALS

TRIMMER RESISTOR, the 20-turn Model 43, has improved setability and stability because of a unique "T" slider block. The 3/4 inch trimmer also features a double-slotted shaft which accomodates a standard or Phillips screwdriver. It has a low profile, standing only 1/4-inch above the board, comes in a sealed case and is available in all 3-pin configurations. Spectrol Electronics Corp., 17070 East Gale Ave., City of industry, CA 91745. Phone (213) 964-6565. **199**

SOLID STATE INDICATOR LIGHTS designated Eldema Series BC, CD and ED meet or exceed requirements of MIL-L-3661. The gallium phosphide devices operate at a forward voltage of a nominal 2.15V dc at 10 mA. For other voltage applications Eldema supplies a built-in resistor. Eldema Division, Genisco Technology Corp., 18435 Susana Rd., Compton, CA 90221. Phone (213) 451-8491. **200**

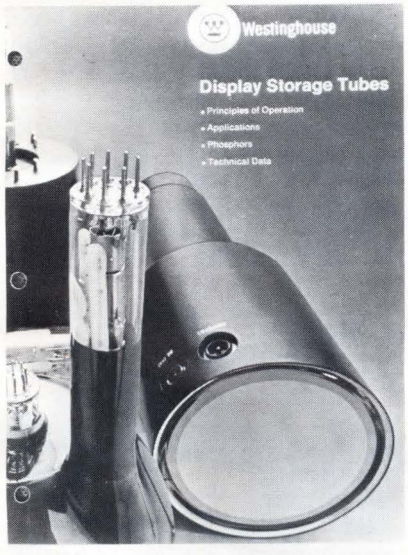
LED PUSHBUTTON SWITCH features long life, high-brightness. Designated the Series 590/D, this unit is believed to be the first standard size lighted switch incorporating a T-1 3/4, midget flanged based LED, and designed for IC signal level switching in computer and control display applications. Contact resistance is less than 25 milliohms. Travel is 0.01 inch total (0.05 inch pre-travel). Price is $2.25 each in 1000 pc. lots. Marco-Oak, 207 S. Helena St., Anaheim, CA 92803. **201**

HEAT CONDUCTING COMPOUND, Thermaflow 2001, provides efficient thermal point between SCR's, Triacs, power transistors and heatsinks. Applied between the device and heatsink it reduces the thermal resistance. In disposable syringes the price is $2.00. In jars containing 5 ozs the price is $6.00 each. Jermyn, 712 Montgomery St., San Francisco, CA 94111. Phone (415) 362-7431. **202**

MULTI-PUSHBUTTON SWITCHES Series 65000, 66000, 67000, 70000 and 71000 can be specified with up to 12 stations in a row, which combines interlock, all-lock or push-lock/push-release mechanical functions with a momentary common release at any location on the switch frame. By simply depressing a common-release pushbutton, all previously depressed stations are restored automatically to normal position. From $1.90 to $14.60. Switchcraft, Inc., 5555 N. Elston Ave., Chicago, IL 60630. Phone (312) 792-2700. **203**

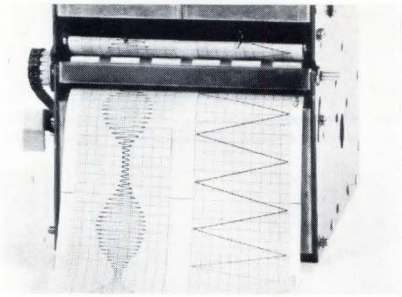
MODULAR CONNECTOR PANELS, Series 161, provide varied quantities of connectors on aluminum backpanels with any number of contacts from 18/36 to 60/120 without costly tooling. These connectors are available with contacts on either 0.125 or 0.150 inch centers and have 0.025 inch square tails for automatic or semi-automatic wire wrapping. They also feature preloaded cantilever contacts which afford ease of insertion and withdrawal yet provide positive board retention. Insulator material is nylon and contacts are gold plated phosphor bronze. Methode Electronics, Inc., 7447 W. Wilson Ave., Chicago, IL 60656. Phone (312) 867-9600. **204**

SNAP-IN PUSHBUTTON SWITCHES come in a wide variety of colors. The 8423 and 8424 Series single-pole switches are rated 3/4 A 125V ac/dc, and 1/4 A, 250V ac/dc, respectively. Standard design features include Zytel nylon-101 buttons and shrouds, snap-in mounting, normally-open or normally-closed-momentary circuits and silver or gold plated contacts. Price is 20 cents each in quantities in excess of 1000. Cutler-Hammer, Inc., 4201 North 27th St., Milwaukee, WI 53216. Phone (414) 442-7800. **205**

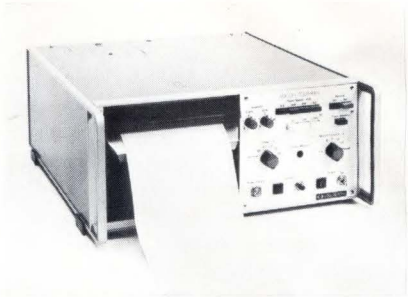


DISPLAY STORAGE TUBE book includes background technical information on display storage tube operation and theory, applications data and a catalog of standard DST types and special tube design services. The 52-page booklet provides technical information on DST operation, including handling precautions, and a listing of the standard phosphors available. Electronic Tube Division, Westinghouse Electric Corp., P.O. Box 284, Elmira, NY. 14902. Phone (607) 739-7951. **206**

EQUIPMENT

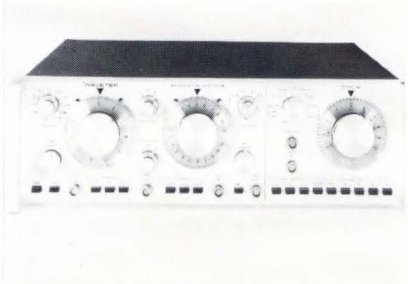


STRIPPED-DOWN CHART RECORDERS costing up to 50% less than comparable units are available equipped with controls and panels. Called the "Bare Bones" Series, the recorders provide a low-cost way to design and construct one's own precision systems for data gathering and monitoring. Astro-Med Div. of Atlan-Tol Industries, Inc., Atlan-Tol Industrial Park, W. Warwick, RI 02893. Phone (401) 828-7010. **229**



DIRECT RECORDING OSCILLOGRAPH Visigraph-300 offers built-in duration control and has galvanometer channels for recording data from dc to 13 kHz. Trace identification is provided as a standard feature. Twelve paper speeds are offered from 0.2 to 120 in./sec. Dixson, Inc., Box 1449, Grand Junction, CO 81501. Phone (303) 242-8863. **232**

RESISTANCE BRIDGE provides 3-digit resolution for measurements from 1 mΩ to 1 GΩ. The DP170/3202P digital resistance meter provides 12-month accuracy of 0.1% over a wide number of ranges. It has 10 decade ranges from 1Ω to 1000 MΩ. Accuracy is 0.1% of reading ±0.1% of full scale. Cost is $690. Hickok Electrical Instrument Co., 10514 Dupont Ave., Cleveland, OH 44108. Phone (216) 541-8060. **230**



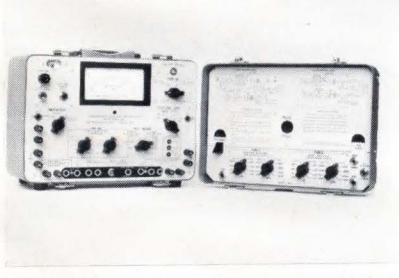
MULTIFUNCTION GENERATOR Model 146 offers sweep frequency modulation, amplitude modulation, frequency shift keying, triggered and gated operation, and swept amplitude modulation in one integrated unit requiring no external drive modules. Not only calibrated sweep, but calibrated modulation of frequency and amplitude are provided. Price is $1495. Wavetek, Box 651, San Diego, CA 92112. Phone (714) 279-2200. **233**

4-1/2-DIGIT MULTIMETER Series 2400 is now available with 0.10000V full scale (0.12000V including 20% overrange) and 10-μV sensitivity. The new feature is designated the B-1 option. Price including the B-1 feature is $680 to $775, depending on functions ordered. Delivery is stock to 30 days. Data Precision Co., Audubon Rd., Wakefield, MA 01880. Phone (617) 246-1600. **231**

DC PICOAMMETER Model WV-511A measures dc current from 1 pA to 30 mA in eighteen overlapping ranges. It has ±3%-of-full-scale accuracy on all ranges and a zero-drift of less than ±2% each 24-hour period. Other features include a zero-center scale for monitoring bipolar current levels and a recorder output connector. Price is $250. RCA Electronic Components, 415 S. 5th St., Harrison, N J 07029. Phone (201) 485-3900. **234**

LOW-COST $78 SUPPLY features a dual output independently variable from 0 to ±22V or 0 to ±45V at 400 mA. Model PZ-455-A provides regulation of better than 10 mV for the line and 30 mV for the load. Ripple is less than 1 mV. It has current limiting, 10-turn voltage controls for each output and rear-panel outputs. Viking Electronics, Inc., 721 St. Croix, Hudson, WI 54016. Phone (715) 386-5188. **235**

DIGITAL COUNTER Model 4320 combines the advantages of a liquid-crystal display and a MOS counter-decoder-driver chip in a portable 3-1/2 digit instrument. The 4320 can replace electro-mechanical counters and is estimated to handle over 100 billion counts—or over 10,000 hours of continuous operation. OEM pricing is $55 and delivery is for April, 1972. Digilin, Inc., 1007 Air Way, Glendale, CA 91201. Phone (213) 240-1200. **236**



TRANSMISSION-LEVEL AND RETURN-LOSS TEST SET Model 9041 is designed to make central office balancing a simple one-man operation with consequent cost savings. Transmission level is measured from + 12 to −48 dBm with 0.1 -dB accuracy. Echo and singing return loss is measured from 10 dB of return gain to 50 dB return loss on 2 or 4-wire circuits. Wiltron Co., 930 E. Meadow Dr., Palo Alto, CA 94303. Phone (415) 321-7428. **237**

EQUIPMENT

DIGITAL TIMING INSTRUMENTS called the LT-20B Series range from microseconds to minutes. Two external control modes are standard. The first mode is accomplished by independent start, stop and reset commands via momentary contact closures or ground-level signals. Delivery is stock to 10 days with prices starting below $90. Durgin & Brown, Inc., 80 Allen Rd., S. Burlington, VT 05401. Phone (802) 863-6873. **238**

SPECTRUM ANALYZER Model 711 features storage and variable-persistance capability. The storage display unit is capable of operating in the standard display mode and variable storage times up to 2 minutes without significant loss of brilliance. Signals may be stored up to 6 hours with reduced brilliance. Price is $2600 and delivery is 30 days. Systron-Donner Corp., Microwave Div., 14844 Oxnard St., Van Nuys, CA 91409. Phone (213) 786-1760. **239**

VARIABLE INDUCTANCE BOX with superimposed dc capability provides an inductance range from 2 μH to 1 mH in 30 positions. It can work from both ac and dc currents, with up to 12A dc. It costs only $55. Magnetic Electronics, Inc., 15414 Cabrito Rd., Van Nuys, CA 91406. Phone (213) 785-3116. **240**

STEP-AND-REPEAT MICROFICHE CAMERA is capable of 42X reduction ratio. The new camera is said to be the first COM-compatible microfiche camera to be offered to the microfilm industry. Using standard 105-mm roll microfilm, it produces directly generated 105-X-mm microfiche, each having as many as 192 frames. The precision-built camera is capable of directly generating microfiche from black-and-white or color originals at true production rates. Image Systems, Inc., 11244 Playa Ct., Culver City, CA 90230. Phone (213) 390-3378. **241**

RECORDING VOLTMETER OSCILLOGRAPH Visigraph-A features six individual galvanometer amplifiers with adjustable gain. The amplifiers have voltage sensitivities as low as 0.77 mV/cm with an input impedance of 10 MΩ to measure frequencies as high as 1200 Hz. Price is $1400. Dixson Instruments, Box 1449, Grand Junction, CO 81501. Phone (303) 242-8863. **242**

1V DC STANDARD permits simple checking and correcting of DVMs, analog meters and scopes. Two flat 9V batteries supply the current to this portable 5-oz unit for a constant-current source, which remains constant irrespective of the state of the batteries. Output is IV ±0.05% and TC is ±1 × 10^{-5}/°F. Price is $47. Traco, Inc., 509 Rolling Hills Rd., Somerville, N J 08876. Phone (201) 725-5333. **243**

EQUIPMENT

TELEMETRY CALIBRATOR designated Model PM2375 is accurate to ±0.05% and has both a precision voltage source and a precision potentiometric voltage indicator. It features a LED readout and is entirely solid state. The standard unit has 5 calibrating voltages: 0.00V, 1.25V, 2.50V, 3.75V and 5.00V in both the measurement and source modes. Pioneer Magnetics, Inc., 1745 Berkeley St., Santa Monica, CA 90404. Phone (213) 829-3305. **244**

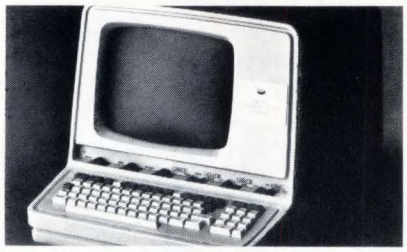
PROGRAMMABLE DATA-ACQUISITION SYSTEMS (PDAS) with 5, 20, 40, 100 and 200 channels for A/D recording offer ASR 33 teletypewriter interconnection with a complete system cost of under $4500. The PDAS systems are designed to use the ASR33 at its maximum speed. They have an input scan rate of 1.5 channels/sec. The systems are fully switch-programmable for each application and can also be set for high or low-alarm systems to protect processes and equipment. Esterline Angus, Div. of the Esterline Corp., Box 24000, Indianapolis, IN 46224. Phone (317) 244-7611. **245**

AC POWER SOURCE/AMPLIFIER features a 250-VA output and line/load regulation of 0.5%. Pacific Electronics Enterprises, Inc. model 250-A has a 5% distortion and an internal oscillator spanning 47 to 500 Hz. A wide bandwidth features full power to 5 KHz. Cost is $595 and delivery is 30 days. Pacific Electronics Enterprises, Inc., 2643 N. San Gabriel Blvd., Rosemead, CA 91770. Phone (213) 573-1686. **246**

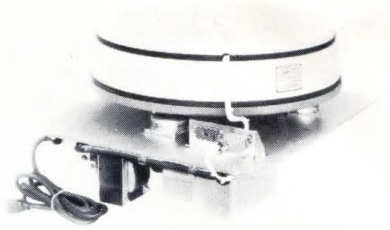
RATE-OF TURN TABLES feature direct drive dc servo and optional N/C programmers. Designated the 1100 Series, both laboratory and portable models can achieve rates to 3200°/sec and are wired for digital control and programming. Laboratory Models 1100-1 through 1100-4 cover the full-scale speed range to 2000°/sec at accelerations to 12,800°/sec². Genisco Technology Corp., 18435 Susana Rd., Compton, CA 90221. Phone (312) 671-0632. **247**

FULLY-PROGRAMMABLE PULSE GENERATOR Model 1501 offers pulse repetition frequency from 0.5 Hz to 50 MHz, with a 10V output into 50Ω. The 1501 provides internal 50Ω termination to allow the output to drive a wide variety of loads without troublesome reflections when driving a mismatched load. All pulse parameters are programmable, including risetime/falltime from 3 nsec to 1 msec, delay and width from 10 nsec to 10 msec and baseline offset from −5V to +5V. The 1501 is priced at $3500 with first deliveries scheduled for mid April, 1972. E-H Research Laboratories, Inc., Box 1289, Oakland, CA 94604. Phone (415) 834-3030. **248**

COMPUTER PRODUCTS

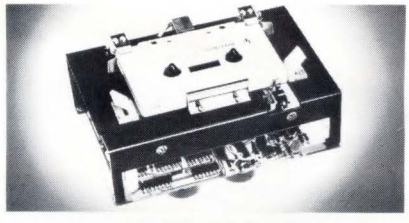


CRT COMMUNICATIONS TERMINAL. Model 4390 features stand-alone operation, A/N keyboard, numeric key pad and 40 or 80-character per line 9 × 7 in display. It provides 10 or 20 lines per display, transmits at rates from 110 to 4800 baud, and nondestructive, blinking underscore cursor. The character format is 5 × 7 dot matrix in upper case with a set of 64 characters. The Bendix Corp., Bendix Center, Southfield, MI 48076. Phone: (313) 352-6233. **261**

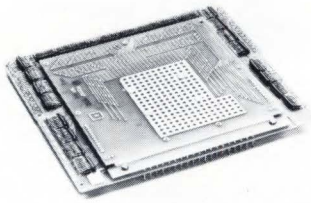


64 TRACK DISC offers 70K bits per track and a 2.1 million bit/sec transfer rate. Access time is 17 msec. Cost per bit starts at .125¢/bit in single quantity. The unit, designed for minicomputer and terminal input/output applications, features a flying head per track design. The new memory provides an integral drive system. Tally Corp., 8301 South 180th St., Kent, WA 98031. Phone: (206) 251-5500. **264**

NEW, LOW COST, 14-DIGIT CALCULATOR has two memories and two operating registers. The Friden Model 1118 has a program dial for choosing any of the following automatic modes: product or quotient accumulation, automatic "constant" retention, combination of both product or quotient accumulation and "constant" retention, and accumulation of first factor and product or quotient accumulation. Price is $595. Business Machines Div., The Singer Co., 2350 Washington Ave., San Leandro, CA 94577. Phone: (415) 357-6800. **262**



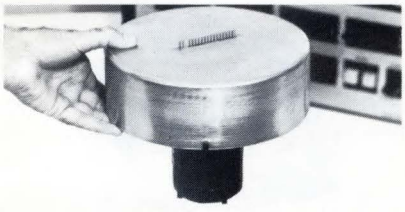
DIGITAL CASSETTE TAPE TRANSPORT. Model 260 uses any cassette that complies with the ANSI, ECMA or ISO standards. Operating characteristics include short term bit-to-bit "jitter" less than ±1% at 10 ips; read and write tape speeds between 5 and 40 ips; 60 msec max. start and stop time and data transfer rate up 8000 bits/sec with densities up to 800 B.P.I. OEM prices are less than $300 based on 500 unit quantity. Computer Access Systems, 2645 East Buckeye Rd., Phoenix, AZ 85034. (602) 267-1444. **265**



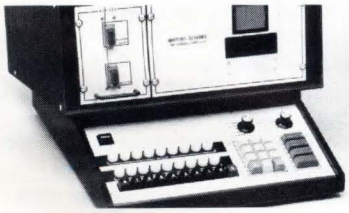
PLANAR CORE MEMORY MODULE. The EM2230 comes in capacities up to 8K × 18 bits. This 3-Wire, 3D stack has cycle times to 700 nsec and utilizes EM 18 mil extended temperature core and 8192 words per sense line. It features double-density packaging with 8K words on a 7.5 × 8 in. pc board. Electronics Memories, 12621 Chadron Ave., Hawthorne, CA. Phone: (213) 644-9881. **263**

NEW DISK FORMATTER is priced at under $2300 in single quantities. The new disk formatter operates with up to four Pertec 5000-Series disk drives and is primarily intended for applications in mini and small computer systems. Access of 15 msec track-to-track (60 msec average) is offered with standard data rates of 720 kHz at 1100 bpi and 1.562 MHz at 220 bpi. Pertec Corp., 10880 Wilshire Blvd., Los Angeles, CA 90024. Phone: (213) 475-8464. **266**

DESK CALCULATOR. Model 8K features: four functions with floating and fixed decimal point selection; constant multiply/divide key and true credit balance. The 8 digit display has overflow indicator, automatic leading zero suppression and 100,000 hour life expectancy. The unit measures 2 in. × 5 in. × 9 in. and uses a single multifunction LSI chip. Price is under $180. Eldorado Electrodata Corp., 601 Chalomar Rd., Concord, CA 94520. Phone : (415) 686-4200. **267**



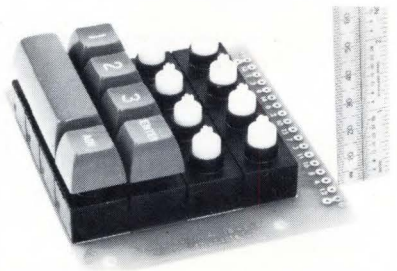
LOW-COST MASS MEMORY SYSTEM. Series 55 drum storage capacities range from 2K to 65K 16 bit words. Access times as fast as 8.3 ms are available. Two frame sizes are offered, both designed for mini-computer packaging requirements. Standard features include self-clocked electronics and proven, reliable head-per-track recording techniques. Prices start at less than $1000. Datum Inc., California Peripherals Div., 170 E. Liberty Ave., Anaheim, CA 92801. Phone: (714) 879-3070. **268**



UNIVERSAL MEMORY PROGRAMMER/VERIFIER field-programs all IC ROMs. Data capacity is 9 bits per word and is expandable. Address readout is a four digit, seven segment display. Model 550 will program and verify fusible-link, diode junction-shorting, electro-chemical fusing, and floating gate avalanche-injection ROMs. Spectrum Dynamics, Inc., 2300 East Oakland Park Blvd., Ft. Lauderdale, FL 33306. Phone: (305) 566-4467 or 564-4369. **269**

COMPUTER PRODUCTS

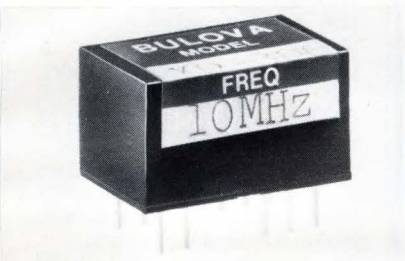
KEYBOARD SWITCH PRICE REDUCTIONS. New prices for gold crosspoint keyboard switches range from $1.27 (was $1.37) in single quantities to $0.34 (was $0.43) in 100,000 piece quantities. For new pricing information, and a completely new brochure of electrical and mechanical specifications on individual key switches and complete keyboards, contact Cherry Electrical Products Corp., 3600 Sunset Ave., Waukegan, IL 60085. Phone: (312) 689-7600. **270**



LOW COST CONTACTING KEYBOARD. Keystations are available in both momentary and alternate action (Push On Push Off). Features slight tactile feel, contact snap action, life expectancy over 10,000,000 operations, contact bounce time less than one msec and switches MOS/TTL. Volume price of the assembled contacting keystation including pc board is less than 25¢/key. Colorado Instruments Inc., Keyboard Marketing, One Park St., Broomfield, CO 80020. Phone: (303) 466-1881. **271**

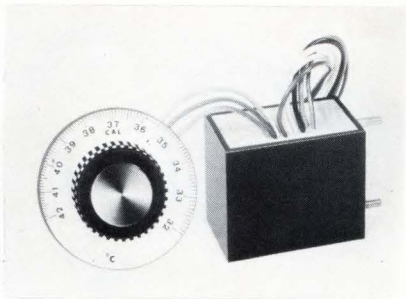
LOW-COST COMPUTER/PLOTTER INTERFACE. Model JH-05 provides timing, storage and transfer of graphic data from Honeywell DDP 516/416/316 computer to most types of incremental plotters. Included are all necessary cables, connectors and software test routines. Utilizing DTL/TTL compatible input signals, it transmits a 10V peak (min) strobed output signal to the plotter. Minuskin & Associates, P.O. Box 135, Tustin, CA 92680. Phone: (714) 833-1022. **272**

MICROWAVE AMPLIFIERS from the thin-film MIC. amp line are the TO-8-cased UTO-521 and UTO-522. These cascadable amplifiers provide 27 and 23 dB of gain per module from 5 to 500 MHz. Minimum output power is +6 and +12 dBm with maximum noise figures of 5.5 and 7.0, respectively. They complement Avantek's existing UTO-500 Series amplifiers whose prices are in the $110-to-$195 range. Delivery is stock to 30 days. Avantek, Inc., 2981 Copper Rd., Santa Clara, CA 95051. Phone (408) 739-6170. **288**



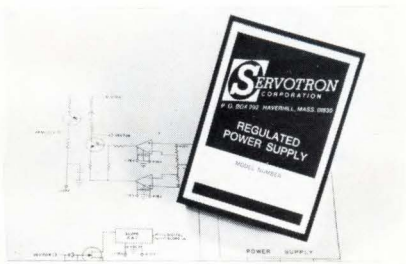
DIP CLOCK OSCILLATORS are specifically designed for medium- and high-speed digital circuits. The series XO-300 features outputs directly compatible with DTL and TTL ICs. Frequency ranges from 1 to 4 MHz in some models, while others go from 4 to 25 MHz. Accuracy is ±15 ppm throughout the series. Configuration is in 14-pin DIPs. Bulova Watch Co., Inc., Electronics Div., 61-20 Woodside Ave., Woodside, NY 11377. Phone (212) 335-6000. **289**

8-BIT D/A, DAC-198B, features 300-nsec settling time (to 0.2% of full scale) and costs only $19. Full-scale output is ±2.5 mA with a maximum voltage compliance of ±1.2V. Output linearity is ±5 μA with a current resolution of 10 μA. Accuracy is ±0.2% and TC is ±15 ppm/°C. Datel Systems, Inc., 1020 Turnpike St., Canton, MA 02021. Phone (617) 828-6395. **290**



NEW TEMPERATURE CONTROLLER called Medi-Temp is designed for medical and biochemical instrumentation. It features solid-state modular construction with a standard temperature range of 32 to 42°C (89 to 107°F). Medi-Temp models can be made in most ac or dc voltages with current ratings up to 40A. Pak-Tronics, Inc., 4044 N. Rockwell St., Chicago, IL 60618. Phone (312) 478-8585. **291**

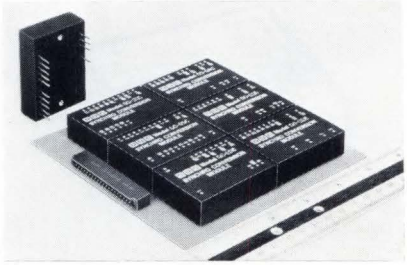
DC-TO-DC CONVERTER series features 32 Models, up to 3.6W of output power and sells from $39 (1 to 9). The series has a low profile of 0.4 in. and pin spacing for plugging into standard logic cards. Accepting input voltages of 5, 6, 12 and 28V dc, the series provides output voltages of ±12, ±15, ±18 and ±24V dc with output currents of 25, 75, or 100 mA. Semiconductor Circuits, Inc., 306 River St., Haverhill, MA 01830. Phone (617) 373-9104. **292**



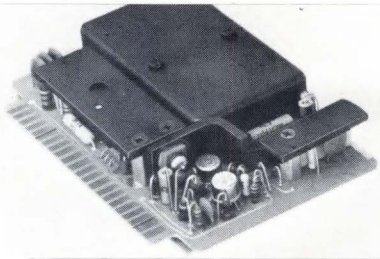
ENCAPSULATED POWER SUPPLIES, Models SE904 and SE902, feature ±15V dc outputs at 50 and 100 mA and measure 2.5 × 3.5 × 0.875 in. and 2.5 × 3.5 × 1.25 in., respectively. Outputs are regulated to 0.05% for line and 0.1% for load. Ripple and noise is less than 500 μV rms and output impedance is less than 0.2 Ω at 10 kHz. Price for Model SE904 is $35 and for Model SE902 is $45. Servotron Corp. Box 292, Haverhill, MA 01830. Phone (617) 374-0777. **293**

CIRCUITS

MOTOR SPEED CONTROLS for 12V permanent-magnet motors (up to 45A) feature infinitely adjustable speed with a high-efficiency circuit capable of delivering armature currents greater than two times battery current at low speeds. These solid-state units measure only 4 × 5 ×2-1/4 in. and are suited for OEM applications. Power Technology, Inc., Box 4403, Little Rock, AR 72204. Phone (501) 565-1750. **294**



SYNCHRO-CONVERSION SYSTEM for converting synchro or resolver analog data to digital form is made up of ten separate modules that may be assembled in 37 different configurations to satisfy any requirement. Designated the A Series, the system offers 2 speeds (60 or 400 Hz) and is compatible with DTL/TTL, binary and BCD. ILC Data Device Corp., 100 Tec St., Hicksville NY 11801. Phone (516) 433-5330. **295**



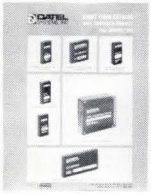
PC-BOARD POWER SUPPLIES, Models PC5-1 and PCD15-250, are said to be the smallest 5 and 7.5W output devices built to date. Output for the Model PC5-1 is 5V at 1A and for the Model PCD15-250 it's ±12 to 15V at 0.25A on each side. Input is 105 to 125V ac, 50 to 500 Hz. Line regulation is 0.01% and zero-to-full-load regulation is 0.03%. Prices start at $99. RO Associates, Inc., Box 2163, Menlo Park, CA 94306. Phone (415) 322-5321. **296**

LITERATURE

CATALOG OF DRAFTING AIDS and pressure sensitive artwork symbols contains over 3500 items. New items featured in this catalog include individually precut sequential reference designations and a complete assortment of letters and numbers of various sizes related drafting words schematic and logic symbols, new connector fingers, and fillets. Centron Engineering, Inc., 24015 Garnier St., P.O. Box 3396, Torrance, CA 90510. **304**

"MINILOG" is a ready reference to ferromagnetic components. Listed in the brochure are part numbers and specifications on a variety of data coils (pulse, wide band, toroidal) and SCR transformers, high-pass, band-pass, and band-reject filters and a large number of variable and fixed inductors. Each product section includes charts, graphs and specification listings, which provide a complete performance profile for each model. Alladin Electronics, 703 Murfreesboro Rd., Nashville, TN 37210. **308**

STANDARD DRY REED RELAYS are described in a 12 page catalog. Catalog Number 901 contains the latest specifications on contact ratings, contact resistance, operate time, release time, insulation resistance and breakdown voltages. Included also are life data and environmental considerations, shock, vibration and temperature. C.P. Clare and Co., 3101 Pratt Ave., Chicago, IL 60645. Phone (312) 262-7700 **310**



A/D AND D/A CONVERTERS are shown in a comprehensive 12-page catalog. It contains detailed electrical and mechanical information on a line of ultraminiature converters, accessories, sample-and-hold modules, analog multiplexers and miniature dc power supplies. Some 71 models of 17 series are described in detail in this new catalog. Datel Systems, Inc., 1020 Turnpike St., Canton, MA 02021. **305**

RENT-OR-BUY GUIDELINES for electronics equipment users are contained in a brochure. Given are basic guidelines for use when making the rent-or-buy decision about expensive equipment. Outlined are all the benefits achieved through renting, as opposed to buying or leasing. Rental Electronics, Inc., 16600 Oakmont Ave., Gaithersburg, MD 20760. **309**

MICROWAVE TUBES off all types are shown in a 12-page catalog. Described are a line of pulsed, pulsed frequency-agile, beacon, voltage-tunable and cw magnetrons, pulsed and cw crossed-field amplifiers, high-power noise generators, klystron oscillators and special-purpose cw reflex klystrons. Varian, 611 Hansen Way, Palo Alto, CA 94303. **311**

AUTOMATIC TEST EQUIPMENT are described in a 16-page brochure. A variety of automatic testers custom-designed to check out such equipment as inertial systems and components, circuit cards and modules, assemblies, computers and associated electronic elements are detailed. The Singer Co., Kearfott Div., 1150 Mc Bride Ave., Little Falls, N J 07424. **306**

TERMINAL STRIPS for use with PC boards are shown in a 4-page folder. Designed specifically for wave-soldering, they include a wide range of sizes, numbers of terminals and specifications. Kulka Electric Corp., 520 S. Fulton Ave., Mount Vernon, NY 10551. **307**

LITERATURE

READ/WRITE NRZI AMPLIFIER is described in a data sheet. The new amplifier is ideally suited for single-speed applications (25 to 200 in./sec) with up to 8 Potter SC1051 SC1081, AT1082 or AT1092 single-capstan magnetic-tape transports. Information transfer rates up to 160,000 characters/sec can be handled and read reverse capability is standard. Potter Instrument Co., Inc., 532 Broad Hollow Rd., Melville, NY 11746. **312**

A DIGITAL-TO-SYNCHRO CONVERTER to NAFI requirements is described in a data file. The converter is composed of Standard Hardware Program (SHP) modules built to NAFI requirements (Naval Avionics Facility, Indianapolis). It consists of a single transformer card module and 7 circuit card modules designed for mounting in a simplified rack. Astrosystems, Inc., 6 Nevada Dr., Lake Success, NY 11040. **313**

SAMPLING AND THE TDR PLUG-INS are described in a booklet from Tektronix. Its 560 Series plug-ins are detailed in this booklet. General-purpose sampling with plug-in heads allowing measurements from dc to 14 GHz with input characteristics from 50Ω to 100 kΩ is a key feature of the 560 Series. Mainframes are available in both storage and non-storage versions. Tektronix Inc., Box 500-A Beaverton OR 97005. **314**

NUMERICAL CONTROLS that provide absolute positioning control for machining centers, drills, mills, welders and assemblers are described in a brochure. They feature two-axis plane-switchable contouring with linear and circular interpolation. Systems Div. of Allen-Bradley Co., 747 Alpha Dr., Highland Heights, OH 44143. **315**

COAXIAL VARIABLE ATTENUATOR literature describes General Microwave's new series of precision coaxial step attenuators covering the frequency range from dc through 18 GHz. The attenuators include a range of up to 69 dB in 1-dB steps. General Microwave Corp., 155 Marine St., Farmingdale, NY 11735. **316**

RESISTOR-CAPACITOR-DIODE NETWORKS known as CORDIP are described in an illustrated eight-page brochure. The brochure cites advantages in design flexibility component density and reduced PC-board space requirements offered by CORDIP component networks. Combinations of up to 23 resistors, glass-ceramic capacitor chips and diodes, interconnected according to customer specifications in dual-in-line packages, are offered by these networks. Electronic Products Div. of Corning Glass Works, Corning, NY 14830. **317**

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ADVERTISERS INDEX

Application Notes

"THE DIFFERENTIAL LINE DRIVER" describes the application of integrated circuit line drivers and receivers to the transmission of incremental encoder pulses down long lines and in noisy environments. Technical Note TRN-103 discusses in detail the use of differential line drivers and receivers, and transmitting pulses down thousands of feet of cable. Trump-Ross Industrial Controls, Inc., 265 Boston Rd., North Billerica, MA 01826. **380**

X-BAND DOPPLER RADAR MODULE, only a handful in size and using only a few watts of power, is described in an applications manual. How to apply this recently-introduced 10-GHz Doppler radar module is shown in the manual. It starts with basic principles and proceeds through the needed engineering calculations. Included are detailed suggestions for antenna equipment, and all necessary dimensional and electrical specifications. Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, CA 94304. **381**

A DIGITAL-PANEL-METER HANDBOOK contains the most complete source of DPM information available today. This comprehensive manual includes 60 pages of specific information on how to use DPMs. Specifications and pitfalls are thoroughly explained and related to common applications. Also described are various forms of a/d conversion with their advantages. Copies are available priced at $3 each. Purchasers may order by sending cash, checks or money orders made payable to Digilin, Inc., 1007 Air Way, Glendale, CA 91201. **382**

DESIGNING WITH LOW-POWER MSI circuits, a four-page application note written by AMD-s digital applications' department, is now available from Advanced Micro Devices. The guide offers the circuit designer rules, characteristics and advantages of using low-power 9300 MSI circuits. Tables showing power and speed equivalents for AMD's extensive line are also presented. Advanced Micro Devices, Inc., 901 Thompson Place, Sunnyvale, CA 94086. **383**

MEASURING DISTORTION to 0.0001% or 1 ppm is described in application note T-155. Two methods are given. One utilizes a pair of tuned amplifiers to measure the level of the second, third or fourth harmonic of the signal under investigation. The other method employs phase-sensitive detection to measure the harmonic levels in the presence of noise. Princeton Applied Research Corp., Box 2565, Princeton, N J 08540. **384**

MODULAR DATA-ACQUISITION SYSTEMS are explained in a comprehensive 23-page applications handbook. The book is divided into six sections. One section provides basic theory on A/D converters, sample/hold circuits and analog multiplexers. Another section describes a wide variety of applications while the third and fourth sections describe input and output timing when interfaced with a minicomputer. Section five describes new modular data acquisition systems. Datel Systems, Inc., 1020 Turnpike St., Canton, MA 02021. **385**

"How TO EVALUATE LIGHT EMITTERS and optical systems for light sensitive silicon devices" is the topic of application note #200.59. Its 14 pages contain information on photon coupling, operation of light activated semiconductors, light measurements and an optoelectronic device selection list. Copies can be obtained from General Electric Co., Semiconductor Products Dept., Electronics Park, Bldg. #7, Mail Drop 49, Syracuse, NY 13201. **386**

"SR-4 STRAIN-GAGE HANDBOOK" Volume 1, has been extensively revised by BLH Electronics, Inc. The handbook on bonded resistance strain gages covers sensing elements, the backings or carriers, lead wire systems and protective coatings. The characteristics of the numerous materials used in strain-gage system components are discussed and compared, enabling the user to select the system best suited to his particular application. BLH Electronics, Inc., 43 4th Ave., Waltham, MA 02154. **387**

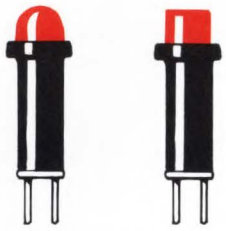
A FREE/TIMER COUNTER SELECTION GUIDE includes a glossary of timer and counter terminology. The guide is directed to one's application, detailing the factors to be considered in the selection of the various types of timers and counters available. It includes columns for scoring various timers and counters as they meet—or fail to—the applications' requirements and enables almost anyone to select the timer or counter that will give the best performance in the long run. Automatic Timing & Controls, Inc., King of Prussia, PA 19406. **388**

REFERENCE COPIES AVAILABLE

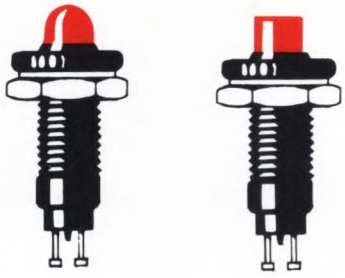
Reference copies of the following articles are available without charge:

Index to Ads, Application Notes, Products and Literature

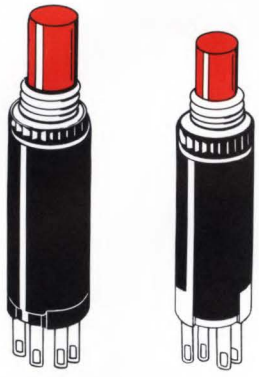
DIODE-LITEs



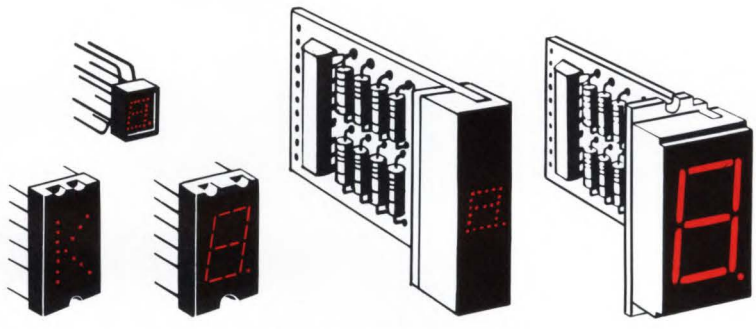
Cartridges



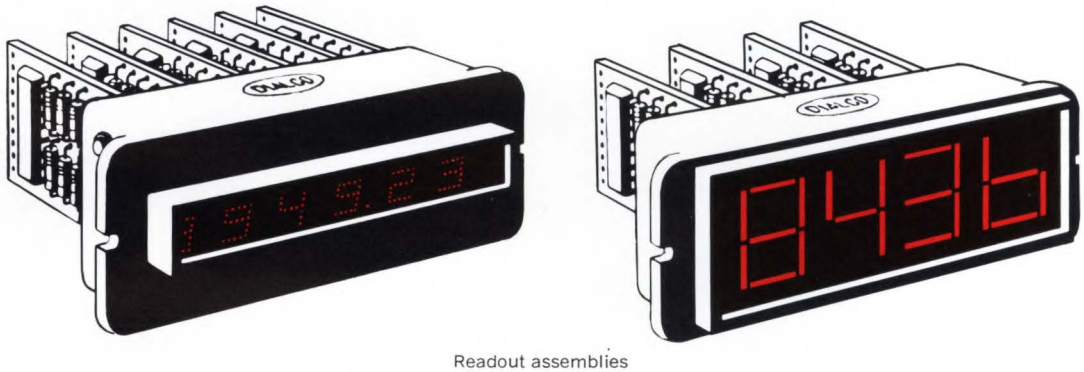
Indicator lights



Lighted push button switches



Readout modules and packages



Readout assemblies

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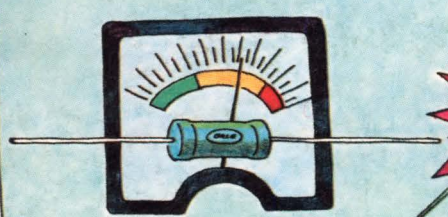
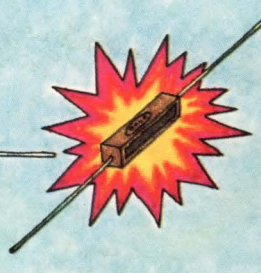


Shuntsmanship

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



Fuse News

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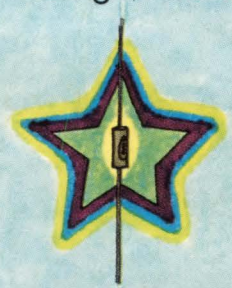

Wirepower in RN50 Size

Dale's tiny new RS-⅛ dissipates up to ¼ watt in .155". Operates to +275°C. Molded body can be automatically inserted. T.C. as low as ±20 PPM.
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WDP wirewound network handles up to 3.5 watts in standard 14-pin DIP size. Contains up to seven resistors which can have closely-matched tolerance (.1%) and T.C. (±5 PPM).
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