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EDN

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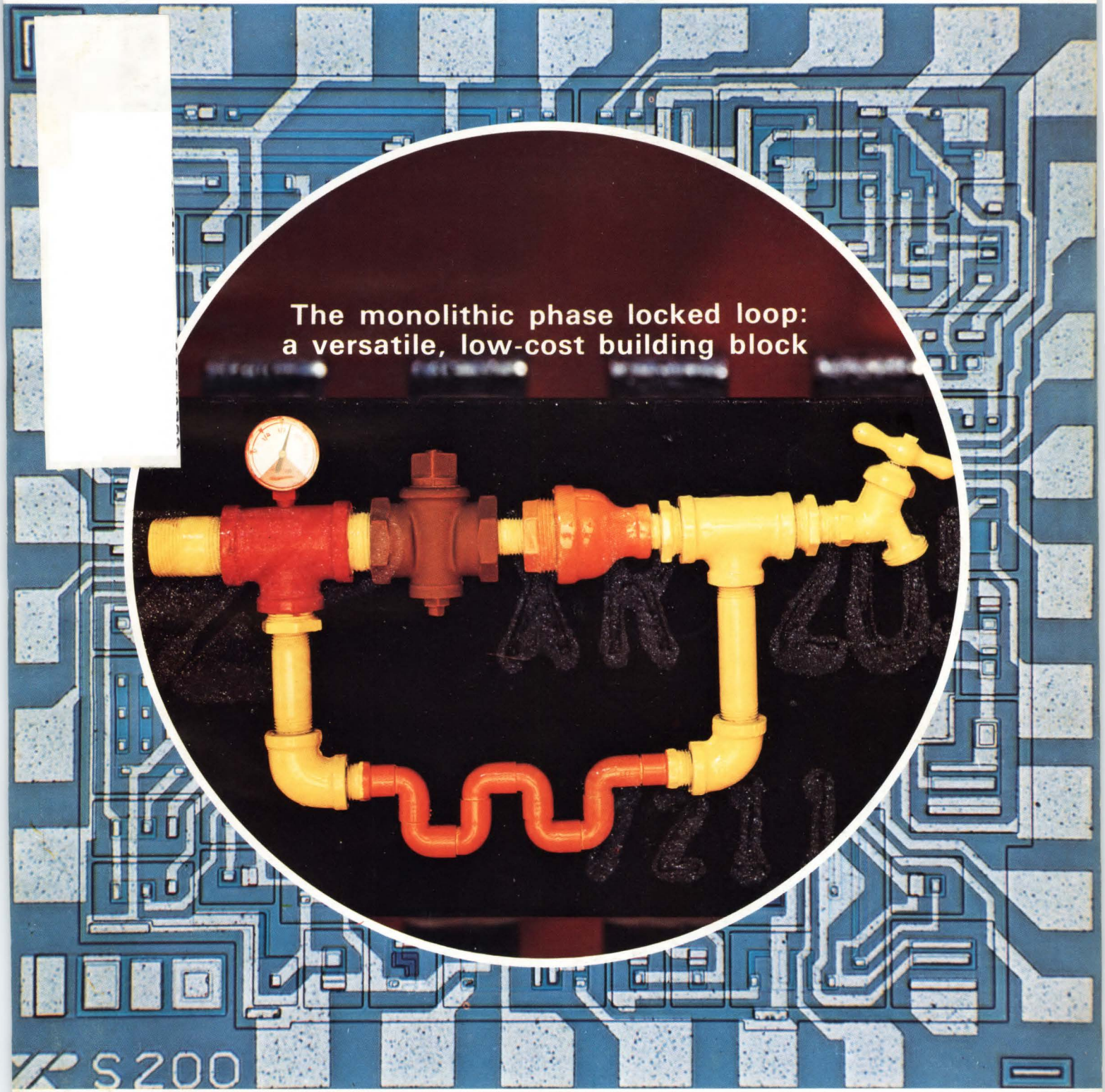
Conductive plastics solve tough design problems



A CAHNERS PUBLICATION

OCTOBER 1, 1972

power supplies for op-amps...$14

These 2.3 x 1.8 x 1-inch modules have tracking outputs of ±15V with regulation of ±0.1% and ripple of 1 mv. The Model D15-03 (25 ma outputs) costs $14.00 in 1000 lots and only $24.00 for one. The Model D15-05 (50 ma outputs) is $39.00. For ±12V, the model numbers are D12-03 and D12-05. Same prices. Three-day shipment guaranteed.

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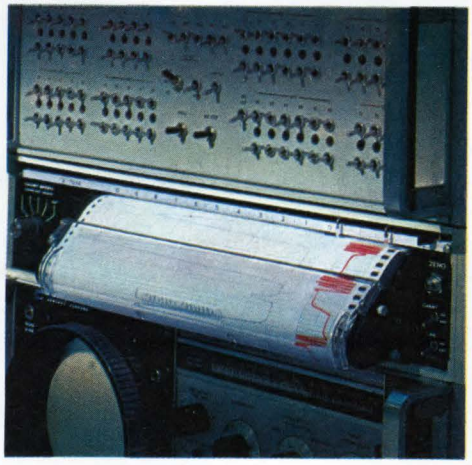
CHECK NO. 1

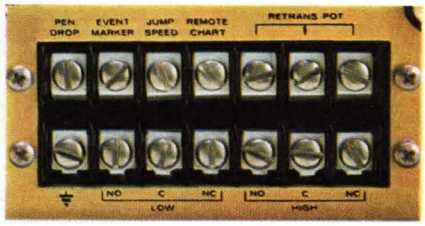
Nobody has to babysit this OEM strip chart recorder.



No more 2 a.m. bottles.
Electric writing option makes child's play of long-term unattended operation. Get a crisp clear trace without pen and ink.

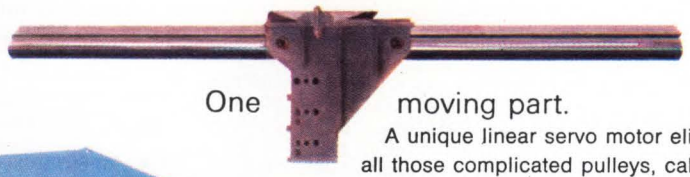
No more messy early morning pen changes.
Disposable pens make changes quick and clean. (Or electric writing eliminates pens altogether.)

OEM from the ground up.
HP's new 7100 strip chart recorder is built for dedicated OEM applications. You select from nearly 50 options to customize this 3½-inch-high recorder for any end-user system.

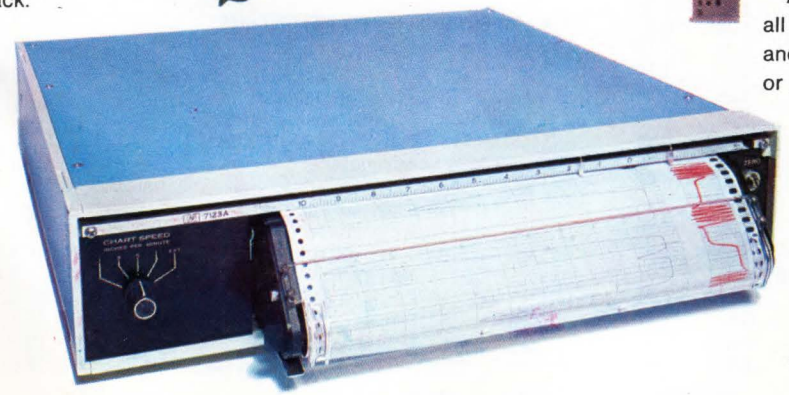


Swing out
to reload, half-rack or full-rack.

An electronic integrator is the simplest way yet to measure the area of a curve. Set zero along any point on the main chart.



One moving part.
A unique linear servo motor eliminates all those complicated pulleys, cables and slip clutches. No wirewound slidewire or boards full of touchy adjustments.



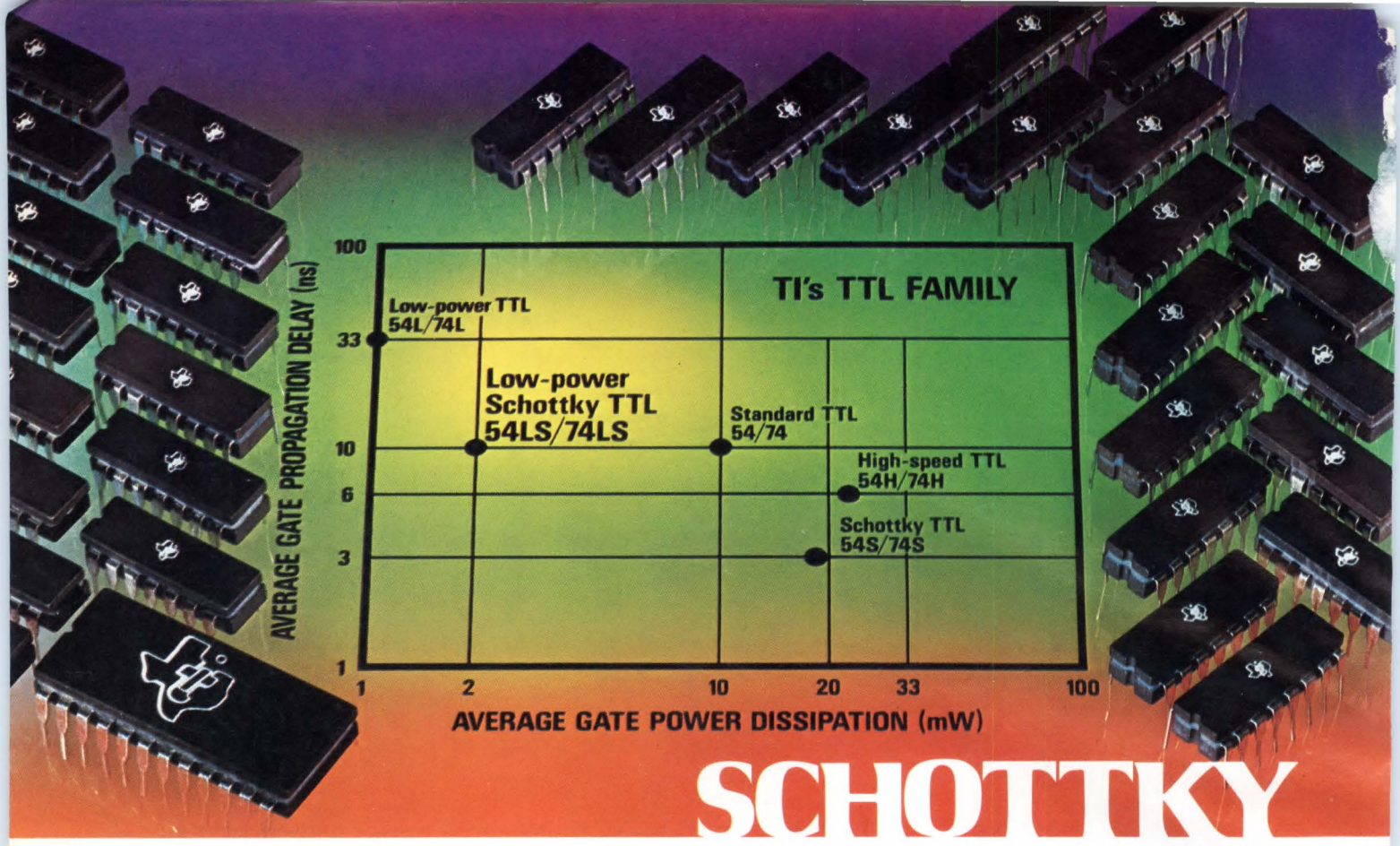
The uncomplicated new Model 7123 never cries for attention. Get details and oem discount data from Hewlett-Packard, Palo Alto, California 94304; Europe: 1217 Meyrin-Geneva, Switzerland.

HEWLETT hp PACKARD

Four-speed incremental chart drive option.

111-05

CHECK NO. 17



Low-power Schottky: 10 ns at <2 mW. Now available in ceramic DIPs.

The 21 SSI and 13 MSI circuits in TI's new low-power Schottky family now come in both plastic and ceramic dual-in-line packages. The new family offers all the performance of low-power TTL (Series 54L/74L) yet provides three times the speed (10 ns) at a power increase of less than 1 mW/gate. This greatly improved speed/power product makes low-power Schottky ideal for portable or remote systems or for any application where minimum power and TTL speeds are prime considerations.

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For data sheets, circle 215 on Service Card. Or write Texas Instruments Incorporated, P.O. Box 5012, M/S 308, Dallas, Texas 75222.

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SN54LS/74LS78 Dual J-K flip-flop, common clock	6.56	1.91
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SN54LS/74LS112 Dual J-K edge-triggered flip-flop	6.56	1.91
SN54LS/74LS113 Dual J-K flip-flop, no clear	$6.56	$1.91
SN54LS/74LS114 Dual J-K flip-flop, common clock and clear	6.56	1.91
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SN54LS/74LS95A 4-bit left-right shift register	16.39	4.78
SN54LS/74LS138 3-to-8-line decoder/ 1-to-8-line demultiplexer	16.39	4.78
SN54LS/74LS139 Dual 2-to-4-line decoder/ Dual 1-to-4-line demultiplexer	16.39	4.78
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SN54LS/74LS197 Presettable binary counter	16.39	4.78
SN54LS/74LS253 3-state version of SN54LS/74LS153	19.67	5.74
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If we didn't put a lot more quality into our capacitors, we couldn't get a little more for them

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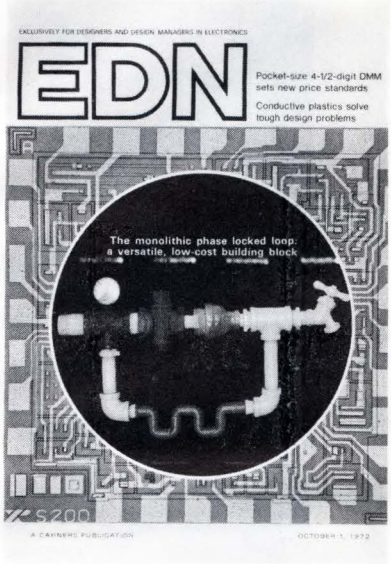
ELECTRONICS

CHECK NO. 6

OCTOBER 1, 1972
VOLUME 17, NUMBER 19

EDN with EEE
EXCLUSIVELY FOR DESIGNERS AND DESIGN MANAGERS IN ELECTRONICS



COVER

Although phase locked loops were originally used in RF circuits, they did not use the type of plumbing shown. For a rundown of the ways today's monolithic PLLs can be used as well as a look at what's available, turn to pg. 26.

DESIGN NEWS

DESIGN FEATURES

PROGRESS IN PRODUCTS

DESIGN PRODUCTS

DESIGN DEPARTMENTS

BPA ABP

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But we're doing 6 things to earn it.

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Resistors & Capacitors

for guys who can't stand failures

Fluke problem solvers

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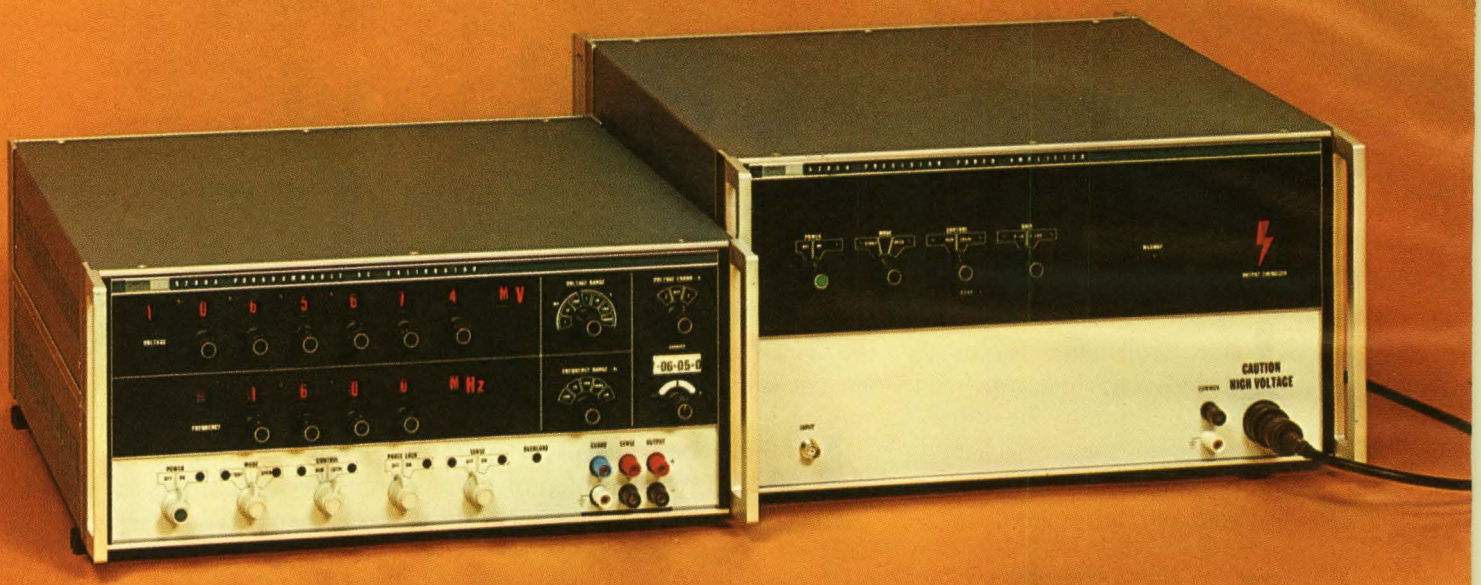

Here's the best ac calibration system you've ever seen. It's designed to give you state-of-the-art performance in the cal lab, in the factory or in automatic test systems.

The new system consists of the Model 5200A AC Calibrator and the Model 5205A Precision Power Amplifier.

Covering a frequency range of 10 Hz. to 1.2 MHz, the Model 5200A output is from 100 microvolts to 120 volts at current levels up to 50 milliamperes. Mid-band accuracy is ±0.02 percent. Short term amplitude stability is ±10 ppm. Six month stability, ±0.01 percent. Working with the 5200A, the Model 5205A provides output voltages from 100 volts to 1200 volts at current levels up to 200 milliamperes. Combined 5200A/5205A amplitude accuracy is ±0.03 percent.

The 5205A can also be used as a stand-alone amplifier providing programmable gains of X10 and X100 for frequencies from dc to 120 kHz. Output amplitudes from 1 millivolt to 1700 volts peak are offered for a wide variety of waveforms including pulses, sawtooths and triangles. All functions are remotely programmable with standard TTL logic levels. Uniquely, the 5205A can be programmed by both the 5200A and another control source so that it can be time-shared in an automatic system to perform a multitude of functions.

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FLUKE®

CHECK NO. 12

What's new in electronics?

Here we are going into the fourth and final quarter of 1972—a year that, if not as good as 1971 was bad, is still turning out to be a respectable year as far as electronics and the fields that it serves are concerned. Sales and profits are up for all but a very few companies, and the downward employment trends of 1970 and 1971 have been reversed. One could probably say, without fear of contradiction, that the field of electronics is resuming the upward spiral that began in the early 1950's and has continued with minor pauses ever since.

It is encouraging to see the transition that is being made from a military/aerospace dominated technology to a technology that is giving us items like hand-held calculators and electronic wristwatches that can be afforded by the masses. Everyone knows that if the electronics industry is to move upward from its $24 billion plateau, it must penetrate in a very large way the consumer, industrial, and commercial markets; and, happily, it appears to be doing just this.

At the risk of being a wet blanket, we'd like to interject a negative note in an otherwise positive picture. This has to do with what might be called revolutionary developments. The field of electronics has been carried forward over the past 20-25 years on the shoulders of such developments. The transistor, the integrated circuit, planar technology, digital-readout instrumentation—these are the types of developments that have advanced electronics without regard to area of application. And these are the types of developments that have kept American electronics in the forefront of what has become an international, no-holes-barred battle.

There are also the kinds of developments that are necessary if we are to continue the growth, both domestic and worldwide, that we have become accustomed to.

But where are the revolutionary developments? There hasn't been one in a while. So far it hasn't hurt us, because no other country has come up with one either. But this is a fierce competition we are in. Not just for today's markets, but for tomorrow's as well. And if we concentrate too much on penetrating today's markets, at the same time scrimping on R&D, which provides tomorrow's markets, we could find ourselves in dire trouble in not too many years. So if we have any leverage on expenditures for R&D activity, let's exert it.

Frank Egan

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CHECK NO. 10

The most usable TTL Data Book for the most usable TTL Family. 250 circuit functions in plastic or ceramic packages.

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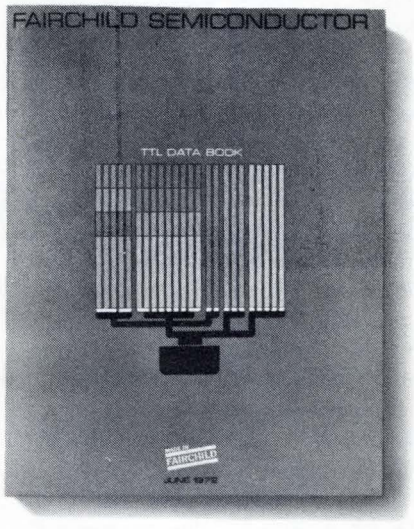
The TTL bible is structured to provide the designer with precise data on our TTL family in the most accessible form. He can find what he's looking for quickly and easily, whether he starts with a device number in any well-known series (9300, 5400/7400, etc.) or simply the device functional nomenclature. The indices and selection guides will direct him instantly to those devices suitable for his application, and complete specifications from which he can determine his best choice. A comprehensive industry cross-reference provides an overview of all major sources of TTL devices and their Fairchild equivalents.

The Fairchild TTL Family is a mix of more than 1,000 proprietary and second source device and package combinations selected to give the designer the broadest choice of performance/cost trade-offs to optimize his system design. Over 100 new devices have been added to the family in the last year alone. There are logic, memory and interface functions in plastic, ceramic or flatpak, commercial or military temperature grade. Together, they provide a comprehensive line of standard off-the-shelf building blocks that can be interfaced directly with each other in the same system for maximum speed/power efficiency.



We offer more than 100 MSI devices, both proprietary and second source, that are widely accepted as the keys to optimum TTL system design.

For example: Our proprietary devices include the most complete range of TTL memories available anywhere – from 8-bit scratchpad registers to our new 93415 1024 x 1 bit RAM (made by Isoplanar) that has 60ns access time at 0.5mW/bit.

Our 9344 parallel multiplier eliminates a lot of hardware and software.

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250 proprietary and second source circuit functions:

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- 74H00 High Speed SSI
- 74S00 Schottky SSI
- 9300 and 54/74 Standard MSI
- 9600 Monostable & Interface devices
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Bill to put engineers on civilian priorities has chance of congressional passage

92D CONGRESS
2D SESSION

S. 32

AN ACT

To amend the National Science Foundation Act of 1950 in order to establish a framework of national science policy and to focus the Nation's scientific talent and resources on its priority problems, and for other purposes.

AUGUST 18, 1972
Referred to the Committee on Science and Astronautics

Bill S.32 that would set up a "NASA-Like" program to work on domestic problems such as pollution, transportation, housing, etc., passed the Senate on August 17th with a 70 to 8 vote, and looks as though it will pass the House this year if the Representatives can get to it before adjournment. The Senate cut the bill down from its original $1.8 billion level to $1.025 billion, but otherwise substantially retained the spirit of the proposals by sponsor—Senator Kennedy. According to estimates by Kennedy's office, this would still be enough to create about 23,000 new jobs for engineers by 1975.

The fact that 32 of the passing votes came from Republicans is considered important by Kennedy's office as S.32 was strongly opposed by the White House and a number of government agencies. It has been warmly supported by engineering organizations such as the N.S.P.E., IEEE, ASME and the American Society of Metals.

The bill provides $800 million to set up the programs to tackle specific national problems. The remaining $200 million would be used to help aerospace engineers make the transition to the programs. It would be administered as a new autonomous part of the National Science Foundation. The membership of the NSF's policy-making board will be broadened by S.32 to include more industrial and technical members (rather than just the university science types running the NSF at present) to provide the direction for the new programs. They will be nominated solely on the basis of their eminence in science and engineering, according to the bill's wording.

Ellis Mottur, who serves as science advisor under Kennedy on this bill, told EDN, "This is only the beginning. I think this could have as big an impact in this decade as the Space program did in the last. Our bill ties the employment of scientists and engineers to these domestic problems in ratio to the growth of our country's GNP."

In the wording of S.32, "Federal obligations for civilian research and engineering activities must be increased so as to reach a level of parity with Federal obligations for defense research and engineering activities, whereupon the level of parity must be maintained or exceeded, except when inconsistent with overriding considerations of national security."

The White House's objections

Engineers who have the feeling that they and their talents have been ignored by Washington will be fascinated to learn that they have become a political football between President Nixon and Senator Kennedy, with respect to this bill. Nixon's official view as expressed in writing to Kennedy's office and reaffirmed by the office of the White House Science advisor, Dr. Edward E. David Jr., run along the following lines.

Engineering unemployment has been greatly overblown. The present programs advanced by the White House are sufficient to take care of engineering unemployment. S.32 would amount to preferential welfare for engineers who are but a small segment of the total U.S. population.

Mottur countered these objections by emphasizing that the bill is really more important to the Nation than to engineers. The important thing is to direct the talents of engineers towards our pressing domestic problems. They represent a national resource we cannot afford to waste. (Besides, EDN gathered from remarks by Mottur that Democrat Kennedy considers most engineers conservative Republicans at heart, men that he could not easily expect to win over to his party.

Both the White House and Kennedy's office agree in principle that putting engineers to work on earth-bound domestic problems is, like motherhood, a good idea. The difference seems to lie in how much of that Nation's budget ought to be directed towards this end. Kennedy (like McGovern) talks in the billions; the White House talks in the hundreds of millions. Another difference is that the White House believes that private industry ought to be doing more of the job of putting engineers back to work on its own, now that the economy is recovering.

How about technical content?

One bone of contention with respect to using sophisticated aerospace engineers on civilian projects has been the question of whether these earth-bound domestic problems really need an engineer's talents. It was on this score and citing the low technical content they saw in problems like urban renewal that Senators Dominick, Packwood and Taft asked that the authorization level for S.32 be reduced.

However, an interesting counter-argument appears in one of the paragraphs that accompanied the original bill. This paragraph suggested that even mundane problems can have a sophistication if they are viewed on the "systems" level. □

Product trial reveals flaws that lab tests did not

A designer can never be too sure of a product until it has had its "bath-of-fire" in the hands of customers. This truism was illustrated again in August by the field trial of a new electronic gambling machine at the Riverside Hotel, Reno, Nevada. The machine, a numbers-type console by Datek West (an affiliate of Datek Corp.), Sparks, Nevada, had already performed flawlessly during engineering laboratory evaluations and a previous month's trial at the Nevada Gaming Commission. But once it got into the hands of customers on the Riverside's casino floor, it showed up several unforseen flaws.

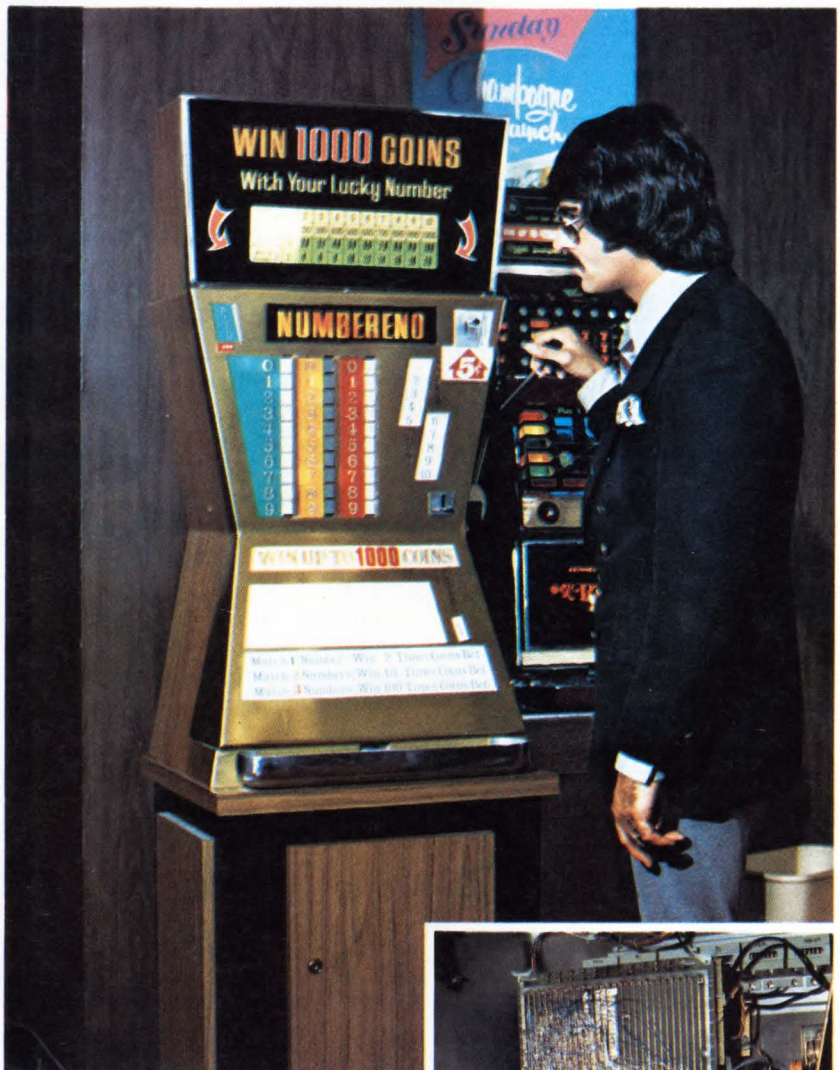
The design was quite sophisticated for a gambling machine for there were about 70 IC logic packages (7400 TTL). These performed as expected according to Datek designer Barry Brown. "I was well aware of the static electricity that a customer can apply after walking across the typical plush carpets of these Nevada gambling rooms," Brown said, "and I kept the wiring lengths as short as possible."

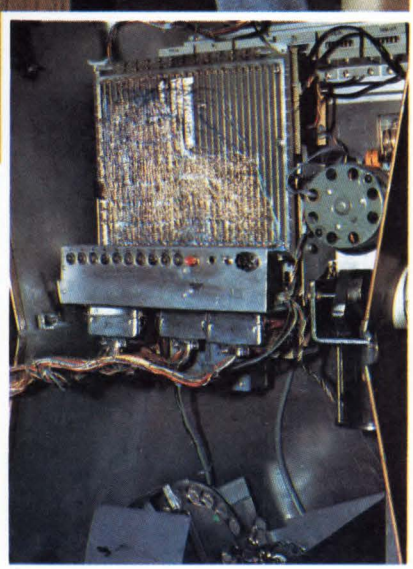
"We got problems not from the electronics directly, but from an electromechanical wheel we used to generate the random numbers. We could have generated them electronically but that wouldn't have given the customer the feeling that he could see the action taking place—like a wheel of fortune spinning and slowing to halt at a given number. Our wheel has rivets which are sensed by variable-reluctance pickups."

"Unfortunately, we made it too easy for the customer, and some of the more determined gamblers at the Riverside began to time their pull of the actuating handle so as to up their odds just enough to turn the machine into a looser for the casino. We fixed this by putting in three P.U.T. type oscillators to introduce a chance delay at the beginning of the wheel's spin, so we could regain control of the odds."

"This fix led to our second problem," Brown said. "We had placed a sign on top of the machine to attract customers. A shift-register drive caused this to flash a come-on, 'Win a thousand coins with your lucky number,' and then all the machine's lights would flash on in gaudy sequence. This seemingly harmless addition caused the machine's internal temperature to rise from 40°C to 60°C, and that caused the three P.U.T. oscillators of our first fix to become erratic. So our second fix was to substitute hex inverter oscillators. The wire-wrap packaging I'd used for the prototype made these changes easy, thankfully."

In retrospect, Brown says that every designer ought to have some watchdog like the Nevada Gaming Commission that forces gambling-machine designers to go through these trial steps. "Now, as we swing into production of our first lot, we have a lot more confidence that most of our surprises are over," he said. □





Electronic gambling machine on trial at the Riverside Hotel, Reno, Nevada. It was learned that a dedicated gambler could beat it and more electronics was added to return the machine to profitability. Machine's insides show the extensive use of TTL logic and the motor that drives the random-number generator. The wire wrapped connections on the large Cambion board made design fixed during the trial easy. The electronic gambling machine was designed and manufactured by Datek West, Sparks, Nevada. A future article by Datek West design engineer, Barry Brown, will describe the layout technique he developed for minimizing wire lengths.

Demand for engineers rises while decrease in college enrollment continues

The need for technical people, showed a 44.6% increase during the first six months of 1972 reports Deutsch, Shea and Evans, Inc., New York. At the same time that the immediate employment picture for engineers begins to brighten, the source of future engineers continues to drop.

In doctorate-granting institutions, first-year, full-time graduate science enrollment decreased 5% between 1970 and 1971, after decreasing 2% in the previous year according to the National Science Foundation. (NSF), Washington, DC.

New York University, one of the nation's largest private schools, has announced plans for closing its school of engineering.

The Engineer/Scientist Demand Index, **Table 1,** maintained by DS&E (Deutsch, Shea & Evans), shows a continuing upward trend, which in June reached 67.2 (the year 1961 is used to provide a base of 100), the highest level in 27 months. "Though overall demand still remains relatively low," says a DS&E spokesman, "this sustained upturn is encouraging evidence that the employment market for technical people has turned a corner." The demand index is compiled from newspaper and technical journal advertisements.

ENGINEER/SCIENTIST DEMAND INDEX
(1961 = 100.0)

	Jan.	Feb.	March	April	May	June
1962	138.0	134.7	131.2	140.0	141.6	120.2
1967	170.7	152.8	133.1	158.2	155.4	140.7
1971	37.4	43.1	42.7	39.2	42.5	37.3
1972	46.4	56.7	55.6	65.6	58.5	67.2

While engineering held first place in the total number of graduate students enrolled in 1971, the general decline in graduate enrollment occurred in all areas of science except psychology and the social sciences.

The continuing downward trend is due to a number of factors including the decline of the engineer/scientist demand from 1967 to the present.

In 1971, the Federal Government reduced its share of support of full-time graduate students to 32% from 37% in 1969. There was a corresponding increase in self supported students—from 19% in 1969 to 22% in 1971. From 1970 to 1971 federally supported fellowships and traineeships were reduced by 13% and research assistantships by 5%.

The physical science students relied on self-support to the least extent; social science students the most. The Federal Government provided support to almost 40% of the full-time students in four areas of science—physical and life sciences, psychology, and engineering. Students receiving institutional support were concentrated in the physical and mathematical sciences.

While total graduate enrollment declined, from 1970 to 1971 full-time graduate faculty (those teaching at least one graduate course or directing at least one graduate student) increased slightly although less than 1% and post-doctoral appointees increased by 5%. Also, as in past years, over one-fourth of all graduate faculty were engaged in the life sciences.

Over 80% of the postdoctoral appointees were engaged in the physical and life sciences. This percentage closely corresponds with the proportion of R & D expenditures in these fields reported by doctorate-granting institutions for the academic year 1970-1971. □

Thin LED display to replace CRT radar pictures for air-traffic controllers

A prototype of this new display was demonstrated at the Farnborough Europe '72 Airshow this September by GEC-Marconi Electronics Co. The display itself is less than an inch thick and was used as a Distance-From-Threshold-Indicator (DFTI)—a small radar display used to provide air traffic controllers with approach or take-off path radar pictures. Display brightness can be as high as 1000-foot lamberts, thus it is quite suitable for high ambient light levels.

The new display uses a matrix of gallium arsenide phosphide diodes, mounted in groups and wired directly on a pc board. The diodes are wired in rows and columns so that any diode can be energized by supplying a voltage across one row and one column, similar to addressing a memory array. Spacings are close enough to provide 1/4 mile resolution of the radar picture.

Apart from a 5V, 15W power supply, the only inputs required are the radar turning information and the raw radar signals after they have been passed through a moving target indication system.

Turning information is converted to digital form to provide 'x' and 'y' co-ordinates of the radar range and azimuth. The radar video signals are passed through a target extractor unit and then to a small 512-bit central memory. As each radar signal enters the memory, the 'x' and 'y' position co-ordinates are stored together with a time signal derived from a central timing clock. This time information controls the effect of 'persistence' and the point at which each new signal is erased from the memory.

Switching current is reduced for each successive sweep in which a particular stored position is scanned to give the effect of a gradual decay in brightness, similar to the afterglow of a CRT. This also gives a "directional tail" to the aircraft as it moves across the screen. The memory is completely scanned at a 400 Hz rate, which produces no observable flicker on the display panel. □

No. 15-72

SEMICONDUCTOR
NEWSBRIEFS

PUBLISHED BY MOTOROLA SEMICONDUCTOR PRODUCTS INC.

Schottky Barrier Rectifiers Break Through To 40 V, 40 A

In 1970, Motorola technology brought you the first Schottky barrier rectifiers – with a peak inverse voltage rating of 20. In 1972, Motorola technology breaks through again – with the first 40 volt devices in the industry. Now you can get 12 new Schottkys ranging from 5 to 40 amperes in 20 V, 30 V, or 40 V PIV. And they're all JEDEC registered!!

Motorola Schottky technology uses majority carrier operation to do away with stored charge resulting in reverse recovery times that are virtually unmeasurable. Operation continues well up into the megahertz range.

Motorola Schottky technology uses epitaxial construction, oxide passivation and very closely controlled metal overlay contacts to produce surge capacity 3 to 5 times greater and forward voltage less than half that of conventional silicon power rectifiers.

When you use Motorola Schottky technology, you get:

- Rectification efficiency flat to beyond 100 kHz – perfect for high-efficiency switching power supplies.
- Power loss 50% less than with conventional power rectifier diodes. You use smaller heatsinks and transformers. Save space, weight.

Even when compared with existing Schottkys, Motorola technology comes through. The new Schottkys feature much lower leakage and transient voltage sensitivity, greater temperature stability and a higher operating junction temperature range to +125°C.

The new Schottkys are supplied in 4 current ratings, each in the 3 voltages – 20 V, 30 V, and 40 V. 1N5823, 4, 5 are 5 A versions in a metal axial lead case; 1N5826, 7, 8 are 15 A, DO-4 stud devices; 1N5829, 30, 31 are 25A, DO-4 stud cased devices; and 1N5832, 3, 4 are 40 A, DO-5 versions. And Motorola Schottkys will soon be available in plastic.

Let Motorola Schottky technology rectify your situation. See your Motorola salesman for evaluation samples and information.

For details, circle 50

Where Op Amps Go, ±15 V Regulator Follows

Mary had her little lamb, and now linear system designers have the MC-1568. For, everywhere their op amps go this dual ±15 V tracking regulator is sure to follow.

Both the MC1468 version and the full MIL temperature range MC1568 represent the best value/price-performance combination available in dual polarity tracking regulators. In addition to the standard metal and dual in-line ceramics, Motorola offers the "R" metal power package. Its 2.4 W power dissipation permits full use of the MC1568's 100 mA load current capability when running at higher voltages. And the MC1568 can handle input voltages up to ±30V.

Other important features of the MC-1568 regulator are excellent tracking with output voltages balanced to ±1%, and output voltage temperature stability assured to a maximum 1%.

Outputs are pre-set internally to ±15 V with initial tolerance of 0.2 V (max) at currents up to 100 mA. When desired, a simple external adjustment is all that's needed to change them. Line and load regulation are 0.6%.

Prices are amazingly low for devices of this sophistication. The MC1468G is a mere $2.80, the L version only $2.90, and the R a modest $3.75. MC1568G, L, and R range from $6.25 to only $7.00. Give a little lamb a place to go. Contact your Motorola distributor or sales office.

For details, circle 51

McMOS Grows On All Sides!

McMOS is the name, growth is the game. We've regularly recited the complementary MOS litany for more than a year: CMOS is the new logic for low power systems . . . CMOS is the new logic for noisy control systems . . . CMOS is the new logic for battery operated and battery back-up remote systems . . . And it's true. McMOS is the low power logic of the seventies.

And before you can say "Leading Edge Of Digital Technology," CMOS will present to designers like you a full range of system optimized functions on a broad scale providing a combination of benefits other digital technologies can't. No complementary MOS line has met this need completely. But McMOS is stretching . . . maturing . . . growing fast! And growth has already led to new lower pricing, too.

Twenty-nine new MSI and simpler functions were introduced from the first of the year through September. The result is an effective combination of the most popular second-source devices with carefully-designed, original Motorola functions filling in the gaps.

Benefits are as great as they have been from the beginning! And prices are even better.

- Lowest quiescent power dissipation . . . 10 nW per gate.
- Top noise immunity – 45% of V_{DD} (typ).
- Single supply operation – plus or minus – over a 3 to 18 V power supply range.
- Simple digital interfacing.
- Choice of standard mil operating temperature range: −55° to +125°C or unusually wide commercial temperature range: −40°C to +85°C.
- And more!

All types listed are available now.

EXPANDING McMOS FAMILY

These recent introductions have been added to the 20 devices previously available in the continuously expanding McMOS low power logic family. New low prices are available on McMOS logic, too, with some devices reduced more than one third.

Motorola Device #	Function	Replaces Pin-for-Pin	Price (100-999)
MC14000AL/CL	Dual 3-Input NOR Plus Inverter	CD4000AD/AE	3.10/0.78
MC14006AL/CL	18-Bit Shift Register	CD4006AD/AE	9.10/3.89
MC14007AL/CL	Dual Pair and Inverter	CD4007AD/AE	2.65/0.78
MC14008AL/CL	4-Bit Full Adder	CD4008AD/AE	10.15/4.02
MC14009AL/CL	Hex Inverter/Buffer	CD4009AD/AE	5.25/1.69
MC14010AL/CL	Hex Inverter	CD4010AD/AE	5.25/1.69
MC14016AL/CL	Quad Analog Switch/Quad Multiplexer	CD4016AD/AE	5.15/1.62
MC14023AL/CL	Triple-3 NAND Gate	CD4023AD/AE	3.40/0.78
MC14028AL/CL	BCD Decimal Decoder	CD4028AD/AE	7.92/3.67
MC14032AL/CL	Triple Full Adder (pos)	CD4032AD/AE	6.91/4.24
MC14038AL/CL	Triple Full Adder (neg)	CD4038AD/AE	6.91/4.24
MC14040AL/CL	12 Stage Binary Counter	CD4040AD/AE	10.20/5.40
MC14506AL/CL	Expandable A.O.I.	—	4.64/2.24
MC14516AL/CL	Binary Up/Down Counter	—	11.47/6.35
MC14522AL/CL	Programmable BCD Divide-by-N 4-Bit Counter	—	11.85/6.60
MC14526AL/CL	Programmable Binary Divide-by-N 4-Bit Counter	—	11.85/6.60
MC14527AL/CL	BCD Rate Multiplier	—	11.85/6.60

For details, circle 52

SEMICONDUCTOR newsbriefs
No. 15-72

Published by Motorola Semiconductor Products Inc., P. O. Box 20912 • Phoenix, Arizona 85036

Twelve MTTL Complex Functions Increase Your Design Options

Reduce package count, increase logic per function with 12 new MTTL building blocks – four data selectors, three counters, two shift registers, a bus transfer switch, encoder, and decoder.

Ideal for data-routing and multiplexing, the MC54150/74150 16-channel data selector generates any five-variable Boolean function. And for multiple data in and/or multiple data out jobs use the MC54460/74460 bus transfer switch.

Looking for 4-bit storage? The MC8280/7280 4-bit shift registers can divide decade or binary (MC8281/7281) or act as storage registers. The MC8280/7280 is sectioned into divide-by-two and divide-by-five functions (decade) while the MC8281/7281 is sectioned into divide-by-two and divide-by-eight functions (binary).

Decoding is simple with the MC9307/8307 BCD-to-seven segment decoder. It accepts a 4-bit BCD 8421 code input producing outputs for seven-segment displays. The MC9318/8318 8-input priority encoder converts a one-of-eight code to a 3-bit binary code in order of priority, with $\overline{D}$ assigned the highest priority.

Input/output conversions are prime applications for the MC8270/7270 and MC8271/7271 4-bit shift registers. And the MC9306/8306 presettable decade up/down counter offers four synchronously driven master-slave J-K flip-flops.

All are exact replacements – pin and function – for older designs and are available in limited and full temperature ranges. Call for evaluation units today.

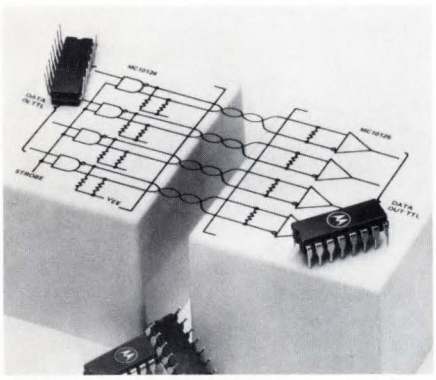
TYPE NO.	FUNCTION	PRICES (100-UP)
MC54150L MC74150L,P	16-Channel Data Selector	$9.70 6.45(L)/4.30(P)
MC54151L MC74151L,P	8-Channel Data Selector	$9.00 6.00(L)/3.45(P)
MC54460F,L MC74460F,L,P	Bus Transfer Switch	$8.05(F,L) 4.10(F,L)/3.15(P)
MC8266F,L MC7266F,L,P	2-Input, 4-Bit Data Selector	$6.08(F,L) 4.05(F,L)/2.70(P)
MC8267F,L MC7267F,L,P	2-Input, 4-Bit Data Selector (Open Collector)	$6.08(F,L) 4.05(F,L)/2.70(P)
MC8270F,L MC7270F,L,P	4-Bit Shift Register	$6.42(F,L) 4.28(F,L)/2.85(P)
MC8271F,L MC7271F,L,P	4-Bit Shift Register	$6.42(F,L) 4.28(F,L)/2.85(P)
MC8280F,L MC7280F,L,P	Presettable Decade Counter	$5.40(F,L) 3.60(F,L)/2.40(P)
MC8281F,L MC7281F,L,P	Presettable Binary Counter	$5.40(F,L) 3.60(F,L)/2.40(P)
MC9306L MC8306L,P	Presettable Decade Up/Down Counter	$11.55 7.70(L)/5.15(P)
MC9307F,L MC80307F,L,P	BCD To Seven Segment Decoder	$7.88(F,L) 5.25(F,L)/3.50(P)
MC9318F,L MC8318F,L,P	8-Input Priority Encoder	$12.00(F,L) 6.00(F,L)/4.20(P)

F Suffix = Ceramic Flat Pack
L Suffix = Ceramic Dual In-Line Pkg.
P Suffix = Plastic Dual In-Line Pkg.

For details, circle 53

MECL 10,000 Translators And Multiplexer/Latches Now Available

Mate low speed TTL sections with high speed ECL systems easier with the MC10124 MTTL to MECL translator and the MC10125 MECL to MTTL translator.



MECL 10,000 translators can materially improve data transmission within a TTL system.

The MC10124 is a quad translator having TTL compatible inputs and MECL complementary open-emitter outputs that allow its use as an inverting/non-inverting translator or as a differential line driver. Typical prop delay is 5.0 ns. MC10124 can drive 50 ohm lines with high fanout capability.

MC10125 is a quad translator incorporating differential inputs and Schottky TTL "Totem Pole" outputs. Differential inputs allow its use as an inverting/non-inverting translator or as a differential line receiver. And a V_{BB} reference voltage is available for Schmitt trigger applications.

The translators can also improve data transmission between TTL equipments. In the illustration, the complementary outputs of the MC10124 drive a twisted pair data line connected to the differential receiver inputs of the 10125. This application provides a toggle rate typically in excess of 75 MHz, excellent noise rejection, and the quad translators offer minimum package count over conventional duals.

Two new multiplexer/latches are ideal for application in high speed central processors, register files, instrumentation, and high speed digital communication systems. The MC10132 dual multiplexer with latch and common reset provides a common select input for both latches. Information selected at the input is latched on the rising edge of the clock pulse. The common reset input is used to reset the latches.

The MC10134 offers two latches with separate select inputs for each of the two pairs of data inputs. Each select input determines the information that will be provided to the appropriate latch.

All four devices are available in the 16-pin dual in-line ceramic package (L). 100-up prices are: MC10124L – $4.50; MC10125L–$4.50; MC10132L–$5.02; MC10134L – $5.02.

Evaluate these new additions to the expanding MECL 10,000 line.

For details, circle 54

First Plastic Power Darlingtons Registered

Here they are! — the first 2N-registered plastic power Darlingtons with super-high gain, voltage and current for those super-low-priced series regulators, hammer drivers and general-purpose amplifiers.

They're the 2N6040 series of 5 and 8 A THERMOPAD devices in two optimum plastic packages. And they're complementary, too, for your transformerless, direct-coupled designs.

Gain? Much! 2,500 h_{FE} typically at 4 amperes with 1,000 minimum spec'd. Lets you go from milliamperes to amperes directly, compatibly and easily with T^2L-to-Darlington hookups. No bother with interface componentry.

Voltage? High! Up to 100 V sustaining capability for your more demanding designs. Safe operating area is excellent with all types providing 1.5 A @ 40 V SOA. On the other end of the scale, a low, low, 2V maximum saturation voltage ensures minimum power loss.

Packaging? Optional! Your choice of the ever-popular, THERMOPAD case 90 with all the traditional, high-efficiency, compact mounting advantages or the newer, easy-mounting THERMOPAD case 199 offering more power-handling, more lead forms, more chip sizes, and more technology than TO-220 parts.

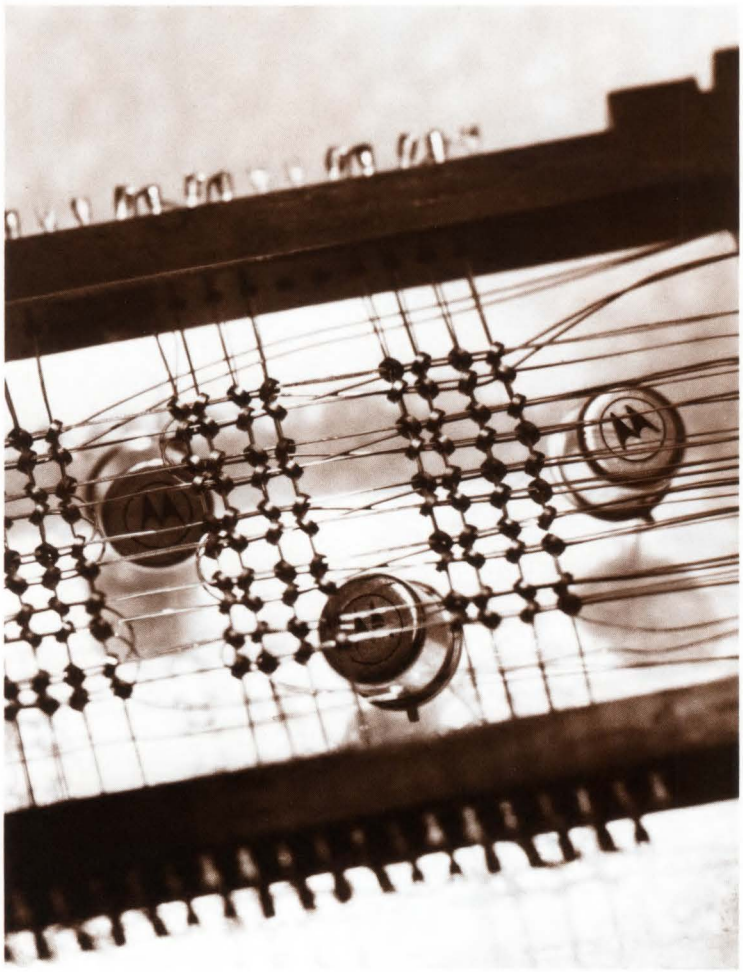
Other advantages include 60 and 80 V ratings, monolithic construction with emitter-base resistors on the one chip, and low price tags. To prove the last, the 2N6043 is only $1.64, 100-up. Not only better-than-discrete performance, but better in price, too!

Check the specs . . . then see your distributor about evaluation units.

		1-99	100-999
Case 90/199	2N6040/MJE6040	$3.05	$2.31
	2N6041/MJE6041	3.33	2.52
8 A	2N6042/MJE6042	3.83	2.90
60-100 V	2N6043/MJE6043	2.14	1.64
NPN/PNP	2N6044/MJE6044	2.37	1.83
	2N6045/MJE6045	2.77	2.14
Case 90/199	MJE1090/2090	2.70	2.05
	MJE1091/2091	2.90	2.23
5 A	MJE1092/2092	3.10	2.40
60-80 V	MJE1093/2093	3.50	2.65
NPN/PNP	MJE1100/2100	1.82	1.40
	MJE1101/2101	1.99	1.53
	MJE1102/2102	2.21	1.70
	MJE1103/2103	2.44	1.88

For details, circle 55

2N3725 Joins The Motorola Core Corps



Whether your frames are large or small, Motorola's 2N3725 gets to the core of the induction problem by providing a 50 volt BV_{CEO}.

Here's a new recruit to help you restore core to its rightful place in the store war. After a short campaign as a house quad in the dual in-line ceramic case, the NPN silicon Annular memory driver transistor that offers the best trade-off between high breakdown voltage and fast switching is here fully armed and JEDEC registered as the 2N3725.

The high f_T and low C_{ob} of the 2N-3725 assure fast switching (at 500 mA, t_r is typically 18 ns, t_f is 15 ns) yet BV_{CEO} is a high 50 V minimum to prevent problems from the "kickback voltages" induced by switching highly inductive lines. And Motorola's 2N3725 is the first to offer the JEDEC-required 500 mA $V_{BE(sat)}$ of 0.8 to 1.1 V.

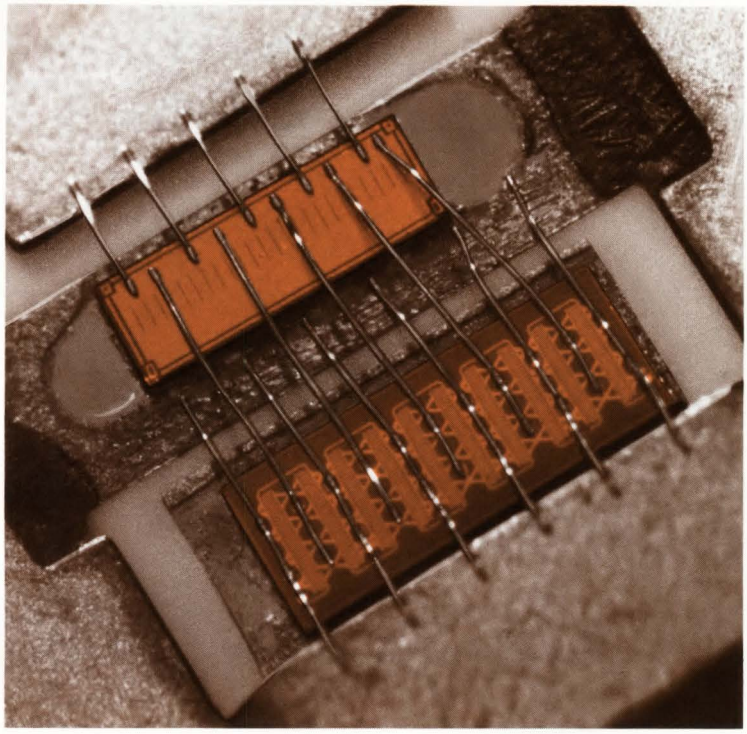
Whether your application is voltage or current driving or both, 2N3725 has the gain, h_{FE} is 35 (min) at 500 mA. And the popular driver is supplied in the TO-39 outline package with untwisted ½" leads for quick, easy assembly into your systems.

Look for the core corps to grow into a driving army. 2N3725 is just the latest recruit. More enlistments announced this fall.

See your nearest Motorola salesman for more information on the 2N3725. And don't let its 100-up price of 75¢ change your battle plans — we're competitive.

Up your esprit de core. Think 2N3725!!

For details, circle 56



Controlled-Q RF transistors employ MOS capacitor chips to transform base impedance and improve broadband performance.

RF Technology Controls Q For Broadband Performance

Brilliant new lights in the RF spectrum – the new MRF618 and MRF620 NPN silicon RF power transistors for large signal applications to 520 MHz in frequency-modulated industrial/commercial equipment. They're operated by 12.5 V supplies.

And, they have Controlled-Q!

Latest evolutionary highlight in the Motorola-developed Stripline-Opposed-Emitter configuration, Controlled-Q devices employ internal impedance-transforming techniques to lower Q at the base aiding broadband designs. An MOS capacitor chip is connected in a T-network with internal and external lead inductances to transform the typical 0.5 ohm input impedance to 4 ohms at 470 MHz. Broadband performance is improved, input matching network problems reduced. And the flange-mounted, Controlled-Q package permits easy, one-sided assembly into your amplifiers.

Characterization provides series-equivalent, large signal parameters. Major specs are: With a 12.5 V supply, MRF-620 offers 40 W at 470 MHz, 4.3 dB minimum common-emitter gain. Collector efficiency is 55%. Under the same conditions, MRF618 provides 15 W, 6.0 dB minimum gain and collector efficiency of 60%.

Rugged? . . . MR620 and MR618's Isothermal chips utilize nichrome-resistor emitter ballasting techniques for load mis-match protection. Isothermal design decreases emitter current under load mismatch conditions and compensates for variations in local temperatures over the chip. They're tested for a 20:1 VSWR at all phase angles at rated output power. So you know they'll last and *last!!*

To focus on the potential performance of an amplifier built using MRF618, we did just that, built a broadband amplifier using 2N5944/MRF618. Testing showed that with 120 mW in, the 11 W output was flat from 410 to 510 MHz. VSWR was less than 1.5:1 across that band.

Try MRF620 or 618 in your amplifier. They're on your distributor's shelf today at the 25-99 price of $40.00 (620) and $21.00 (618). But wear your sunglasses.

For details, circle 57

Hybrid IC Line Fattened By Five Fet Analog Switches

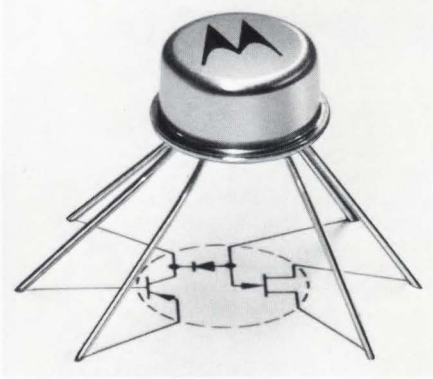
Five new analog switches – the MCH-2222-1,2 and MCH2223,1,2,3 – are now offered as standard off-the-shelf functions.

The hybrid ICs feature as low as 10 ohms (max) drain-source "ON" resistance at 1.0 mA and a signal handling capacity up to 20 volts peak-to-peak.

Minimum signal error is assured by zero intrinsic offset voltage and outstanding logic noise isolation.

They're designed for switching applications in A/D and D/A converters, sample and hold circuits, and track and hold circuits for instrumentation and in modulators and demodulators for communications equipment.

Both the MCH2222 and MCH2223 series have other important applications in solid state relays, commutators, gain changers and in general-purpose low-level switching. Their low static drain-source "ON" resistance capability offers designers minimum voltage loss and they have a nimble 300 ns typical turn-on and turn-off switching time.



Separate FET, transistor and diode chips on a common substrate are wire-bond connected in the MCH2222/23 series of Fet Analog Switches.

For details, circle 58

Available in 6-leaded TO-5 metal cans, and are mechanical pin-for-pin replacements for competitive devices.

Warehouse shelves are now well-stocked with devices carrying the following 100-up price tags:
MCH2222-1: $5.60 and MCH2222-2: $6.00; MCH2223-1: $10.00; MCH-2223-2: $15.00 and MCH-2223-3: $21.50.

NEW PRODUCT BRIEFS

MLM 101A OP AMP SERIES

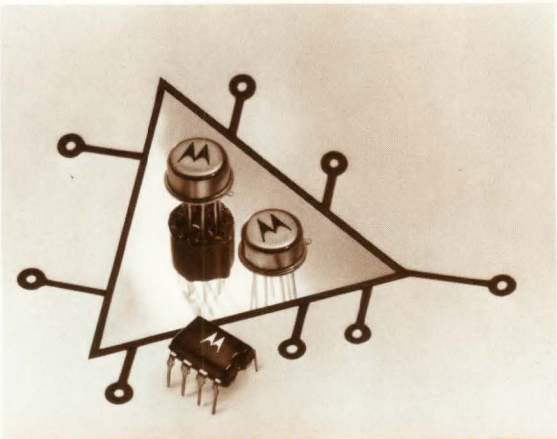
— Leads Growing Linear Second Source Availability

Two op amps and a negative voltage regulator expand Motorola's linear second source offerings. Heading the new intros are the MLM101A series, pin-for-pin equivalents to the popular general purpose LM101A series op amps.

MLM210G and MLM310G are direct replacements for the LM210 and LM310 op amp/voltage followers, and the MLM104G series negative regulators directly replace the LM104 types. These three introductions join the MLM105G series positive regulators, MLM107G series internally-compensated op amps, and the fixed 5.0 V MLM109K regulators, bringing to six the number of LM device series made available by Motorola in recent months. All are supplied in standard metal packages, and the MLM301A is also available in plastic.

Prices (100-999) range from $7.95 for the MLM101A down to $0.60 for the MLM301AP and from $8.00, MLM104, down to $2.50, MLM304. MLM210s sell for $6.00 and MLM310s for $3.25 in 100-999 quantities. All are available off-the-shelf.

For details, circle 59



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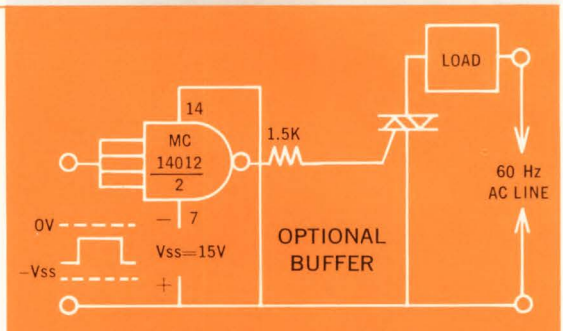

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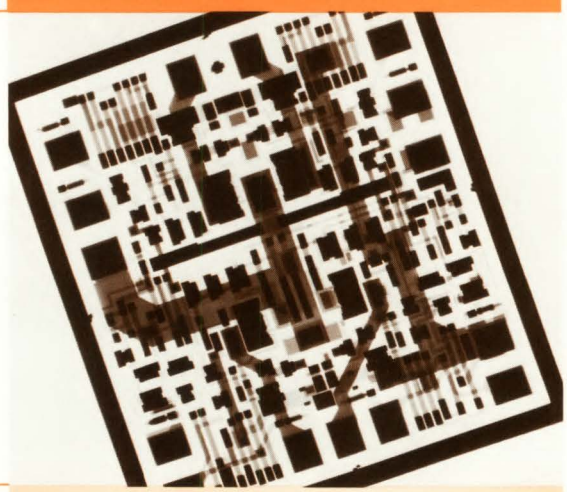
For details, circle 61



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MC686's flip-flop change state on the negative transition of the clock pulse. Q outputs are available from all four stages, and $\overline{Q}$ from the last register stage. A clock-independent asynchronous master reset (MR) clears all flip-flops simultaneously. Individual set inputs ($\overline{S}$) enable any flip-flop to be set regardless of the state of the clock.

This new MHTL 4-Bit shift register operates across the −30°C to +75°C temperature range and is also available for use over the −55°C to +125°C range and/or with hi-rel processing on special order. 100-up prices, in the dual-in-line 16-pin plastic or ceramic package are $3.25 and $4.25, respectively.

For details, circle 62

COUNT	D	Q3	Q2	Q1	Q0
0	1	0	0	0	0
1	1	0	0	0	1
2	1	0	0	1	1
3	1	0	1	1	1
4	1	1	1	1	1
0	0	1	1	1	1
1	0	1	1	1	0
2	0	1	1	0	0
3	0	1	0	0	0
4	0	0	0	0	0

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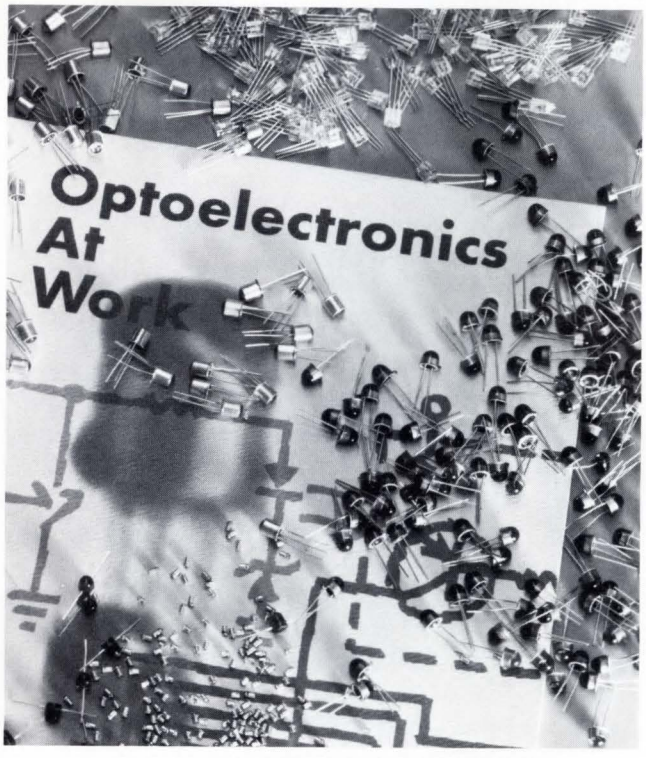

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A report summarizing reliability levels achieved by Motorola's MECL 10,000 family of Emitter Coupled Logic integrated circuits over an 8-month period has been prepared. The report presents results determined from operating and storage life tests as well as thermal and mechanical tests. Failure rates are estimated and discussed.

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These DICs utilize nichrome resistors, post-metalization passivation, monometallic interconnections, and very small, high-frequency transistor structures. Their circuit designs feature the isolation of individual components in high-resistance islands, preventing metal interconnection burnout or power failure due to destructive photo currents.

For details, circle 63

D.I.C. DEVICE TYPE NO.	FUNCTION	PACKAGE	100-UP PRICE UNIT
MCE7003	7-Diode Array	(Case 607) TO-86 14-pin ceramic flat pack	$14.00
MCE7005	Diode-Resistor Network	(Case 606) TO-91 10-pin ceramic flat pack	11.00
MCE7006	16-Diode Array	Case 606	16.00
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LocaLogic design — a look into "do it yourself" LSI.

Upon arrival at the center you are assigned an office as a base of operation during the course of your program. If you are new to the Polycell system, the Motorola design staff conducts a training program and once a design is started, the staff can help with any step in the sequence. Experience proves that, after brief on-site training, a logician or circuit designer with no prior background in semiconductor design or processing can very effectively use the system.

The LocaLogic Design Center is a completely self-contained operation and covers the stages of design between original logic definition and mask artwork generations. For most design programs, the center has two outputs:

1. A verified data base for generating production mask artwork.
2. A completely graded program for computer testing of the final product.

In Motorola's new LocaLogic Design Center, two designers use an X-Y plotter to visualize cell placement.

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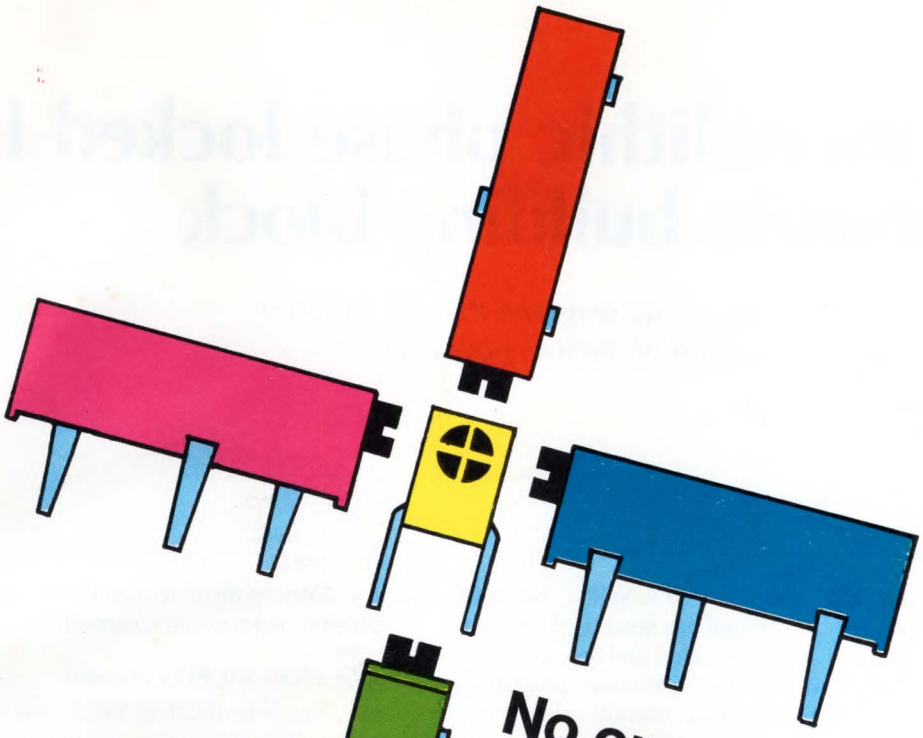

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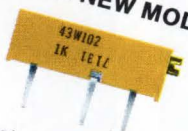

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CHECK NO. 8

The monolithic phase locked loop: a versatile building block

Here's a rundown on the many ways the PLL can be used as well as a look at the kind of devices now available.

Alan B. Grebene, Exar Corp.

The basic concept of the phase locked loop (PLL) has been around since the early 1930's and has been used for a variety of applications in instrumentation and space telemetry. However, before the advent of monolithic integration, cost and complexity considerations limited its use to precision measurements requiring very narrow bandwidths. In the past few years, the advantages of monolithic integration have changed the phase locked loop from a specialized design technique to a general-purpose building block. Therefore, what is "new" at this point is not the concept of the PLL, but its availability in a low-cost self contained monolithic IC package.

In many ways, this is similar to the case of the monolithic operational amplifier, which, until less than a decade ago, was an expensive building block. Today, with the advent of monolithic technology, it has become a basic building block in nearly every system design. The monolithic phase locked loop also offers a similar potential. In fact, many of the applications of the PLL outlined in this article become economically feasible only because the PLL is now available as a low-cost IC building block.

Today, over a dozen different integrated PLL products are available from a number of IC manufacturers. Some of these are designed as "general-purpose" circuits, suitable for a multitude of uses; others are intended or optimized for special applications such as tone detection, stereo decoding and frequency synthesis. This article is intended as a brief survey of the expanding field of monolithic phase locked loops. Its purpose is to familiarize the reader with their individual characteristics, capabilities and applications.

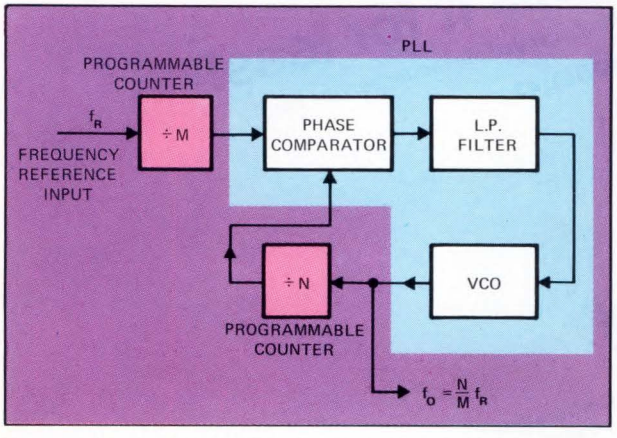


Fig. 1—A frequency multiplier/divider can be constructed using a phase locked loop.

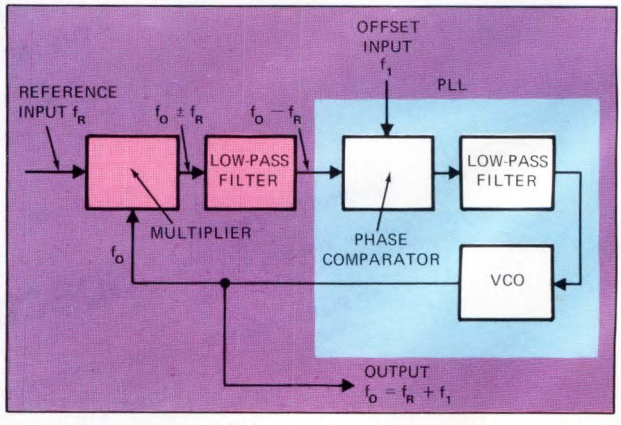


Fig. 2—Frequency translation can be accomplished with a phase locked loop by adding a multiplier and an additional low-pass filter to the basic PLL.

Applications for PLLs abound

As a versatile building block, the PLL covers a wide range of applications. Some of the more important are the following:

FM demodulation: In this application, the PLL is locked on the input FM signal, and the loop-error voltage, $V_d(t)$ in **Fig. A** (see Box), which keeps the VCO in lock with the input signal, represents the demodulated output. Since the system responds only to input signals within the capture range of the PLL, it also provides a high degree of frequency selectivity. In most applications, the quality of the demodulated output (i.e., its linearity and signal/noise ratio) obtained from a PLL is superior to that of a conventional discriminator.

FSK demodulation: Frequency-shift keyed (FSK) signals are commonly used to transmit digital information over telephone lines. In this type of modulation, the carrier signal is shifted between two discrete frequencies to encode the binary data. When the PLL is locked on the input signal, tracking the shifts in the input frequency, the error voltage in the loop, $V_d(t)$, converts the frequency shifts back to binary logic pulses.

Signal conditioning: When the PLL is locked on a noisy input signal, the VCO output duplicates the frequency of the desired input but greatly attenuates the noise, unde-

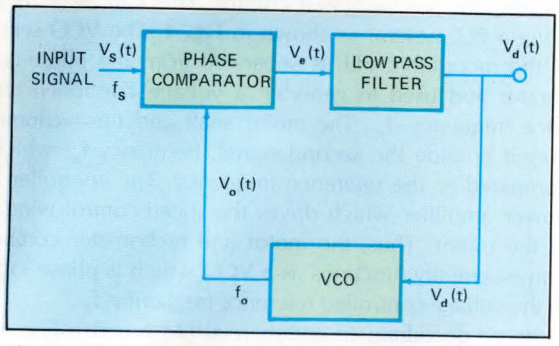


Fig. A – The basic phase locked loop consists of three functional blocks.

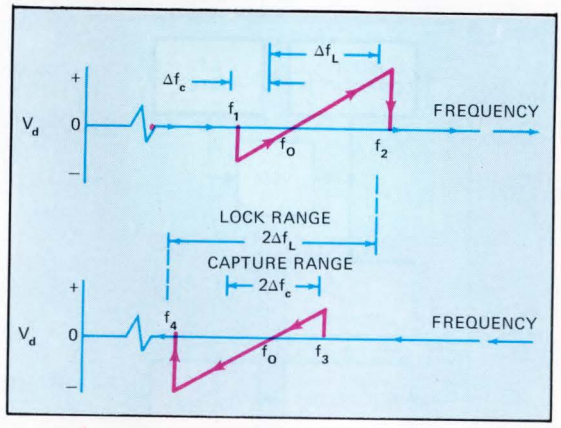


Fig. B – Typical PLL frequency-to-voltage transfer characteristics are shown for increasing (upper diagram) and decreasing (lower diagram) input frequency.

Basics of phase locked loops

The phase locked loop provides frequency selective tuning and filtering without the need for coils or inductors. As shown in **Fig. A**, the PLL in its most basic form is a feedback system comprised of three basic functional blocks: a phase comparator, low-pass filter and voltage controlled oscillator (VCO).

The basic principle of operation of a PLL can briefly be explained as follows: With no input signal applied to the system, the error voltage V_d is equal to zero. The VCO operates at a set frequency, f_o, which is known as the free-running frequency. If an input signal is applied to the system, the phase comparator compares the phase and frequency of the input signal with the VCO frequency and generates an error voltage, $V_e(t)$, that is related to the phase and frequency difference between the two signals. This error voltage is then filtered and applied to the control terminal of the VCO. If the input frequency, f_s, is sufficiently close to f_o, the feedback nature of the PLL causes the VCO to synchronize, or lock, with the incoming signal. Once in lock, the VCO frequency is identical to the input signal, except for a finite phase difference.

Two key parameters of a PLL system are its lock and capture ranges. They can be defined as follows:

Lock range: The range of frequencies in the vicinity of f_o, over which the PLL can maintain lock with an input signal. It is also known as the tracking or holding range. Lock range increases as the over-all gain of the PLL is increased.

Capture range: The band of frequencies in the vicinity of f_o where the PLL can establish or acquire lock with an input signal. It is also known as the acquisition range. It is always smaller than the lock range and is related to the low-pass filter bandwidth. It decreases as the filter bandwidth is reduced.

The lock and the capture ranges of a PLL can be illustrated with reference to **Fig. B**, which shows the typical frequency-to-voltage characteristics of a PLL. In the figure, the input is assumed to be swept slowly over a broad frequency range. The vertical scale corresponds to the loop error voltage.

In the upper part of **Fig. B**, the loop frequency is being gradually increased. The loop does not respond to the signal until it reaches a frequency f_1, corresponding to the lower edge of the capture range. Then, the loop suddenly locks on the input, causing a negative jump of the loop error voltage. Next, V_d varies with frequency with a slope equal to the reciprocal of the VCO voltage-to-frequency conversion gain, and goes through zero as $f_s = f_o$. The loop tracks the input until the input frequency reaches f_2, corresponding to the upper edge of the lock range. The PLL then loses lock, and the error voltage drops to zero.

If the input frequency is now swept slowly back, the cycle repeats itself as shown in the lower part of **Fig. B**. The loop recaptures the signal at f_3 and traces it down to f_4. The frequency spread between (f_1, f_3) and (f_2, f_4) corresponds to the total capture and lock ranges of the system; that is, $f_3 - f_1$ = capture range and $f_2 - f_4$ = lock range. The PLL responds only to those input signals sufficiently close to the VCO frequency, f_o, to fall within the "lock" or "capture" range of the system. Its performance characteristics, therefore, offer a high degree of frequency selectivity, with the selectivity characteristics centered about f_o.

sired sidebands and interference present at the input. It is also a tracking filter since it can track a slowly varying input frequency.

Frequency synthesis: The PLL can be used to generate new frequencies from a stable reference source by either frequency multiplication and division, or by frequency translation. **Fig. 1** shows a typical frequency multiplication and division circuit, using a PLL and two programmable counters. In this application, one of the counters is inserted between the VCO and phase comparator and effectively divides the VCO frequency by the counter's modulus N. When the system is in lock, the VCO output is related to the reference frequency, f_R, by the counter moduli M and N as:

$$f_o = \left(\frac{N}{M}\right) f_R$$

By adding a multiplier and an additional low-pass filter to a PLL (**Fig. 2**), one can form a frequency translation loop. In this application, the VCO output is shifted from the reference frequency, f_R, by an amount equal to the offset frequency, f_1, i.e., $f_o = (f_R + f_1)$.

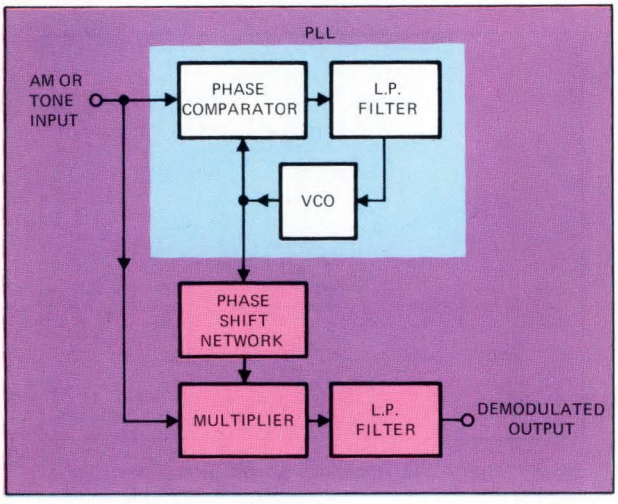


Fig. 3—AM and tone detection are possible by adding three functional blocks to the basic phase locked loop.

Data synchronization: The PLL can be used to extract synchronization from a composite signal, or can be used to synchronize two data streams or system clocks to the same frequency reference. Such applications are useful in PCM data transmission, regenerative repeaters, CRT scanning and or drum memory read-write synchronization.

AM detection: The PLL can be converted to a synchronous AM detector with the addition of a non-critical phase-shift network, an analog multiplier and a low-pass filter. The system block diagram for this application is shown in **Fig. 3**.

In this application, as the PLL tracks the carrier of the input signal, the VCO regenerates the unmodulated carrier and feeds it to the reference input of the multiplier section. In this manner, the system functions as a synchronous demodulator with the filtered output of the multiplier representing the demodulated audio information.

Tone detection: In this application, the PLL is again connected as shown in **Fig. 3**. When a signal tone is present at the input, within a frequency band corresponding to the capture range of the PLL, the output dc voltage is shifted from its tone-absent level. This shift is easily converted to a logic signal by adding a threshold detector with logic-compatible output levels.

Motor speed control: Many electromechanical systems, such as magnetic tape drives and disk or drum head drivers, require precise speed control. This can be achieved using a PLL system, as shown in **Fig. 4**. The VCO section of the monolithic PLL is separated from the phase-comparator and used to generate a voltage controlled reference frequency, f_R. The motor shaft and the tachometer output provide the second signal, frequency f_M, which is compared to the reference frequency. The controller is a power amplifier which drives the speed-control windings of the motor. Thus, the motor and tachometer combination essentially functions as a VCO which is phase locked to the voltage controlled reference frequency, f_R.

Stereo decoding: In commercial FM broadcasting, suppressed carrier AM modulation is used to superimpose the stereo information on the FM signal. To demodulate the complex stereo signal, a low-level pilot tone is transmitted at 19 kHz (1/2 of actual carrier frequency). The PLL can be used to lock onto this pilot tone, and regenerate a coherent 38 kHz carrier which is then used to demodulate the complete stereo signal. A number of highly specialized monolithic circuits have been developed for this application. Typical examples of monolithic stereo decoder circuits using the PLL principle are the MC 1310 and CA 3090E, manufactured by Motorola and RCA, respectively.

A survey of monolithic PLLs

Presently, a relatively wide choice of monolithic PLL circuits are commercially available, and this list is bound to grow rapidly in the coming months. The user of a monolithic PLL is usually faced with two questions at the onset of his design: (1) What is available? (2) What is the most suitable PLL circuit for the job? These questions are answered in the following paragraphs, based on available circuits at the time of this writing.

What is available?

Table 1 is a comparative listing of some of the presently available monolithic PLL circuits. In the table, the circuits are listed in ascending order of their product numbers. The table also lists some of the key performance characteristics and major applications of these circuits. All data listed are typical values unless indicated otherwise. It should be noted that such a brief table does not do justice to the full potential of a device for a specific application, since the measurement techniques for some of the specifications vary from manufacturer to manufacturer.

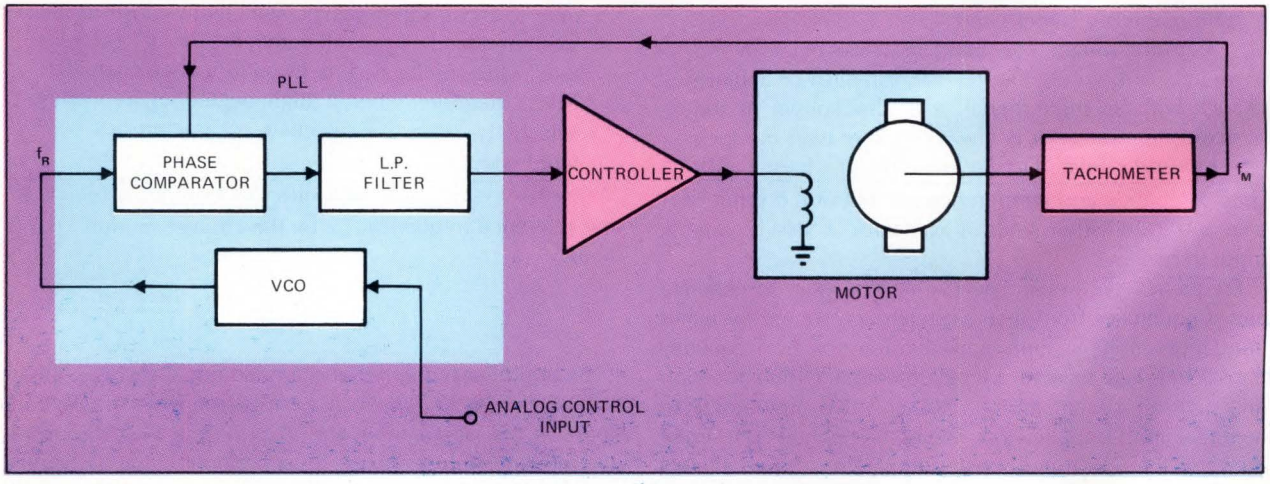


Fig. 4—Very precise motor speed control is possible with a phase locked loop system of this type.

The monolithic PLL circuits listed in **Table 1** also illustrate the wide range of design philosophies used by IC manufacturers. In one extreme are the "uncommitted," or multi-function designs, such as the XR-S200 and the SL-650, which strive for maximum versatility by keeping each of the functional blocks on the same substrate independent of each other. In the other extreme are the "committed" special-function devices, such as the SE-567 and the XR-2567 tone decoders. Each of the PLLs of **Table 1** are briefly reviewed on the basis of their functional block diagrams and most common applications

The XR-S200 (Exar Integrated Systems) is a multi-function PLL containing a four-quadrant analog multiplier, a high-frequency VCO and an operational amplifier (**Fig. 5A**), and is housed in a 24-pin package. Each of the functional blocks and their control inputs are independent of each other. In other words, they can be externally connected in any order. Thus, it is essentially a custom, or do-it-yourself, PLL. The user determines the function and performance characteristics by his choice of external connections and components.

The XR-210 (Exar Integrated Systems) was designed for FSK modulation/demodulation applications (**Fig. 5B**). In addition to the basic PLL, it contains a voltage comparator and and a RS232-C compatible output logic driver. The VCO section can be used for FSK modulation and has independent mark/space adjustments.

The XR-215 (Exar Integrated Systems) is a general-purpose PLL circuit particularly suited for FM demodulation, frequency synthesis, and tracking filter (**Fig. 5C**). The high-gain amplifier section can be used as an active filter, or can function as an audio preamplifier for FM detection. The VCO section has sweep and gain control options. A single PLL circuit can be time-multiplexed between two input channels by applying a binary input to its range-select control.

The SE-560 (Signetics) was the first monolithic PLL circuit to be introduced (**Fig. 5D**). It is a high-frequency circuit suitable for FM demodulation or signal conditioning. It contains a limiter block in series with the VCO section to control tracking range. The VCO output is internally connected to the phase comparator.

The SE-561(Signetics) is similar in basic design and performance to the SE-560 (**Fig. 5E**). However, it contains an additional multiplier/modulator section which is internally connected to the VCO. Thus it can be used for AM demodulation as well as for FM detection. AM demodulation is achieved by placing an external RC phase-shift network between the AM and FM input channels.

The SE-562 (Signetics) has basic features similar to their SE-560, except that the VCO output is not internally connected to the phase comparator input (**Fig. 5F**). This allows the circuit to be used for frequency-synthesis applications by inserting an external binary-counter into the loop. The VCO section has buffered differential outputs which have higher voltage swings than the 560 and 561 circuits (4.5V p-p., vs 0.6V p-p).

The SE-565 (Signetics) is a general-purpose PLL designed for low-frequency FM and FSK detection and frequency synthesis (**Fig. 5G**). Its frequency range is limited to 500 kHz (typical); however, its temperature stability is better than the other 560-Series circuits. The VCO section provides both square and triangular wave outputs, not internally connected to the phase-comparator inputs. However, the outputs can be dc coupled by shorting two adjacent pins in the package. (Signetics' SE-565, National Semiconductor's LM-565, and Raytheon Semiconductor's RM-565 are electrically-equivalent and interchangeable.

The SE-567 (Signetics) monolithic tone-decoder contains an internal current controlled oscillator (CCO) and two separate phase-detectors driven from the same oscillator (**Fig. 5H**). The quadrature phase detector, along with

Table 1 - A Summary of Commercially Available PLL Circuits

Product designation	Package	Operating supply range	High Frequency Limit	VCO stability		Primary Applications
				Power supply (%/V)	Temp. (ppm/°C)	
XR-S200	24 Pin DIP	6V to 30V ±3V to ±15V	30 MHz	0.08 (typ) 0.5 (max)	300 (typ) 650 (max)	Multi-function building block for FM/FSK detection, frequency synthesis
XR-210	16 Pin DIP	5V to 26V	20 MHz	0.05 (typ) 0.5 (max)	200 (typ) 550 (max)	FSK modem, frequency synthesis, data synchronization
XR-215	16 Pin DIP	5V to 26V	35 MHz	0.1 (typ) 0.5 (max)	250 (typ) 600 (max)	General purpose PLL. FM demodulation, tracking filter, frequency synthesis
SE-560	16 Pin DIP	Not specified	30 MHz	0.3 (typ) 2 (max)	600 (typ) 1200(max)	FM demodulation, signal conditioning tracking filter
SE-561	16 Pin DIP	Not specified	30 MHz	0.3 (typ) 2 (max)	600 (typ) 1200 (max)	AM and FM detection
SE-562	16 Pin DIP	Not specified	30 MHz	0.3 (typ) 2 (max)	600 (typ) 1500 (max)	Frequency synthesis, FM detection, signal conditioning
SE-565, LM565, RM565	14 Pin DIP 10 Pin TO	±5 to ±12V	500 kHz	0.1 (typ) 1 (max)	100 (typ) 525 (max)	FM, SCA detection, FSK demodulation
SE 567, XR567 LM567, RM567	8 Pin DIP 8 Pin TO	4.75V to 9V	500 kHz	0.5 (typ) 1 (max)	30 ± 140 (typ)	Tone detection
SL-650	24 Pin DIP	±3V to ±12V	1 MHz	0.05 (typ)	20 (typ)	Multi-function building block for signal generation/detection; FSK modem, FM detector
XR-2567	16 Pin DIP	4.75V to 15V	600 kHz	0.05(typ) 0.2 (max)	80 (typ)	Dual tone decoder, (Dual 567 equivalent)
HI-2800	16 Pin DIP	±5V to ±15V	30 MHz	0.1 (typ)	250 (typ)	FM demodulation, frequency synthesis, signal conditioning
HI-2820	14 Pin DIP	±6V to ±12V	3 MHz	0.1 (typ)	100 (typ) 250 (max)	FSK modems, data synchronization, motor speed control

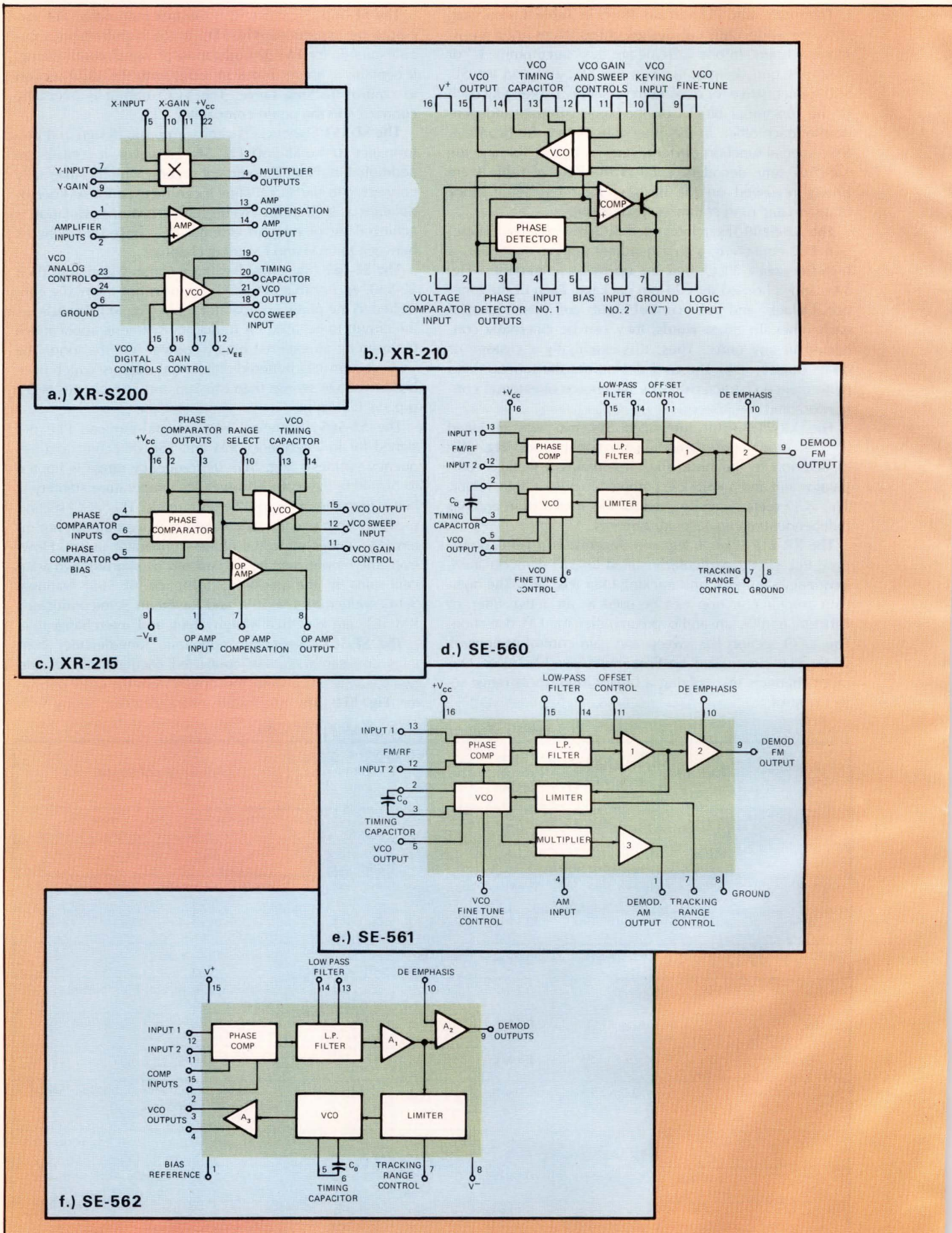
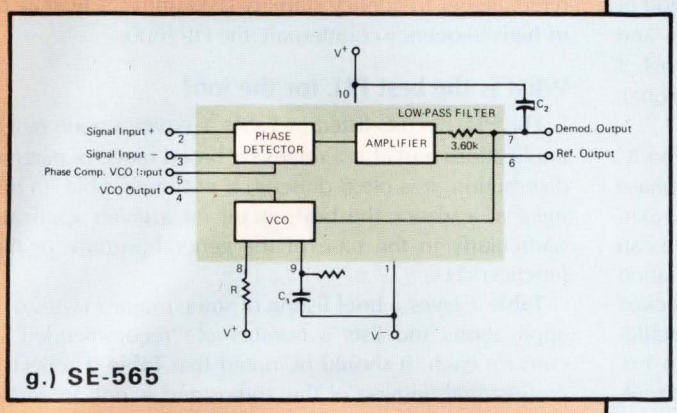
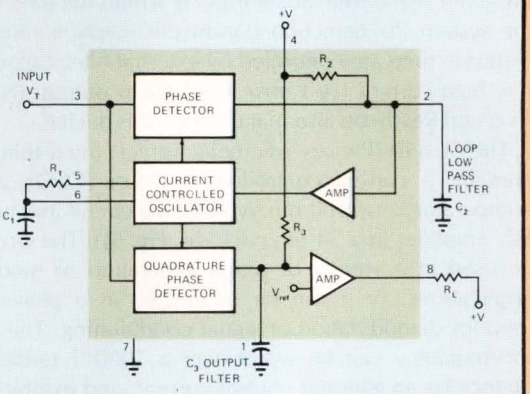


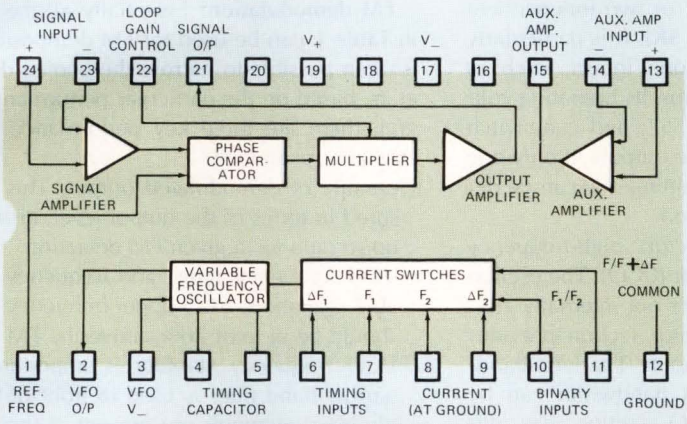
Fig. 5 – Functional block diagrams of IC phase locked loops.



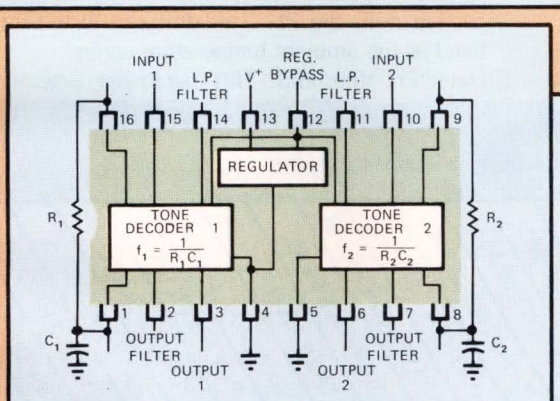
g.) SE-565



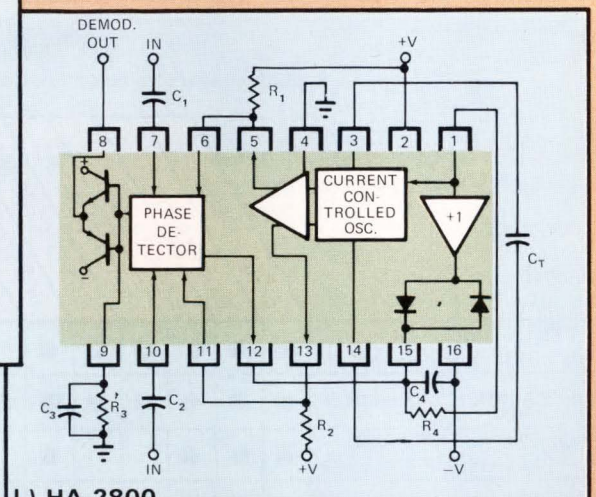
h.) SE-567



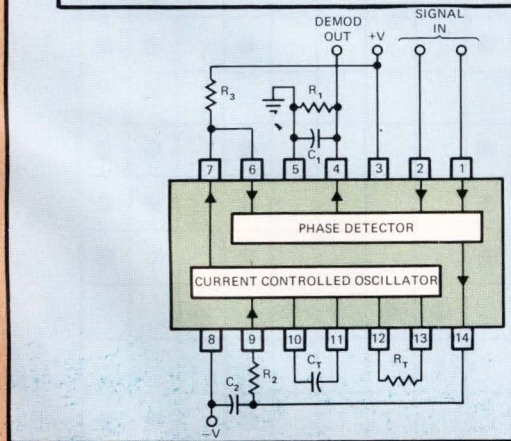
j.) SL-650



k.) XR-2567



l.) HA-2800



m.) HA-2820

the buffer amplifier, is used to generate a binary output pulse if a signal tone at the input is within the pass-band of the system. Its detection bandwidth (capture range) and response time are controlled by external filter capacitors. It has high-current (100 mA) logic driver output. (National, Exar and Raytheon also manufacture this device.)

The SL-650 (Plessey Microelectronics) multi-function IC contains a current controlled oscillator (CCO), a phase comparator, a two-bit binary interface circuit and an auxillary amplifier in a 24-pin package (**Fig. 5J**). The circuit can be used in a variety of signal generation or modulation applications; or it can be connected as a phase-locked loop for demodulation or signal conditioning. The oscillator frequency can be swept over a 1000:1 range in frequency by an external control current, and exhibits excellent temperature stability (typically ±20 ppm/°C).

The XR-2567 (Exar Integrated Systems) dual tone-decoder system contains an equivalent of two independent 567 decoders on the same chip (**Fig. 5K**). It is particularly well suited for decoding multiple-tone inputs, such as those used in telephone dialing systems. Its operating voltage range is wider than that of the 567, and can switch two simultaneous 100 mA loads at the outputs. If only one of the two decoders is used, the remaining one can be deactivated to minimize power dissipation.

The HI-2800 (Harris Semiconductor) high-frequency PLL uses a current controlled oscillator (CCO). The oscillator and the phase-detector sections are not internally connected (**Fig. 5L**). The phase comparator section provides two independent high-impedance outputs. The loop bandwidth and the demodulation output bandwidth can be independently controlled. The CCO section has differential outputs with 1.2V p-p minimum swing.

The HI-2820 (Harris Semiconductor) low-frequency PLL has TTL compatible VCO outputs (**Fig. 5M**). It contains independent phase detector and oscillator sections and offers higher frequency stability (100 ppm/°C, typical) than its high-frequency counterpart, the HI-2800.

What is the best PLL for the job?

The PLL circuits listed in **Table 1** cover a wide range of applications and also a relatively broad range of parameter distribution. It is often difficult, if not impossible, to determine at a glance the best circuit for a given application, particularly in the case of the general-purpose or multifunction PLLs.

Table 2 gives a brief listing of some major classes of PLL applications and lists a number of "recommended" circuits for each. It should be noted that **Table 2** reflects the professional opinion of the author and is not an endorsement of one product over any other. The products are listed in numerical order by part numbers.

FM demodulation: Essentially all the PLL circuits listed in **Table 1** can be used for FM demodulation. However, it is often possible to narrow the choice down to 2 or 3 circuits, based on the particular performance criteria. In general, there are three key performance parameters which should be examined:

- ☐ Quality of demodulated output: This is normally measured in terms of the output level, distortion, and signal/noise ratio for a given FM deviation.
- ☐ VCO frequency range and frequency stability: For reliable operation, VCO upper frequency limit (see **Table 1**) should be at least 20% above the FM carrier frequency. VCO frequency stability is important, especially if a narrow-band filter is used in front of the PLL, or multiple input channels are present. If the VCO exhibits excessive drift, the PLL can drift out of the input signal band as the ambient temperature varies.
- ☐ Detection threshold: This parameter determines mini-

TABLE 2.
Applications for commercially available monolithic PLL circuits

MAJOR APPLICATION / PRODUCT AND MANUFACTURER	EXAR XR-S200	EXAR XR-210	EXAR XR-215	SIGNETICS SE-560	SIGNETICS SE-561	SIGNETICS SE-562	SIGNETICS SE-565	NATIONAL LM-565	RAYTHEON RM-565	SIGNETICS SE-567	EXAR XR-567	NATIONAL LM-567	RAYTHEON RM-567	PLESSEY SL-650	EXAR XR-2567	HARRIS HI-2800	HARRIS HI-2820
FM DEMODULATION HIGH FREQUENCY (>5 MHz)	●	●	●	●	●	●										●	
LOW FREQUENCY (<5 MHz)	●	●	●	●	●	●	●	●	●					●		●	●
FREQUENCY SYNTHESIS HIGH FREQUENCY (>5 MHz)	●	●	●			●										●	
LOW FREQUENCY (<5 MHz)	●	●	●			●	●	●	●					●		●	●
FSK DEMODULATION	●	●	●				●	●	●					●		●	●
SIGNAL CONDITIONING	●	●	●	●	●	●	●	●	●					●		●	●
TONE DETECTION					●					●	●	●	●		●		
AM DETECTION					●												
MOTOR SPEED CONTROL	●	●	●											●		●	●

mum signal level necessary for the PLL to lock and demodulate an FM signal of given deviation.

In most FM demodulation applications, it is also desirable to control the amplitude of the demodulated output. This feature is provided in some of the PLL circuits (such as the XR-215, SL-650 or HI-2800) by means of a variable-gain amplifier contained on the chip.

For the low-frequency FM demodulation applications (in the kHz range) the following circuits are recommended: XR-215, SE-565 (or its equivalents), SL-650, HI-2820.

For high-frequency FM demodulation (1 MHz and above), the preferred circuits are the XR-215, the SE-560 and the HI-2800.

FSK decoding: Frequency-shift keying used in digital communications is very similar to analog FM modulation. Therefore, any PLL IC can be used for FSK decoding, provided that its input sensitivity and the tracking range are sufficient for a given FSK signal deviation. Some of the basic requirements and desirable features for a PLL used in FSK decoding are:

- ☐Center frequency stability.
- ☐Logic compatible output.
- ☐Control of VCO conversion gain.

Center frequency stability is essential to insure that the VCO frequency range stays within the signal band over the operating temperature range. A logic compatible output is desirable to avoid the need for an external voltage comparator (slicer) to square the output pulses. It is particularly convenient if the output conforms to RS-232C standard, thereby eliminating the need for a separate line/driver circuit. Control of the VCO's conversion gain allows the circuit to be used for both large deviation FSK signals (such as 1200 baud operation) as well as for small deviation (75 baud) FSK signals.

Concerning frequency stability, the recommended PLL circuits for FSK decoding are the XR-210, the SE-565 (and equivalents), the SL-650 and the HI-2820. Of these, the SL-650 has the highest frequency stability. Both the XR-210 and the SL-650 contain internal slicer and logic driver sections, whereas the SE-565 and the HI-2820 need an external voltage comparator to provide logic compatible outputs. In the XR-210, VCO conversion gain is controlled by means of an external resistor. With the SE-565 this control can be achieved by using an external PNP transistor.

Frequency synthesis: This application requires a PLL circuit with the loop opened between the VCO output and the phase comparator input. This includes most of the circuits listed in **Table 1**; namely: XR-S200, XR-210, XR-215, SE-562, SE-565, (or its replacements, LM-565, RM-565) SL-650, HI-2800 and HI-2820. Most frequency synthesis applications require high-frequency operation, which narrows the choice to the five devices shown in **Table 2**. One of the basic requirements for frequency synthesis applications is that the TTL logic-compatible output swings from the VCO. This requirement is met by all of the PLL circuits listed for frequency synthesis on **Table 2**. However, depending on the choice of circuit and supply voltages, dc level shifting may be necessary to interface with TTL logic.

Signal conditioning: Most signal conditioning applications require very narrow-band operation of the PLL. This in turn may require the use of active filters within the loop (between the phase detector and the VCO). The PLL circuits which allow active filters to be inserted into the loop are the XR-S200, the XR-215, the SL-650, the HI-2800 and the HI-2820. XR-S200, XR-215 and SL-650 already contain an op amp on the chip for active filtering.

Time decoding: The two different PLL circuits especially designed for this application are the SE-567's and the XR-2567. Both circuits have comparable performance characteristics. The XR-2567 contains two independent 567-type circuits on the same chip; therefore, it may be more economical to use in multiple tone-detection systems. Both circuits have relatively high input threshold (≈20 mV, RMS), and may require input preamplification.

AM detection: This application requires an additional multiplier section to be added to the basic PLL. Only Signetics SE-561 has this particular design feature. However, all the other PLL circuits can be modified for this application by adding an external balanced modulator (such as Motorola's MC-1596) to the basic PLL.

Motor speed control: In most speed-control applications, a tachometer connected to the motor shaft is used as the VCO in the loop and the actual VCO on the monolithic chip is either not used or used to generate a reference frequency (**see Fig. 6**). Thus, a PLL system which can be broken between the low-pass filter and the VCO is needed. The circuits which fit the need are the XR-S200, the XR-215, the SL-650, the HI-2800.

There is no simple definative answer to the question, "What is the best PLL for the job". The answer depends on the many specifics of the application and the overall performance requirements. Therefore, the recommendations given in this section are no more than a rough guide line. ▭

Manufacturers of monolithic PLLs

Signetics
811 East Arques Ave.
Sunnyvale, CA 94086

National Semiconductor
2900 Semiconductor Dr.
Santa Clara, CA 95051

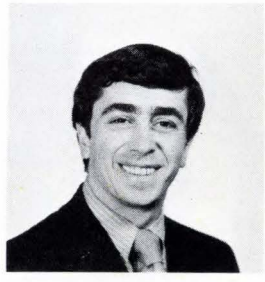
Raytheon Semiconductor
350 Ellis St.
Mountain View, CA 94040

Harris Semiconductor
Post Office Box 883
Melbourne, FL 32901

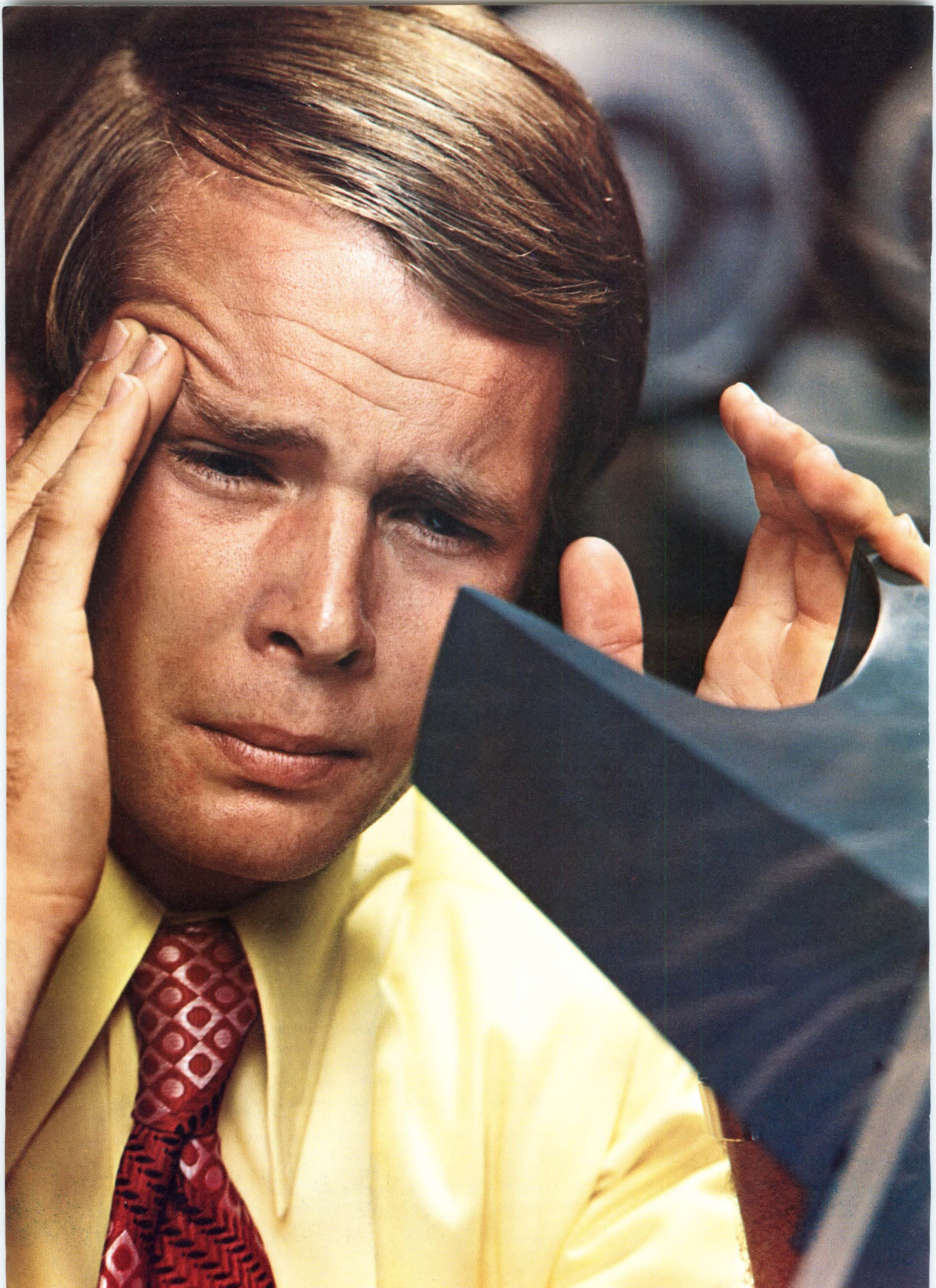
Plessey Semiconductor Div.
170 Finn Court
Farmingdale, NY 11735

Exar Integrated Systems
733 North Pastoria Ave.
Sunnyvale, CA 94086

Author's biography



Alan B. Grebene received his MS degree from the University of California, at Berkeley, in 1963 and his PhD from Rensselaer Polytechnic Institute, Troy, N. Y., in 1968. Since July, 1971, he has been with Exar Integrated Systems, Inc., of Sunnyvale, Calif., where he is the Vice President of Engineering. Dr. Grebene has authored over twenty five papers and holds several US patents in the area of integrated circuits and solid-state devices. He is also the author of the book *Analog Integrated Circuit Design* to be published by Van Nostrand Reinhold Co., in 1972.



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Scopes Are Changing; Think Twice.

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Slew-rate limiting of IC op amps is easy to predict, and to avoid

Slew-rate limiting is a grey area, not a black and white dividing line. You can operate inside that area, but you must make some tradeoffs.

Marvin K. Vander Kooi, National Semiconductor Corp.

The simple equations and graphs presented here should help you avoid the pitfalls of slew-rate limiting, and also provide a means of using engineering tradeoffs to extend the response of the single dominant-pole type of amplifier.

This analysis of sine- and step-voltage responses applies to all single dominant-pole op amps, such as the LM101A, 107, 108A, 112, 118 and 741. Each of these op amps has an open-loop response curve with a shape similar to the one shown in **Fig. 1**. The distinguishing feature of this curve is the single low-frequency breakpoint from a flat response to a uniform −20 db per decade of frequency (−6db/octave) drop in gain, at least until the curve passes through the 0 db line. Closing the loop to 40 db (X100 gain), as shown with a dotted line on **Fig. 1**, does not change the shape of the curve, but it does move the break-point to a higher frequency. These open loop and closed loop response curves determine the gain applied to small signal inputs. The logical question, then, is when does a signal cease to be a small signal and when does the amplifier response begin to deviate from this curve?

The answer lies in the slew-rate limit of the op amp. The slew-rate limit is the maximum rate of change of the amplifier's output voltage and is due to the fact that the compensation capacitor inside the amplifier has only a finite current[1] available for charging and discharging. A sinusoidal output signal will cease being small signal when its maximum rate of change equals the slew-rate limit S_r of the amplifier. The maximum rate of change for a sine wave occurs at the zero crossing and may be derived as follows:

$$v_o = V_p \sin 2\pi ft \tag{1}$$

$$\frac{d\,v_o}{dt} = 2\pi f\, V_p \cos 2\pi ft \tag{2}$$

$$\left.\frac{d\,v_a}{dt}\right|_{t=0} = 2\pi f\, V_p \tag{3}$$

$$S_r = 2\pi f_{max}\, V_p \tag{4}$$

where:

v_o = output voltage
V_p = peak output voltage
S_r = maximum $\frac{d\,v_o}{dt}$

The maximum sine-wave frequency an amplifier with a

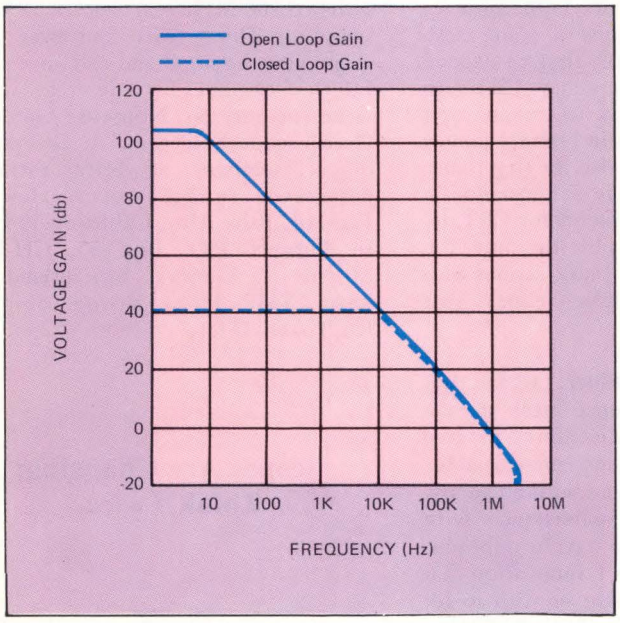

Fig. 1 — Small signal response of the most commonly used op amps is typified by this curve. The −20 db per decade rolloff is unchanged by gain limiting; however, the break-point will shift as a function of the closed loop gain. Large-signal response will deviate from this curve due to slew-rate limiting.

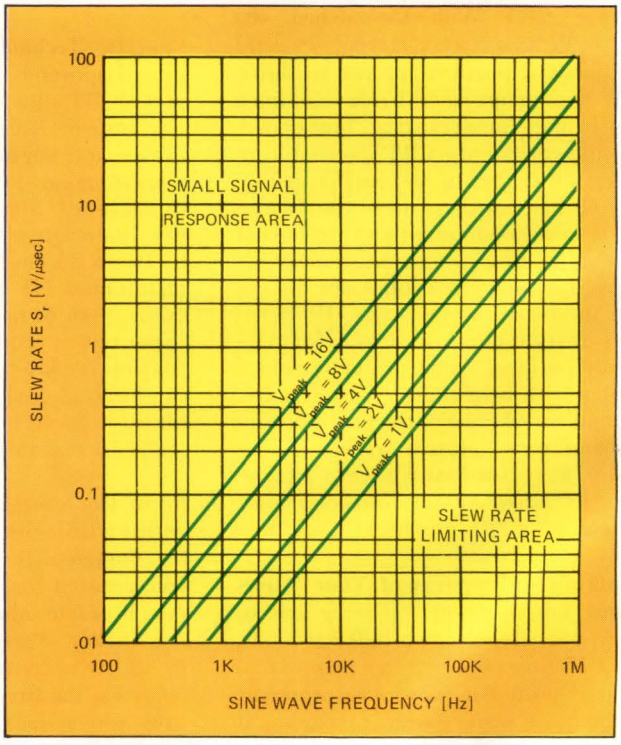

Fig. 2 — The peak amplitude curves demonstrate the relationship of sine wave frequency and peak amplitude. These curves define the borderline between small signal response and slew-rate limited response. The obvious design tradeoff here is that of amplitude for frequency.

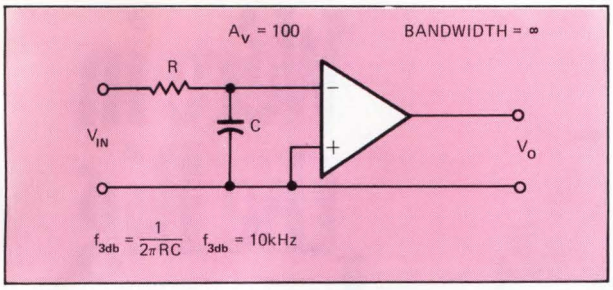

Fig. 3—An op amp can be thought of as an RC low-pass filter input section followed by a broadband amplifier section. The response time of such an input section circuit can seriously limit step function response time.

given slew rate will sustain without causing the output to take on a triangular shape is therefore a function of the peak amplitude of the output and is expressed as:

$$f_{max} = \frac{S_r}{2\pi V_p} \tag{5}$$

Equation 5 demonstrates that the borderline between small signal response and slew-rate limited response is not just a function of the peak output signal, but that by trading off either frequency or peak amplitude you can continue to have a distortion-free output. **Fig. 2** shows a quick-reference graphical presentation of equation 5 with the area above any V_{peak} line representing an undistorted small signal response. The area below a given V_{peak} line represents distorted sine-wave response due to slew rate limiting.

As a matter of convenience, amplifier manufacturers often give a "full-power bandwidth" or "large signal response" on their specification sheets. This frequency can be derived by inserting the amplifier slew rate and peak rated output voltage into eq (5). The bandwidth from dc to the resulting f_{max} is the full-power bandwidth or "large signal response" of the amplifier. For example, the full-power bandwidth of the 741 with a 0.5V/μsec S_r is approximately

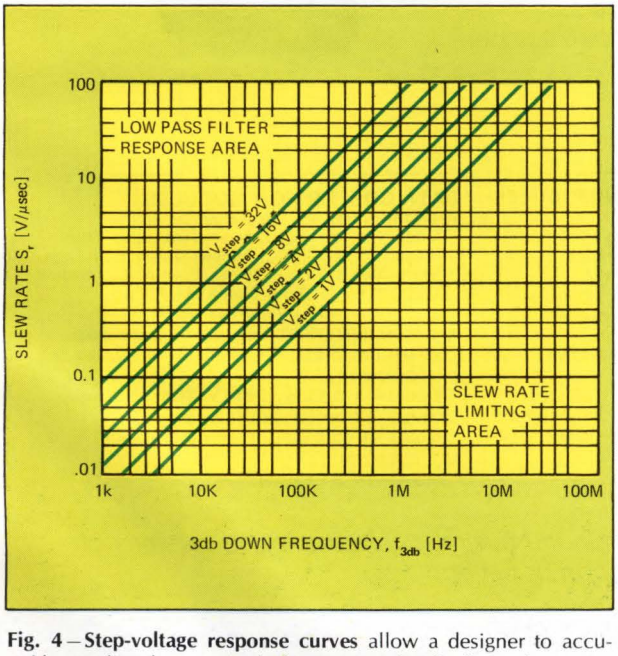

Fig. 4—Step-voltage response curves allow a designer to accurately predict the required slew-rate, and 3db down frequency requirements for a given step-voltage amplitude. Conversely, you may find that your frequency and step requirements dictate an op amp with higher slew-rate.

6 kHz while the fullpower bandwidth of the LM118 with an S_r of 70 V/μsec is approximately 900 kHz.

The step-voltage response at the output of an op amp can also be divided into a small signal response and a slew-rate limited response. The single turnover and uniform −20db/decade slope shown in the small signal frequency response curve of **Fig. 1** are also characteristic of a low pass filter and you can, in fact, model an op amp as a low pass RC filter followed by a very wideband amplifier. **Fig. 3** shows a model of a circuit with a gain of 100 and a 3db down rolloff frequency of 10 kHz. From basic filter theory[2] the 10% to 90% rise time of a single-pole low-pass filter is:

$$t_r = \frac{0.35}{f_{3\ db}} \tag{6}$$

which for this example would be 35μsec. Again this small signal or low-pass filter response ceases when the required rate of change of the output voltage exceeds the slew-rate limit S_r of the amplifier. Mathematically stated:

$$\frac{V_{step}}{t_r} \geq S_r \tag{7}$$

where:

V_{step} = amplitude of the output step.

This means that as soon as the amplitude of the output step-voltage divided by the rise time of the circuit exceeds the S_r of the amplifier, the amplifier will go into slew-rate limiting. The output will then be ramp function with a slope of S_r and a rise time equal to:

$$t_r = \frac{V_{step}}{S_r} \tag{8}$$

Substituting equation 6 into equation 7 gives the critical value of V_{step} directly in terms of f_{3db}:

$$\frac{V_{step}\ f_{3db}}{0.35} \geq S_r \tag{9}$$

which can be plotted as shown in **Fig. 4**. Any point in the area above a V_{step} line represents an undistorted low pass filter type response and any point in the area below a given V_{step} line represents a slew-rate limited response. □

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(1) Solomon, J. E., Davis, W. R. and Les, P. L.: *"A Self-Compensated Monolithic Operation Amplifier with Low Input Current and High Slew Rate,"* pp. 14-15, ISSCC Digest Tech. Papers, Feb. 1969.

(2) Millman, J. and Hawkins, C. C.: *"Electronic Devices and Circuits,"* pp. 465-466, McGraw-Hill Book Company, New York, 1967.

Author's biography

Marvin Vander Kooi is an applications engineer for linear ICs at National Semiconductor Corp., in Santa Clara, Calif. He received his B.S. and M.S.E.E. degrees from Ohio State University and he is a member of Sigma Xi and the IEEE.

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- Model 330 250V CM Input, 0.1-100 Gain

OPERATIONAL AMPLIFIERS
- Model 350 FET-Input, Low-Drift
- Model 360 Noninverting Chopper Amplifier
- Model 370 Low Noise, Low-Drift
- Model 380 Electrometer Amplifier
- Model 390 Chopper-Stabilized Amplifier

NONLINEAR FUNCTION MODULES

MULTIPLIERS
- Model 550 ±0.5% Accuracy
- Model 551 ±0.25% Accuracy
- Model 560 ±0.1% Accuracy

RMS-to-DC CONVERTERS
- Model 591 RMS-to-DC Converter, ±0.2%
- Model 592 RMS-to-DC Converter, ±0.1%

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A/D CONVERTERS, Integrating Types
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- Model 105 3½ Digit, 750μsec Conversion Time
- Model 106 3½ Digit, 8msec, Sign & Magnitude
- Model 115 3½ Digit, Sign & Magnitude with Differential-Input

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- Model 160 & 161 10 & 12-Bit, 20 to 100μsec

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- Model 192 8-Channel, 1μsec

And we have the most responsive engineering team in the business for customized versions of these modules. So circle the bingo card and get to know us better.

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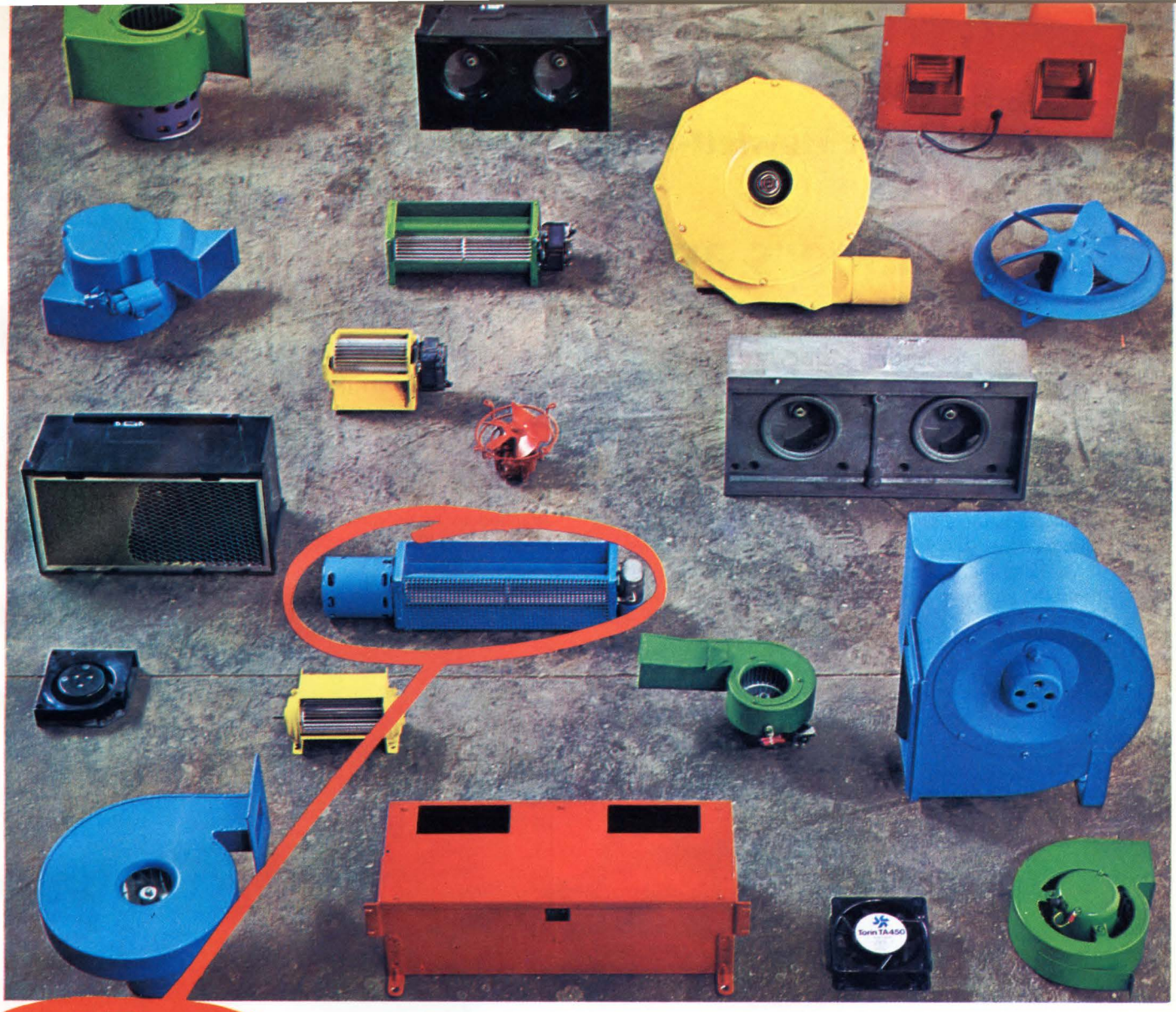

This one does a job for your competitor. But it might not be for you.

Torin Flexibility

Problem: A computer manufacturer handed us a knotty air-supply problem. Their new model had a memory and a logic system with gates of 18 cards each. Both systems required an equal air flow for each card, and the rate of flow was different for each system.

Installations would be at a wide range of altitudes, and since their market was foreign as well as domestic, both 50 and 60-cycle motors were called for.

Because of the proximity of the motors to the gates, a high degree of EMI containment was vital. And, finally, guards were required for maintenance protection.

Solution: Our engineers considered the horizontal configuration of the gates and utilized transverse blowers. Impeller length was matched to the width of the gates to provide an equal air flow to each card.

We used shaded-pole motors for altitudes up to 3,000 feet. Both 50 and 60-cycle versions. For altitudes above 3,000 feet we selected a permanent split-capacitor motor.

That makes three motor capacities, each with left and right-hand mounts. Six in all, and all adaptations of one basic blower. Each met the high EMI containment, and the maintenance guards were designed so as not to hinder flow requirements.

See? There's a lot to it, even when you know how.

Your competitor's air-moving problems are his. Yours are yours. And both are firmly dictated by optimum product performance. Often we can produce exactly what you require through modifications of existing units. But if custom design is called for we can turn that out too. More than 500,000 square feet of modern production space results in competitive pricing and realistic deliveries.

You see here just one example of our flexible problem-solving experience. There's so much more to the Torin story. Get it first hand from one of our twenty Technical Sales Representatives. Or, write or phone for our tells-it-all booklet.

CHECK NO. 16

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Torin

Jesse Pipkin of Hewlett-Packard speaks out

On engineers and profits

Many engineers think strictly in terms of the ingenuity of their designs. As a result their products are not only prone to failure, but almost impossible to test.

It's really unfortunate, but too many design engineers don't care about profitability—or perhaps it's just that they don't consider all the factors that constitute a profit. Every time I hear an engineer talk about how many IC packages he has eliminated, or how small the final product is, I appreciate how expensive it can ultimately be to isolate the designer from the profit responsibility. Production test costs and warranty repairs come directly out of profit. And these can represent far more dollars than the saved packages, or the imagined value of a mini-sized product **(Fig. 1).**

It would seem that an 8-input integrated-circuit NAND should be easier to test than a comparable circuit of discrete transistors. The problem with the integrated NAND is that the troubleshooter has 9 pins to worry about simultaneously. In the discrete case, he can isolate single components and, on a 1-pin- or 2-pin at a time basis, determine whether it works properly or not. This is an example of analog testing applied to digital problems—single-path signal tracing. It worked well for the early digital systems using discrete component designs, but it won't for complex IC systems (**Fig. 2**). Face it, the ground rules for digital troubleshooting have changed.

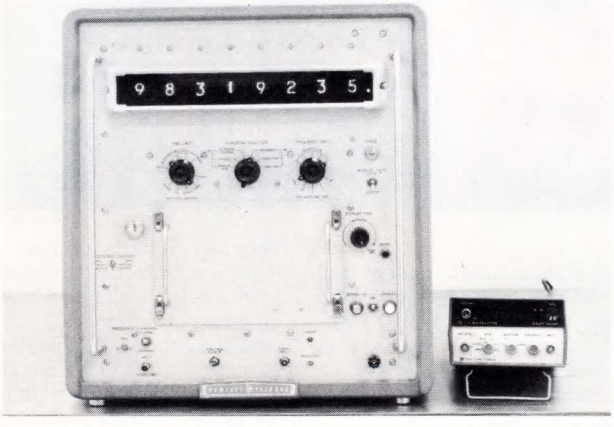


Fig. 1—Reducing size while maintaining equal capability should not compromise serviceability. The small counter above will not only out perform its large predecessor at a fraction of the cost, but it also has test circuits that diagnose its own malfunctions.

Digital troubleshooting is a multi-pin, multi-signal, ten fingered complex problem. The troubleshooter must look at two (a signal and a clock) or more lines, hence, the popularity of four-channel scopes and the absolute necessity for two-channel capacity. But ICs don't lend themselves to attaching multiple probes with any degree of ease. One hundred mil centers conserve space, but they don't invite probes on adjacent pins.

Several companies have addressed the multi-pin problem and manufacture products that can aid the digital troubleshooter. A number of companies (AP, Pomona, Jermyn) make clip-on devices that allow probes to be attached to many pins. A couple of companies (Stanley Electronics, HP) make a "viewer" which clips onto an IC package, letting the troubleshooter monitor the states of

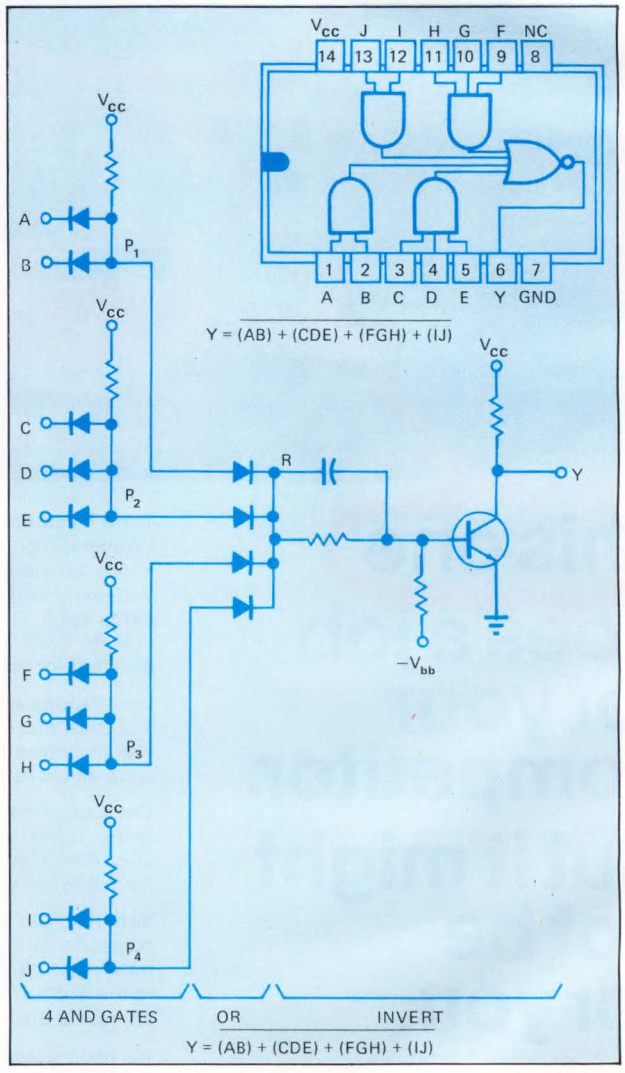


Fig. 2—The integrated circuit at the top of the illustration, an AND-OR gate, is functionally equivalent to the collection of diodes, resistors, and transistors shown. Troubleshooting the discrete implementation allows concentration on individual components, at worst a 2-node problem. For the 74L54 integrated circuit, though, the Y output is a function of all inputs A through J, with no access to internal nodes. Simultaneity of signals becomes a severe problem when components are crammed so closely that access to intermediate nodes is impossible.

all pins via lights, one per pin. HP makes an in-circuit tester that "clips" onto an IC and allows a functional test of the IC without removing it. These devices require but one design concern – a little physical space around the IC.

When product designers attempt to cram 10 pounds of components into a 2-pound sack, something must give.

Usually, it's the space around the IC. I've seen a computer board with 175 ICs on a 10-layer board. It must, at best, be impossible to troubleshoot and repair. Production testing costs soar, field repair gives way to board-exchange programs (an extremely expensive method of servicing), and no one with less than 5 years of test experience can find failures with such products. We have statistics showing that a simple test instrument (HP 10529A Logic Comparator) can save $50 per warranty repair for a relatively complex piece of equipment.

In another studied application, this test instrument cut typical production test times for troubleshooting from 1-1/4 hours to under 10 minutes. In addition, functional

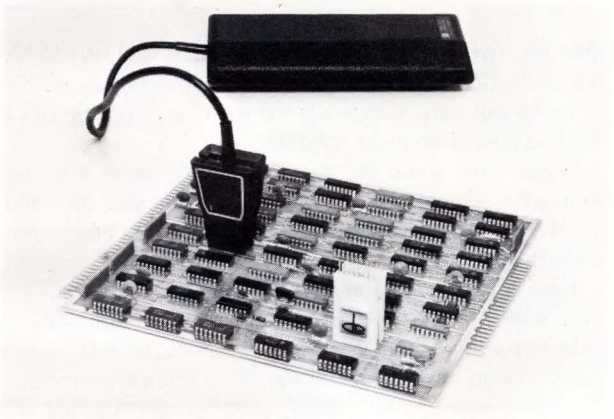


Fig. 3 – All 60 ICs on this PC board are accessible by multi-pin clips. Thoughtless placement of resistors and capacitors immediately adjacent to DIPs will result in troubleshooting problems when several pins on an IC must be accessed simultaneously. Your design guidelines should require allowing sufficient room for this type of clip.

failures were found in boards that had been declared "unfixable." This is real money back in terms of profits. But such test instruments require about 100 mils around the circumference of the ICs it tests. No space, no test (**Fig. 3**).

I cannot subscribe to the theory that "all else being equal, smallness is goodness," except perhaps in aerospace products for missiles, aircraft and satellites. Smallness means heat, heat means aging and aging means early failure. There is a popular rule of thumb that for each 10-degree temperature rise, failure rates double (**Fig. 4**). There is another way of expressing this: For each 10-degree temperature rise, warranty costs double.

Smallness also complicates repair. How do you fix something that you cannot access? When designing with his breadboards, the engineer doesn't try to cram ICs on top of each other or solder in his passive components so close that he can't get his scope probe into the circuit. Invariably he'll leave enough room to get an AP clip on the ICs so that he can conveniently look at waveforms on his oscilloscope. But somewhere between the breadboard and the final production prototype, the spectre of size has ordained the smallest possible package that won't burst into flames. The production and warranty service technicians are then barred from using the multi-pin testing aids that would cut costs and raise profits.

If you don't make your boards testable, it's your company's profits.

In the last six months, I've talked to dozens of manufacturers about scores of new digital products. The guys that claim the most for the buck seem to have the most untestable boards! The more ICs on a given board, the lower the percentage of test points that may be brought to connectors. Vast sums that production facilities spend on automatic board testers and their expensive fault-isolation software are wasted. Few key test points are ever brought out to connectors, mostly because designers do not take the necessary time to determine just what the "key" signals for testing really are. Everyone gets hurt (the buyer and the seller) when circuits are not testable. The buyer, of course, pays the tariff; he is hurt hardest. His problems, unfortunately, never end. How is he to repair his defunct purchase after the warranty has expired?

Even if you can afford the best in test equipment to find bad ICs, what happens when you are faced with the inevitable and often fatal problem of multi-multi-layer boards? One minicomputer manufacturer is proud that they can make 10-layer boards for their solid-state memory. Can you imagine replacing a defunct IC with some confidence that you are going to successfully get the new IC in? Multilayers come from one problem – not enough room on the two sides of the board to accommodate a high packing density.

I just hate to see manufacturers throwing away good profits. Managers with profit responsibility should insist upon the designs being testable. Tricks that clever engineers play, listed below, are practices that no engineering

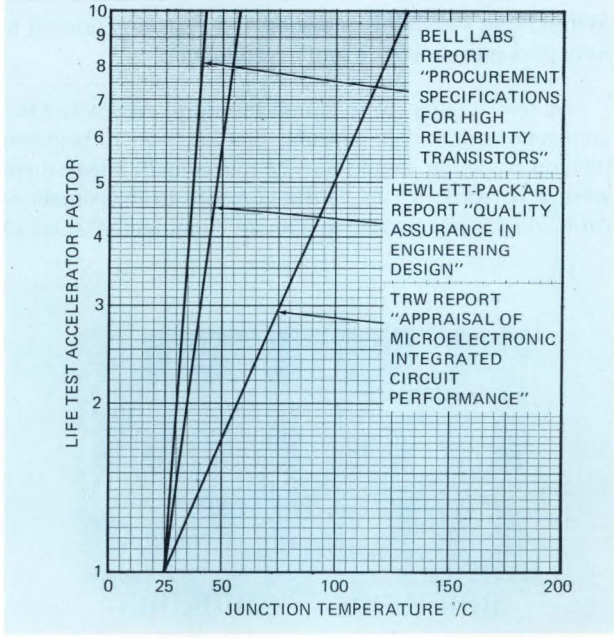
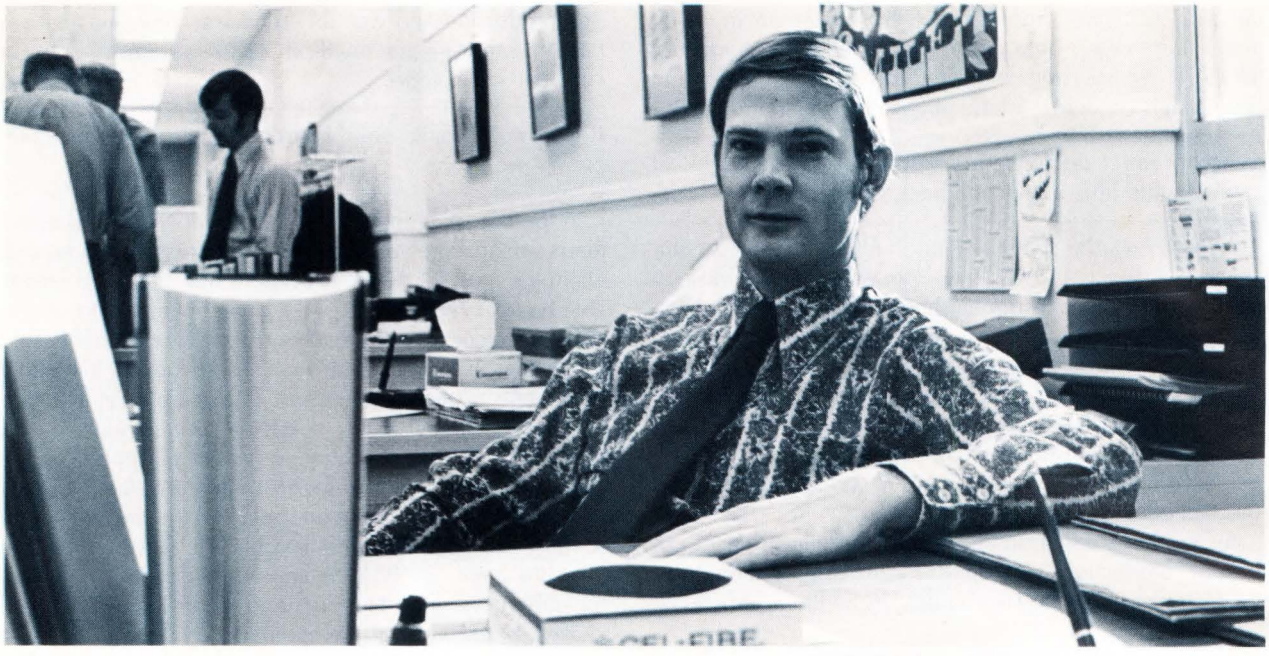


Fig. 4 – The precise relationship between heat and IC aging is not clear, but studies of a considerable amount of data at Hewlett-Packard indicate that failure rates double every 9°C between the ranges of 20°C to 60°C. Two other reports, from Bell Labs and TRW, plotted above, indicate the accelerated aging of components with temperature to be considerable.



manager should condone:

- making ICs operate at not quite legitimate, but tolerable levels,
- stretching loading to an absolute limit,
- implementing components between ICs to alleviate critical timing problems and pulse races,
- wire-ORing,
- et cetera.

The guy with the profit responsibility, who has to pay out of the profit for extra test time in production or excess warranty repairs—he is the one who should clamp down on the prima-donna engineer who is more concerned with his neat design that its shabby side effects.

Wire-ORing should be outlawed and designers using it to save packages should be sent to production

The real scourge of in-circuit testing is the "wire-OR" connection. (I find it amusing that such an ill-begotten method of design should also be misnamed!) If ever there were a paradox, it can hardly compare to this situation: An IC device is supposed to operate "improperly" some of the time, (when another device on the bus is LOW). When it actually does operate improperly, some tester is supposed to figure out why. Catch 22? Which device on the bus is causing the erroneous LOW state?

If you have some profit responsibility, or as a professional, have some personal regard for what you are building, I suggest that you take a long look at the design procedures you follow.

Take advantage of the digitally oriented test equipment available. Appreciate that ICs are multi-pin solutions. A little more time spent laying out your PC boards; a little thought as to what are good signals to bring to connectors for board testers; and a little space around ICs that will allow the various multi-pin test devices to help will be rewarded in greater profitability. □

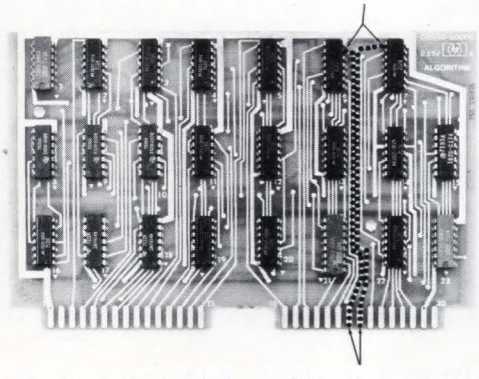


Fig. 5—Due to a complex timing problem, the engineer who designed this circuit was "impelled" to wire-AND several outputs. To insure testability, he brought the outputs to the edge connector and joined them on another board. This simplifies testing, as the connection is easily "unbugged."

Who is Jesse Pipkin?

Five years as a US Air Force navigator taught Jesse Pipkin how to get where he wants to go. So far, that's been to the University of Florida, where he got his BSEE degree in 1967, and then to HP as an applications engineer specializing in the 8540A Network Analyzer. Coincidentally, among the duties of that job was to be navigator/pilot for a mobile network analyzer demonstration unit. Jesse finally landed at HP's Santa Clara Division, where he's now product manager for logic test devices. He's a member of IEEE and an avid skier.

From the fall of 1968 to mid-1969, Jesse managed a tour bus on the west coast giving seminars on microwave measurements. He left HP in late 1969 to attend the University of California at Berkeley for a short time, then returned to HP in 1970. He joined the systems group, worked on the Fourier analyzer project, then got involved in an IC test program. This led to his present position in logic test devices, and his present title is Product Manager, Digital Circuit Testing.

To *isolate*
power switching devices, SCR's, Triacs and the like, from low level IC control circuits —

—Optical couplers (a) and reed relays are among the most attractive alternatives. One form of optical coupler is made by Sigma and doesn't cost three or four bucks (50¢ is more like it); unlike those using phototransistors or diodes, its output is totally passive.

Reed relays (b) are the classical electromagnetically operated mechanical switch, but with the switch totally enclosed in a minute glass envelope *inside* the actuating coil. They are available either separately or combined with a triac (at c); operate fast (200 usec.), have life expectancies of many millions, and may have elaborate configuration, both multipole and transfer switching contacts (Form C). Their cost is moderate, ranging as low as 75¢ or less, and they have close to zero output circuit resistance. Because our reed capsules are made *in-house*, quality control is a particular Sigma reed relay advantage.

Light substitutes for magnetism as the connecting link for the other class of isolating couplers offered by Sigma. In-house manufacture of photosensitive resistors led us to develop Sigma's optical couplers which contained a photoresistor and an internal light source. Control current to the internal light causes a rapid (stepless) decay of output resistance from circa 10meg to a few hundred ohms. There is no electrical feedback, either conductive or inductive; there is total isolation, at kilovoltages when required; and there is no noise generation in the output (a good deal for audio control also). Best of all, output is passive, can be either AC or DC.

The Ladybug featured above is the latest and lowest cost Sigma optical coupler. (It was developed by a lady—our senior physicist!) For 50¢ in production quantities, you can get them as pictured (at a) with one input and one output. The light can be incandescent or neon (attractive for lock-on potential plus absence of circuit loading til energized). You can also, for more money, have an LED light source. Also one may specify two or more lights, either capable of controlling the photoresistor (and isolated from each other). Or there can be several photoresistors controlled by one light . . . passive input, passive output, infinite isolation . . . all for 50¢.

You will need details, and to give our best, we will need yours. If you outline your project and purpose in a personal letter or phone call to Jim Seppala, Applications Manager, you'll be well pleased with the promptness and thoroughness of our reply. Write or call Sigma Instruments, Inc., 170 Pearl St., Braintree, Mass. 02185. Telephone 617-843-5000.

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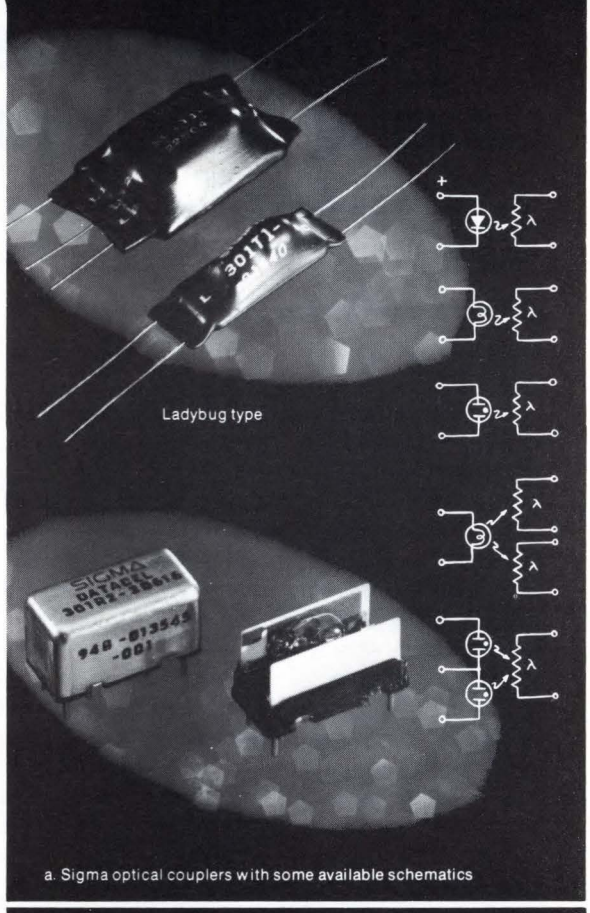
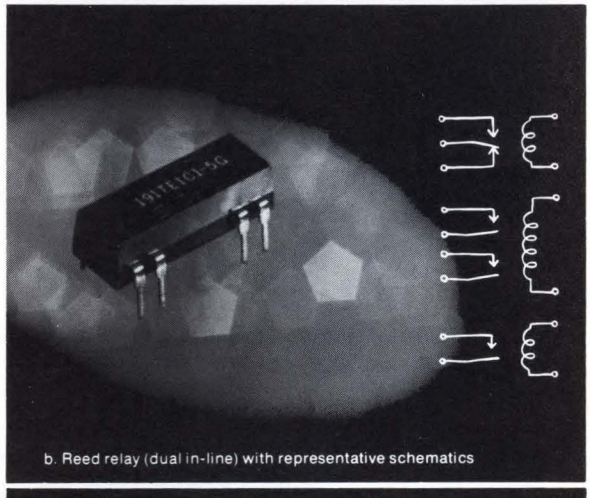


a. Sigma optical couplers with some available schematics



b. Reed relay (dual in-line) with representative schematics

c. Reed relay gated triac

CHECK NO. 15

Conductive plastics emerge as unique problem solvers

First introduced to EEs as an RFI gasketing material, metal filled polymers are finding their way into unique designs that solve a lot of tough problems.

Richard Seeger, Chomerics, Inc.

Conductive polymers are one group of materials that have found new applications due to the profound impact of MOS/LSI in the last few years. Many such new materials have become viable design components due primarily to two MOS/LSI characteristics: high impedance and pile-driver pricing. First, the high impedance of MOS has meant that conductors less efficient than copper are now acceptable. In addition, the fantastic price erosion of MOS/LSI has brought increasing pressure for price reduction on all associated hardware.

Conductive polymers are generally as flexible as rubber (**see Fig. 1**) and nearly as conductive as copper. Typically, these are dispersions of micron-size metal particles in a cross linked polymer. Such a composite might consist of a copper base filler in a silicone rubber binder. Usually, the

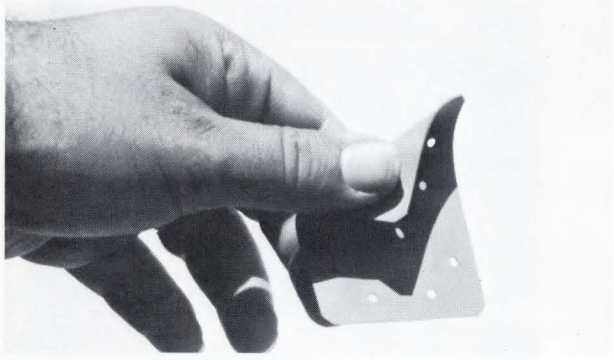


Fig. 1—Flexible conductive elastomers, such as this sample from a low cost keyboard, offer designers a new dimension in interfacing MOS devices.

copper particles must be segregated to an optimum size and particle shape and subsequently plated to prevent surface oxidation. The properties of the composite resulting from the mixture of metal and plastic can be made to approach the most useful parameters of each of its constituents; that is, it becomes an elastomeric (stretchable) conductor. Metal filled elastomers are, typically, orders of magnitude more conductive than conventional carbon elastomers and give greater electrical stability. A volume resistivity of $10^{-3}\Omega$ cm is attainable with a 65 durometer elastomer. These metal filled composites typically contain 80% metal, by weight, and are capable of 300% elongation and tensile strenghts of 200 psi. By using the combination of properties offered by such elastomeric conductors many new and complex design concepts are now within the reach of system designers. As an example of the utility of these composites, consider the new generation of special function terminals and electronic calculators presently arriving in the marketplace.

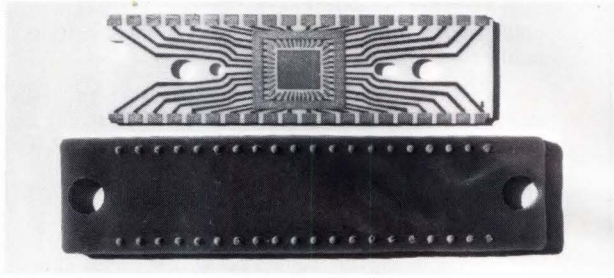


Fig. 2—Leadless MOS/LSI, shown at top, can be connected directly to the pc board by using a conductive elastomer carrier, bottom. This allows mounting without soldering and without the costly plated-through holes that are normally required.

These devices typically consist of one or two monolithic MOS/LSI chips with some associated discrete electronic components, a keyboard and display unit. The cost and packaging of the keyboard and display unit can dominate the cost of the low-cost calculator, something that certainly wasn't true before LSI. Due to the high impedance of the MOS/LSI circuitry, highly conductive metallic contacts and etched printed circuits are not required in calculator applications. In many cases a conductive elastomer can perform the same interfacing function more reliably, and at less cost.

Packaging and mounting of LSI

Conductive elastomers might prove beneficial in the packaging of small digital systems. By the use of an interconnector (EDN, Aug. 1, 1972), shown in **Fig. 2**, a ceramic (or plastic) package can be mechanically and electrically connected to a printed circuit board. The interconnector consists of an array of elastomer contacts molded in place on a non-conductive carrier as shown in more detail in **Fig. 3**. This array of resilient contacts can be used to connect the LSI package to the circuit board. This connection is made without the use of leads, pins or solder; thus elimi-

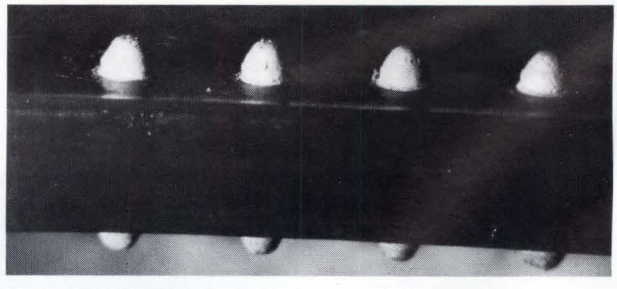


Fig. 3—Conductive plactic connectors for leadless LSI are constructed of inexpensive plastic with conductive elastomer contacts inserts. The elastomer compresses against the LSI contacts on one side and the pc board on the other.

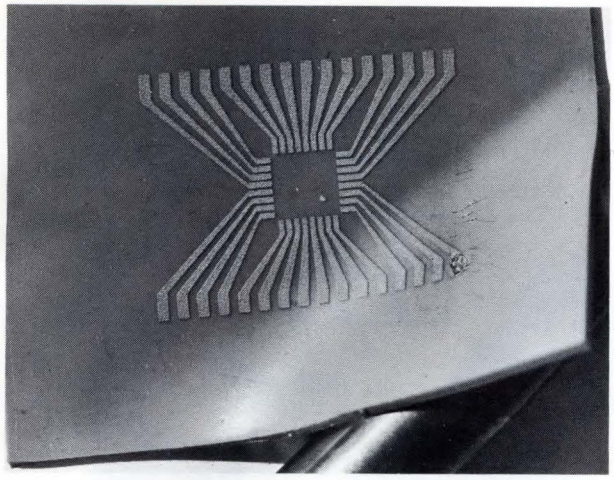


Fig. 4—Experimental elastomer carriers for LSI chips may eliminate wirebonding from chip to carrier assembly. Flexible conductive inks are screened on an insulating elastomer substrate.

nating the problems of solder and lead-frame damage.

Such a connector technique can also be used to make connection to some of the new glass/ceramic display modules used today where solder or connectors are cumbersome. This system will provide good long term connections. Additional benefits are good shock mounting and easy replacement.

Elastomers may yield direct mounting for LSI chips

There are also many applications using conductive elastomers in packaging at the chip/wire-bond level. **Fig. 4** shows an enclosed contact array with conductor widths of 0.006 in. screened onto an insulating, flexible substrate, using an ink made from conductive polymers. Even at these dimensions, this unit retains all the properties of the elastomers previously mentioned. Such printing techniques permit direct mounting of a monolithic chip without the use of conventional wire-bonding procedures. The pressure contacts provided by this method can produce a very reliable contact and also permit extraction of the circuit without damage. A closer view of these patterns is shown in **Fig. 5**.

Alternatives to etched copper boards are here, too.

Next, consider the circuit board. It, too, can be fabricated from composite materials, specifically by screening conductive inks onto a rigid substrate.

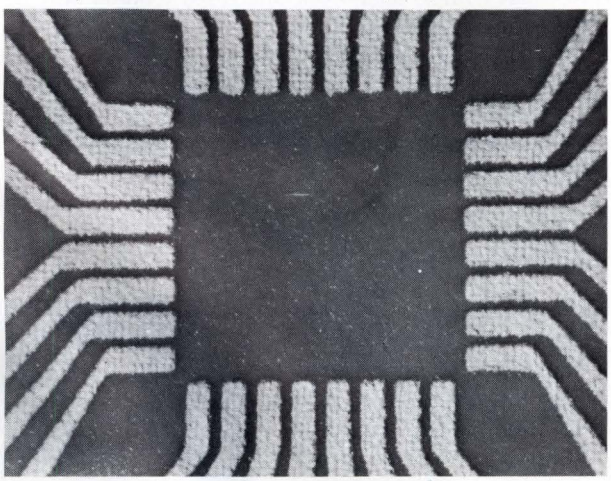


Fig. 5—Closeup of elastomer chip carrier shows conductive ink patterns. Pad areas are 0.006 in. wide, and can be screened by conventional techniques.

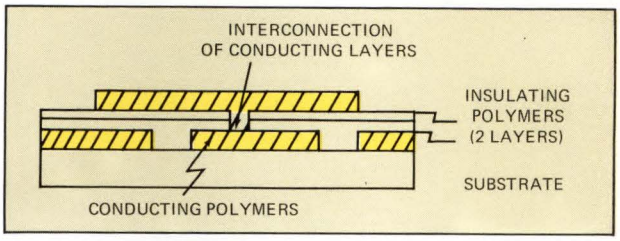


Fig. 6—Conductive inks can be screened onto circuit boards to form multilayer circuits. Two layers of insulation are used to minimize pinholes and accidental connections between conductors.

In reasonable volume, this technique is very economical, especially when a multilayer board is required. Conductive inks or coatings consist of a metal dispersed in some polymer matrix. Here, other parameters of the composite become important such as proper viscosity and cure cycles to permit efficient screening. Circuit boards containing up to five layers can be produced by the screening of alternate conductive and non-conductive layers by the method shown in **Fig. 6**. The savings here result from the absence of plated thru holes and the avoidance of etching or plating operations. The polymer inks are simply screened on and cured in place. With proper processing they will remain stable indefinitely. The only limitation with this technique is the resistivity (approximately $10^{-3}\Omega$ cm). But, as previously mentioned, this does not present a problem with high-impedance circuits. Also, unless these coatings are subsequently plated, the coatings are not solderable. An example of a board used to provide BCD output from a calculator keyboard is shown in **Fig. 7**.

Suitability is already proven.

While some of these uses are conjecture, the suitability of the material is not. Calculator keyboards made by this technique are available from several manufacturers. The switch contacts have been, as shown in **Fig. 8**, fabricated entirely of elastomeric composites. Elastomer switches are already a reality and potentially they offer reliability equal to more complex switches at a much lower cost.

Conventional moving gold or silver-plated contacts are replaced by the deflection of an elastomer onto a circuit board. Thus, in some cases the entire keyboard can have four or five parts, only one of which moves. In its simplest form, such a keyboard would consist of a printed circuit board, a non-conductive separator, the elastomer contact

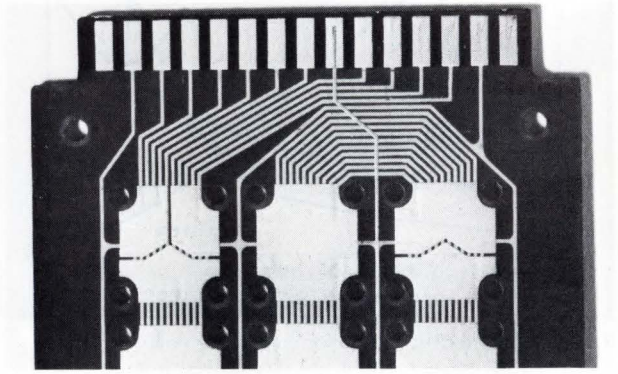


Fig. 7—Production multilayer board made with conductive inks provides BCD coded output for calculator circuits. Five layers of conductive ink are used in this model.

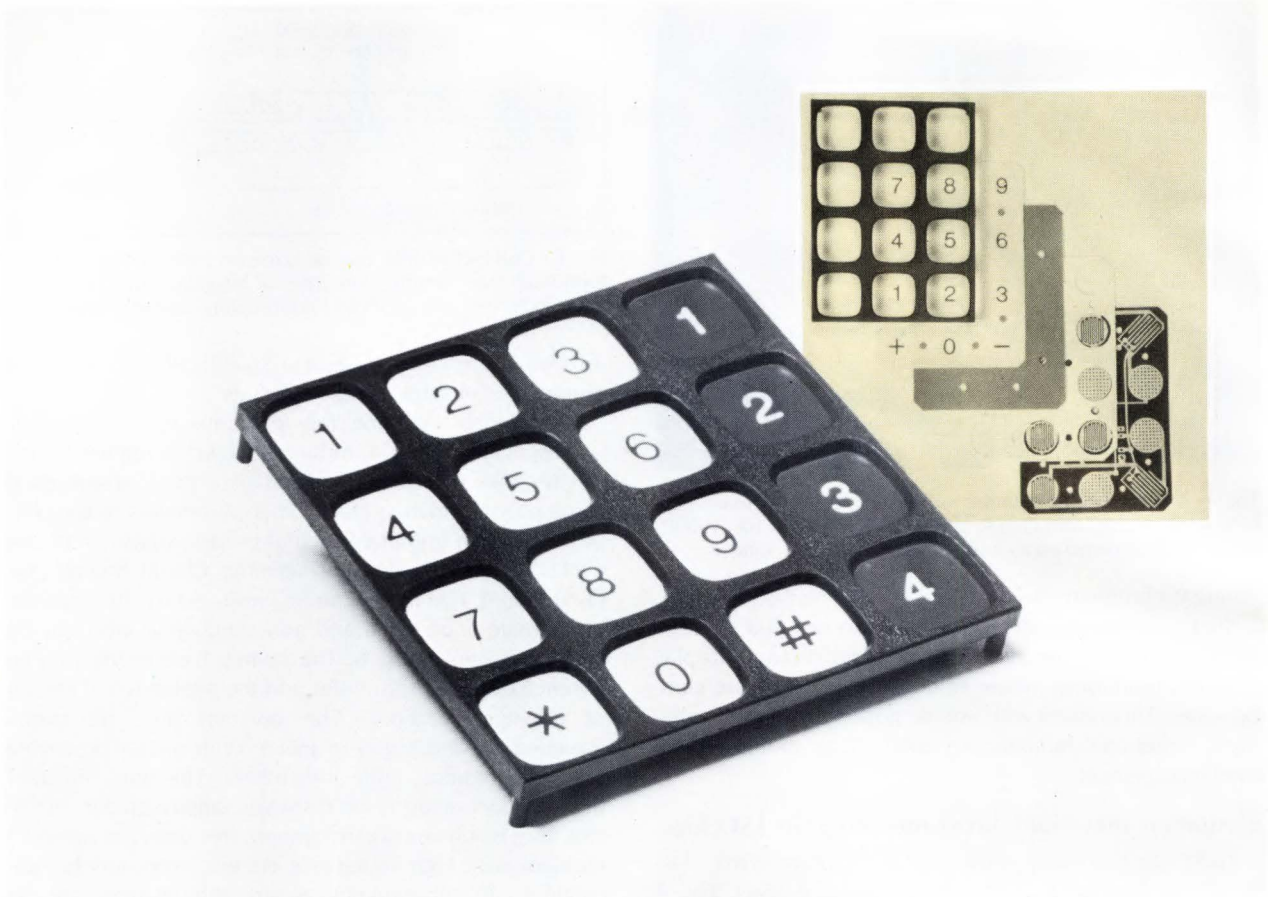


Fig. 8—All plastic keyboard uses conductive ink and a conductive polymer sheet with plastic spacer and faceplate. Other than the metallic fillers in the conductive plastics, absolutely no metal is used in the entire keyboard.

pad and a legend to indicate key locations and functions.

It is also possible to construct a more conventional key switch by adding a key and guide assembly if desired. Neither of these concepts contain any metallic parts other than springs. The use of inexpensive molded parts in conjunction with the conductive elastomer yields a simple, low-cost device. Note though, that due to the conductivity of the composite materials, the closed resistance of such a switch might well be up to 10Ω. This is well under the threshold of a typical MOS device. Many MOS system designers are now specifying switch contact resistances of up to 1000Ω.

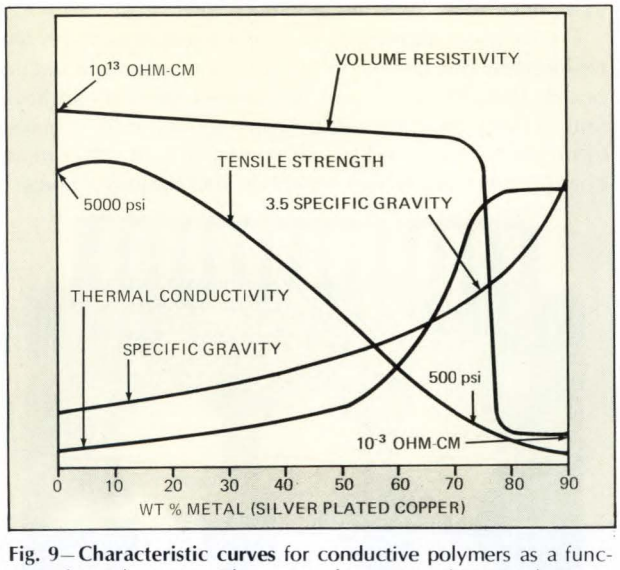
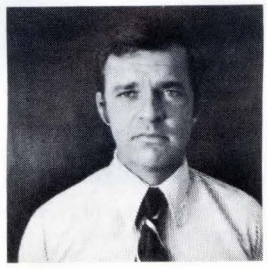


Fig. 9—Characteristic curves for conductive polymers as a function of metal content. The major changeover, from insulating to conducting, occurs between 70 and 80% loadings of metal. Metallic content in excess of 80% brings only slight improvement in conductivity, while tensile strength continues to degrade.

The graph in **Fig. 9** shows some typical properties of a metal filled silicone rubber. Notice the sharp change in volume resistivity as the loading of the metallic filler reaches 75 to 80%. It is at this loading level of approximately 80% weight of metal that the electrical and thermal properties tend to flatten out. Increased loading only degrades the physical properties.

With an understanding of the behavior of this new family of materials and the options available in their formulated properties, many heretofore complex switching and connecting applications can become a reality for a reasonable cost. □

Author's biography



Richard Seeger is General Manager of Components at Chomerics, Inc. in Woburn, Mass. Rick received a BSME from Northeastern University and holds seven patents. He is a member of PI TAU SIGMA and his hobby is sailing along the New England coast.

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CHECK NO. 18

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EDN DESIGN AWARDS

CMOS and LPTTL gates make low-power Schmitt trigger

Roger Cox
Hewlett-Packard Co., Loveland, Colo.

One half of a low power NAND package, and one CMOS inverter make a low-power Schmitt trigger, for applications where the power consumption of a 7413 IC Schmitt trigger is acceptable.

The two NAND gates form an $\overline{SR}$ flip-flop. Q goes high when Vin > 2.1V, the CMOS threshold $\overline{Q}$ will not go low until Vin < 1.2, the low-power TTL threshold.

Both polarities of the output signal are available. The power savings of this circuit over standard TTL methods is quite impressive, as shown in Table I. □

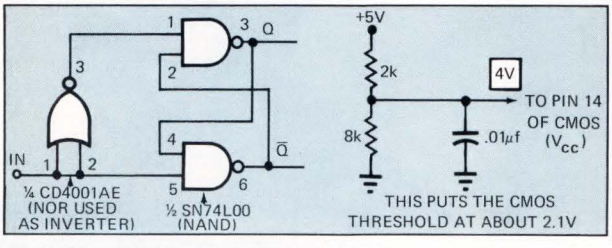


Fig. 1—One CMOS and 2 LPTTL gates are all that are needed for a very low power Schmitt trigger. Threshold for the CMOS gate is dependent upon its Vcc. Using 4V for V_{cc} as shown, will result in a threshold of approx. 2.1V.

Table I

Power Comparisons:	(for 2 Schmitt triggers)	
STANDARD TTL	LOW POWER TTL/CMOS	
1 SN7413 32mA	1 SN74L00	1.4mA
	1 CD4001AE	.5mA
	(for resistors)	
Worst case current:	32mA	1.9mA
Worst case power:	160mW	9.5mW

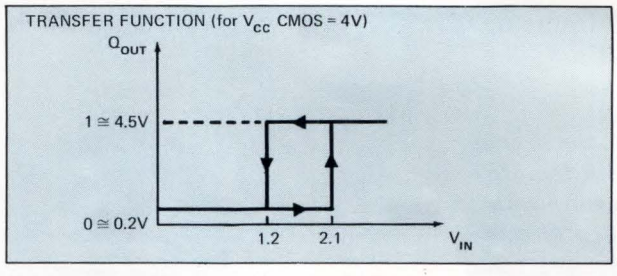


Fig. 2—Switching thresholds for the low-power Schmitt circuit, when Vcc for the CMOS gates is 4V, provide about 900 mV of hysterises. The 1.2V threshold is fixed, but the upper threshold can be varied from 2.1 to 2.5V by increasing CMOS V_{cc}.

To Vote For This Circuit
Check 150

Simple stair-step generator uses 1 IC and 3 transistors

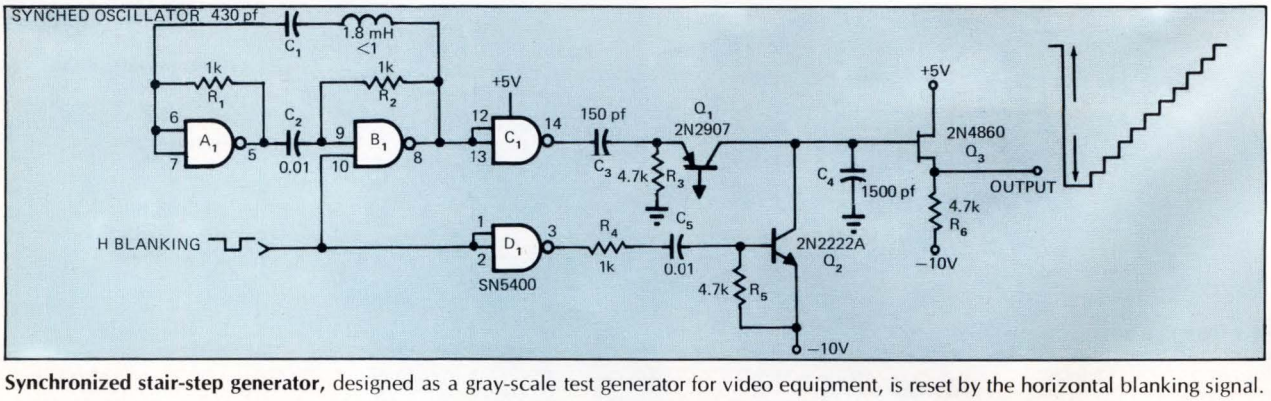
Edwin E. Morris
General Electric Corp., Utica, N.Y.

Synchronized stair-step generators are needed for, among other things, a gray-scale test signal for television equipment.

The illustrated circuit is a synchronized LC oscillator driving the stair-step generator, both of which are reset by the horizontal-blanking input signal.

The synched oscillator is a simple, positive-feedback LC oscillator composed of two TTL gates biased at their linear range by negative feedback resistors R_1 and R_2. With a LOW input on pin 10 of G_1, pin 8 goes to its HIGH output level regardless of the input on pin 9. During this OFF condition, C_1, C_2 and L_1 assume their steady state conditions. As a result, the oscillator always starts in the same condition.

The circuit generates a stair-step by integrating a train of equally spaced pulses. The voltage across C_4 is −10V at



Synchronized stair-step generator, designed as a gray-scale test generator for video equipment, is reset by the horizontal blanking signal.

the start of the stair-step due to the clamp Q_2. As a function of time the voltage across C_4 is expressed by:

$$V_{C4} = -10 + \frac{1}{C_4}\int_o^t i\,dt.$$

The only currents into C_4 are a small amount of leakage from Q_2 and the gate of source follower Q_3 and the input current from Q_1.

The current from Q_1 is a series of pulses due to input current to this common base stage. The input current pulses result from applying a series of step voltages across the capacitor C_3. The current into C_3 is expressed by:

$$i_{C3} = C_3\frac{dv}{dt}$$

Since the step voltage of the low output impedance TTL gate is applied directly to both C_3 and the low impedance input to the common base stage, Q_1, the current approximates one pulse.

C_3 charges rapidly into the emitter of Q_1 on the positive going transition of the square wave input. On the negative going transition Q_1 is turned off and C_3 slowly discharges through R_3.

The magnitude of each step is determined by:

$$[(G_1 \text{ Step Voltage Change}) - (V_{EB})] \times [C_3 \div C_4]$$

The number of steps is determined by the frequency of the oscillator.

Q_3 is simply a source follower buffer stage. □

To Vote For This Circuit
Check 151

Two TTL gates drive very long coax lines

Robert W. Stewart
Control Data Corp., Santa Ana, Calif.

Need a great TTL coax driver and receiver? This circuit has all the good features you want and haven't been able to find. It will transmit information via coax or twisted pair over long lines at bit rates exceeding 10 Mb per sec. And the best part is its cost, that of standard logic gates, plus a few resistors.

The distance over which this driver/receiver will work is a function of the channel used (coax or twisted pair) and the data bit rate, due to both rolloff and phase distortion in the channel.

Safe operating maximums for two types of coax can be derived from **Fig. 1**. Twisted pair typically has a characteristic impedance in the range of 50 to 120Ω and has approximately the same loss characteristics as RG 174 below 10 MHz. For a convenient rule of thumb, the channel attenuation should not exceed 10 db for the data clock frequency. That is, if the clock frequency is 5 MHz, the overall channel attenuation should not be greater than 10 db at 5 MHz to support a data rate of 5 Mb per sec.

In **Fig. 2**, the device types have been chosen to provide two drivers or two receivers per IC package. The unused input in the receiver could also be connected as a strobe.

Success of the circuits depends upon operating about the threshold point of the receiving gate. This threshold is very accurately determined by connecting output to input of an adjoining gate on the same IC chip. The diffusion process by which the ICs are fabricated insures that the bias gate and the receiving gate have identically the same threshold and will track each other with temperature and voltage. Being a linear feedback amplifier, the bias gate, G_3, exhibits a low output impedance and can easily terminate the channel load resistor. Operation of the receiver is enhanced by forcing the driver to operate symmetrically about the receive threshold voltage. When the input to the driver is high, the driver output becomes saturated at near ground potential and when the input is low, feedback around the driver limits its output to twice the driver threshold voltage. Although different from the receiver threshold, close matching is not necessary and only becomes important for channel losses greater than 20 db. The logic input to the driver circuit should be a standard TTL gate with a positive swing of 3.0V or better and a saturated zero level of about 0.25V.

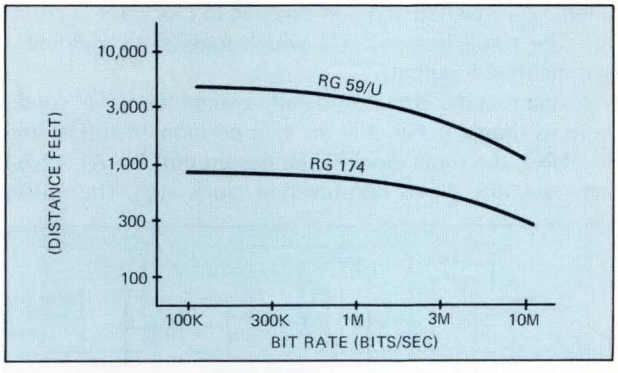


Fig. 1—Performance curves for driver circuit when used with RG59 or RG174 coax. Twisted pair lines approximate the performance of RG174 at data rates below 10 MHz.

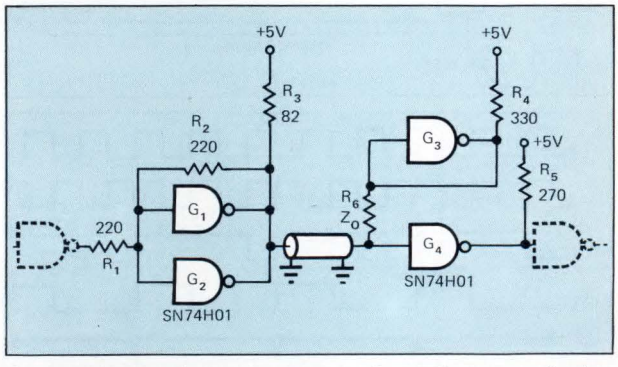


Fig. 2—Driver/receiver pairs require only 4 TTL gates, and a few resistors. R_6 is the coax termination resistor.

If you're at all concerned about operating these gates in their linear mode, a quick check of the open collector gate circuits will show that power dissipation is being kept within reasonable bounds and that nothing catastrophic can happen. □

To Vote For This Circuit
Check 152

Reader responds to odd modulo divider in July 1st EDN

Charles W. Hardy
Rixon Electronics, Silver Spring, Md.

After reading your July 1, 1972 edition, in particular the Circuit Design Awards, I was compelled to write this letter. The odd modulo 50/50 duty cycle divider circuit violates two "good design" principles,

1. It is too "partsy", contains 5 bits of storage and 5 gates for a symmetrical ÷ 5. A ÷ 5 should require 3 bits plus gates, a ÷ 7, 3 bits plus gates, a ÷ 9, 4 bits plus gates.
2. Intermix of too many digital chip types 74163, 7404, 7402, 7400 and 7474.

The circuit I will describe has all the advantages of the July 1 version while having less total chip count and containing only two digital chip types. In addition, the design is more flexible, allowing any odd modulo count.

Fig. 1 is a logic diagram of the circuit. An input clock is alternately inverted and non-inverted to clock a ÷ 3 counter. The result is a ÷ 2 1/2 which toggles A3 yielding a symmetrical 5 output.

Examining the circuit in detail, assume the initial conditions as shown in **Fig. 2** at the start position. With Ⓔ at logic ZERO, the input clock when passed thru the A1-A2-A3 gate structure yields non-inverted clock at Ⓐ. The A5-A6 shift register is clocked until logic ONE is sensed at both A5-Q and A6-Q at which time Ⓓ goes from logic ONE to logic ZERO clocking A7 and clearing A5 and A6. After the shift register has been cleared, Ⓓ returns to logic ONE by action of the feedback involved. This point is shown by 1 in the timing diagram. Now Ⓔ having changed to logic ONE, causes the input clock to be inverted at point Ⓐ and the shift register begins another cycle 1/2 clock period after 1 in the timing diagram. When time 2 is reached, another regenerative cycle starts causing A7 to toggle once more and the clock to become non-inverted at Ⓐ. The result at A7 output is a perfect square wave of one fifth the output frequency using only 2 1/2 chips.

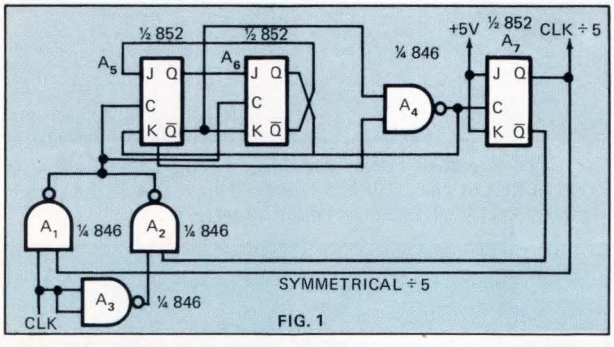


FIG. 1

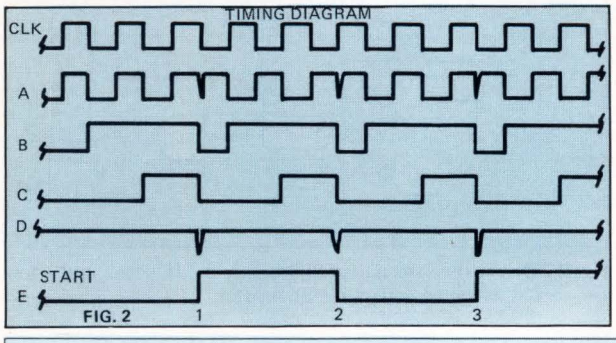
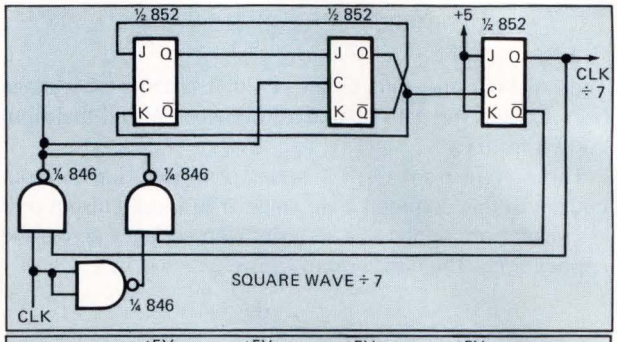


FIG. 2



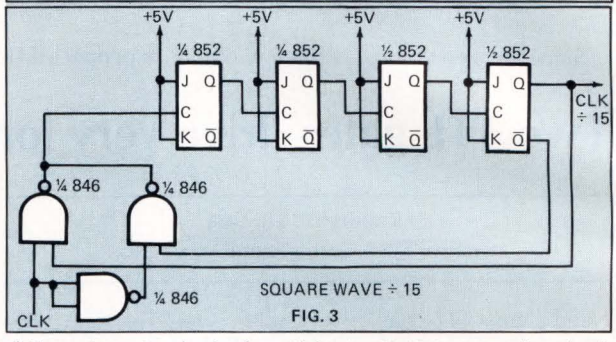


FIG. 3

Note: A1-A2-A3 are actually performing an "exclusive OR" of the input clock and signal Ⓔ. The circuit would appear even more simple by showing A1-A2-A3 as a single "exclusive OR" gate. I have elected to use the remaining 3 gates from 846 needed to perform the decoding of A4.

To illustrate the flexibility, **Fig. 3** shows logic diagrams of a ÷ 7 and a ÷ 15 using this principle. Note that only 3 bits are required for the ÷ 7 and only 4 bits for the ÷ 15. □

To Vote for This Circuit
Circle 153

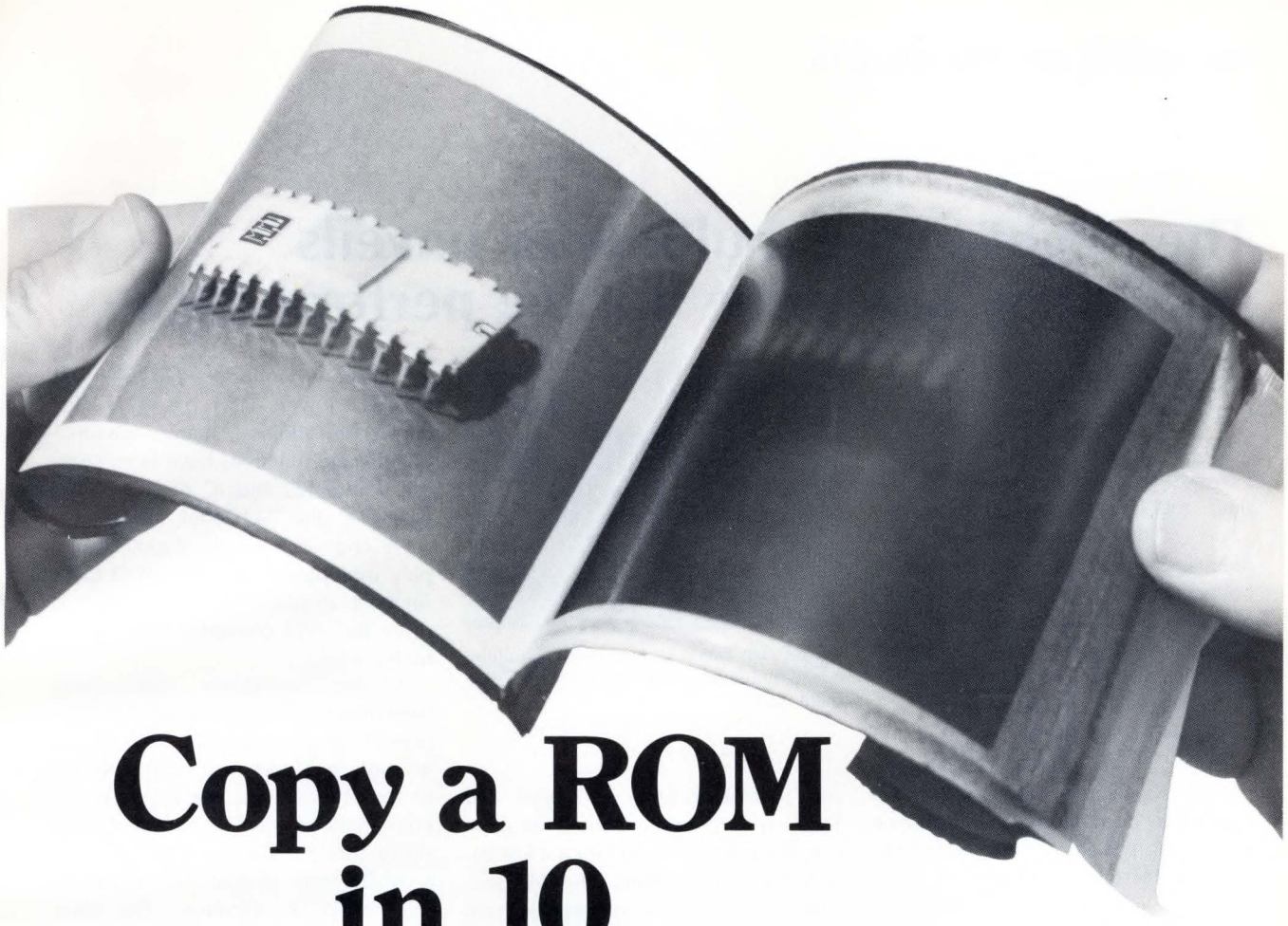
Rules & Announcements

Your vote determines this issue's winner. All circuits published win a $20 cash award. In addition, all issue winners receive a $50 U.S. Savings Bond and become eligible for the annual $1000 U.S. Savings Bond Grand Prize.

Vote now, by checking the appropriate number on the Information Retrieval card.

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

Readers have voted:
Leslie A. Mann winner of the July 1st Savings Bond Award. His winning circuit is "Divider circuit maintains pulse symmetry". Mr. Mann is with Radiation Inc., Melbourne, Fla.



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MM 6330	32x8	50	Open Collector	$ 12.00	MM 6230
MM 5330	32x8	50	Open Collector	$ 20.00	MM 5230
MM 6331	32x8	50	Tristate	$ 12.00	MM 6231
MM 5331	32x8	50	Tristate	$ 20.00	MM 5231
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CHECK NO. 19

The mighty-mite multimeter unveils small size, low price but big performance

PROGRESS IN INSTRUMENTATION

How would you like to have a 4-1/2-digit multimeter costing about the same as the lowest-cost 3-1/2-digit meters, yet performing just as well or better than 4-1/2-digit units costing twice as much—and have it fit into your jacket pocket besides? That's what you get with the new $295 Data Precision Model 245 Multimeter.

Think of what this does for the field engineer. He can tuck a 245 into one pocket, slip a new, powerful, pocket calculator into another, and maybe clip a tiny portable oscilloscope onto his belt. He then becomes a walking lab capable of diagnosing almost any field problem. With all this equipment, he still has both hands free to carry spare parts and operating manuals.

In order to evaluate just how good the "mighty mite" is, compare it with its rivals—the 3-1/2- and 4-1/2-digit meters. Why? Because the 3-1/2-digit DMMs compete price-wise but not performance-wise, while the 4-1/2-digit units compete performance-wise but not price-wise. None really compete in size.

Some 3-1/2-digit DMMs sell in the $285-300 range, but most sell in the $385-495 range. Most 4-1/2-digit multimeters are in the $495-695 price bracket.

Like the competitive DMMs, the 245 offers resistance and ac/dc voltage and current-measuring scales. However, unlike most of the other meters, the 245 has less sensitivity by offering only four voltage and current ranges vs. five. But this appears to be the only place where it suffers in the comparison.

Accuracy in the ac and dc voltage ranges compare favorably (0.05% on dc and 0.08-1.0% on ac, depending on frequency) with competitive 4-1/2-digit meters and are better in most cases than 3-1/2-digit meters. Input impedances (1000 MΩ on 1V range and 10 MΩ on other dc ranges- and 1MΩ on ac ranges) are about the same across the board, except for the lowest-cost 3-1/2-digit meters. The 245 specifies accuracies at frequencies from 30 Hz-50 kHz while most others specify 40-60 Hz to 10-20 kHz.

Pocket-size DMM features full capabilities and easy reading with bright Sperry 7-segment display.

Although the 245 has 4 current ranges vs 5 for other meters (except low-cost 3-1/2-digit units which have only one), dc accuracy (0.10%-0.20%, depending on range setting) is better than most 3-1/2- and 4-1/2-digit meters. Accuracy in the ac ranges are comparable, except that the 245 specifies both higher and lower frequencies.

For resistance measurements the 245, like its 3-1/2- and 4-1/2-digit competitors, offers 5 ranges (a couple may have 6 ranges). However, it has about twice the accuracy (0.07%-0.25% depending on range setting) as both classes of competitors.

There are some areas where other DMMs don't compare at all with the "mighty mite". These include: size—5 x 1-3/4 x 3-1/2 inches, weight—1 lb with batteries, internal batteries (6 hrs. min. operation) and automatic zero (no front panel tweaking).

How does Data Precision achieve this minor miracle? For one thing, they don't use any black magic. Instead, they improved their Tri-phasic A/D converter and Isopolar reference techniques, both of which proved to be significant factors in the design of their low-cost DVM introduced in 1971 (see EDN/EEE July 1, 1971 pgs. 12-13 for details). In addition, many individual circuits and functions have been combined into ICs and IC packages. For example, one P-channel silicon gate MOS chip includes the counters, display multiplexing circuits, BCD to 7-segment display converter, logic to drive the A/D converter and latches for the display.

Another innovation uses clever switching to allow some precision components to do a variety of jobs. There are only two precision resistor strings in the entire measuring circuitry and both are housed in DIP packages. One string serves as a dc attenuator, ac feedback gain control, and as ratiohmic resistance standards. The other contains all the current shunts.

All of these design tricks, along with the use of about one-half dozen CMOS circuits for control logic, help to hold power consumption to 0.75W, with all digits displayed.

The 245 provides 100% overrange on all scales except 1000V ranges, and an automatic fast-time-constant return function in the A/D to allow accurate readings to be taken on the next cycle after removal of an overload condition. Current measurement protection is provided by a fuse located in the specially constructed probes.

The DMM will run off of either the rechargeable NiCad batteries or through the transformer/rectifier charger supplied. When connected to the ac line, the 245 will operate normally even though the batteries may be completely discharged. The batteries always receive a trickle charge, whether the meter is in operation or not, as long as the charger is connected.

Full production of Model 245 is expected by November 1972, with deliveries 30 days ARO. Price is $295 in unit quantities. Data Precision Corp, Audubon Rd., Wakefield, MA 01880. Phone (617) 246-1600.

267

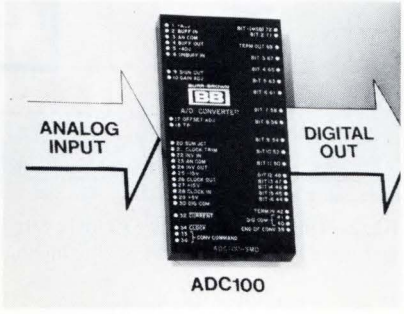
High-resolution integrating A/D converter features extremely low linearity errors

PROGRESS IN CIRCUIT MODULES

A new 16-bit A/D converter boasts maximum linearity errors of 0.005%, maximum accuracy drift of 5 ppm/°C, and a unit price of $200.

Aimed at industrial process control, data logging and high-accuracy instrumentation applications, the Model ADC100 is a true-integrating-type converter. Integration of the input voltage occurs over the entire conversion period, thus eliminating random high-frequency noise and those frequencies having an integer number of cycles during a conversion period. The conversion time can be easily adjusted to obtain 50 or 60 Hz rejection.

These converters are designed so that the resolution of a BCD unit may be expanded to 4-1/2 or 5 digits by using no more than two external logic ICs. Expansion to 4 digits will double the basic 30 msec conversion time, while 5-digit conversion will require 300 msec. Provision is included to allow the linearity error of the ADC100 to be adjusted typically to 0.002%. With expanded resolution and lowered linearity error, it should be possible to use the ADC100 as the heart of a high-resolution 5-digit voltmeter.



With expanded resolution and lowered linearity error, the ADC100 could be used in a high-resolution 5-digit voltmeter.

The ADC100 is housed in a low-profile 2-in. x 4-in. x 0.4-in. module with dual-in-line pin spacing. The module is available mounted on a PC card, as well as in a rack enclosure for mounting in any of several racks, including Burr-Brown's 16A powered or unpowered rack. Both options include gain and offset-adjust potentiometers and connections for clock and linearity-adjust potentiometers. Units are available 2 weeks ARO in small quantities.

Burr-Brown Research Corp., International Airport Industrial Park, Tucson, Ariz. 85706. Phone (602) 294-1431. **268**

Optically coupled logic gates provide 2000V isolation

PROGRESS IN MICROELECTRONICS

High speed opto-isolator projects are presently underway at most companies that produce LEDs and/or photodiodes. One of the first of these projects to reach fruition is Monsanto's. Their introduction of the MCL 600, 601, 610 and 611 goes much deeper than merely announcing higher operating frequencies. These new devices are called "optically isolated logic gates" and like conventional opto-isolators, they incorporate an LED and a photodiode. It is the circuitry which follows the detector that sets the logic gates apart. As shown in the schematic in **Fig. 1** the new logic gates incorporate a comparator and a Schmitt trigger. A standard TTL active (totem pole) output circuit is provided on the 600 and 610 while open collector outputs will be available for the 601 and 611. Designed to operate from a standard TTL 5V supply, these four devices are characterized as follows:

•MCL 600 - 1 mA input diode current
- Active TTL output
- 100 kHz data rate

•MCL 601 - 1 mA input
- Open collector output
- 100 kHz data rate

•MCL 610 - 10 mA input
- Active TTL output
- 1 MHz data rate

•MCL 611 - 10 mA input
- Open collector output
- 1 MHz data rate

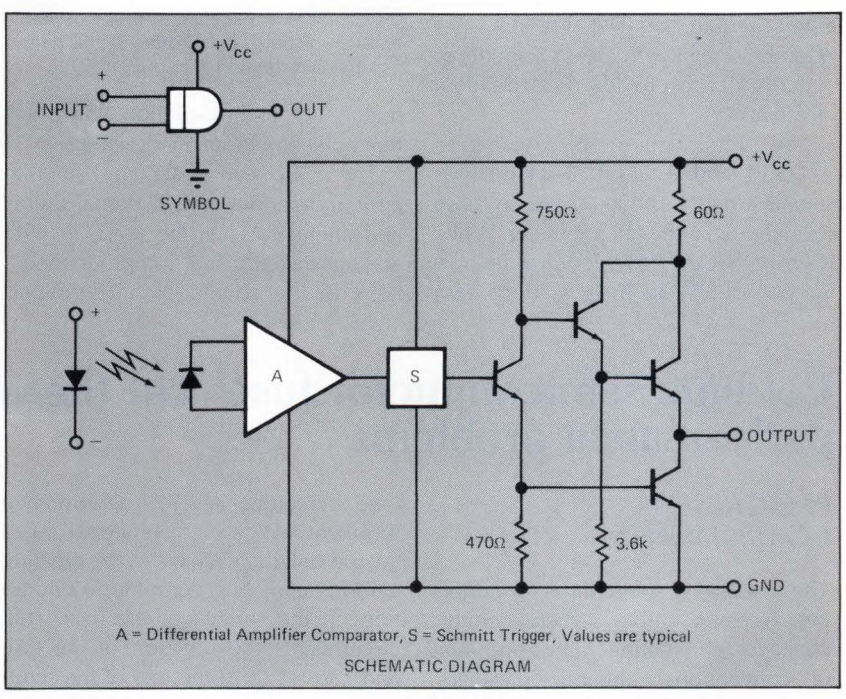


Fig. 1—Optically Isolated Logic Gates incorporate an LED, photodiode, comparator, Schmitt trigger and TTL output circuitry, either "totem pole" as shown here or open collector, in a single 8-pin plastic DIP.

The MCL 610 and 611 provide 10 nsec rise and fall times and their switching characteristics are shown in **Fig. 2**. In-

put current requirements for the 600 and 601 are roughly one tenth of those shown, and switching times are slower.

All four units are priced indentically: $9.80 each in small quantities and $5.95 each in lots of a thousand or more.

An application note, AN-510, soon to appear is now being prepared by Monsanto. Monsanto Commercial Products Co., 10131 Bubb Rd., Cupertino, CA 95014. Phone (408) 257-2140.

264

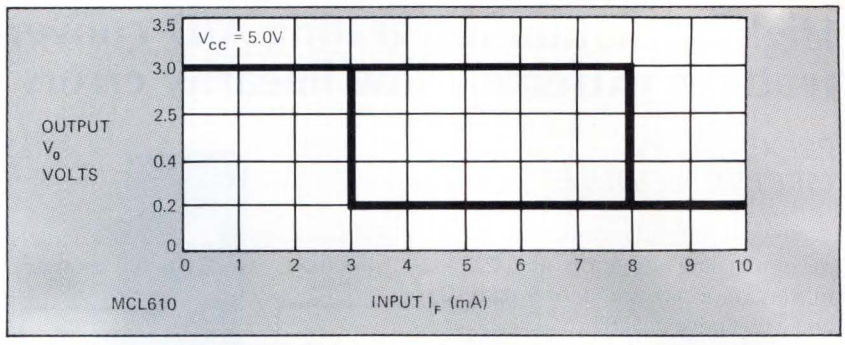


Fig. 2 – Output of the MCL 610 logic gate shows noise immunity afforded by the threshold and hysterises characteristics of the internal Schmitt trigger. Data rate of the 610 is 1 MHz.

3-digit panel meter smashes $50 price barrier

PROGRESS IN INSTRUMENTATION

Analog panel meters have maintained control of a multimillion dollar segment of the readout market because they:

- Are priced lower than a DPM.
- Are 2-terminal, free-floating devices, therefore easily applied.
- Don't require separate supplies.
- Can be scaled with external shunts or attenuators to provide direct readout in an arbitrary unit.

The introduction of Analogic's AN2530 and AN2330 3-digit DPMs signals a direct frontal assault on those strongholds of the analog meter. While it's true that the 2530 requires its own 5V power (3W of it, in fact), its easy readability and resolution will offset that objection for many designers.

3-digit DPM provides most of the desirable features of both analog and digital meters – 3-place resolution at less than $50.

The 2530 can scale any input to arbitrary readout units. External shunts and attenuators can be used, as with analog meters, and jumper connections to the counter-circuit terminals can provide least-count resolution of 1, 2, 5 or 10 units.

The units have 0.2% full scale (±1 count) linearity and relative accuracy. They can be used in high common mode environments – up to 300V dc or ac peak – as a 2-input, free-floating meter.

In addition, the 2530 features guaranteed monotonicity, independent decimal point selection, arbitrary overload blanking indicators, over-range capability, and parallel TTL compatible BCD output.

Price is less than $50 in orders of 100 or more, and single units are available for $75 each.

Analogic, Audubon Rd., Wakefield, MA, 01880. Phone (617) 246-0300.

265

Ceramic semiconductor fuses cut thermal performance problems

PROGRESS IN COMPONENTS

The first line of semiconductor protective fuses to utilize a metal-ceramic package, eliminating many problems of conventional phenolic packages, has been introduced by the Semiconductor Division of International Rectifier Corp.

Initial versions will be available with ratings of 130 and 250V and 10 to 800A. Units with higher voltage ratings will be introduced at a later date.

Conventional fuses use a phenolic case, creating several performance problems. When conventional fuses get too hot, the package chars, creating carbon, and thus permitting conduction on the surface of the fuse. That circumvents the function of the fuse and can result in the loss of the semiconductors before the dangerous condition is noted.

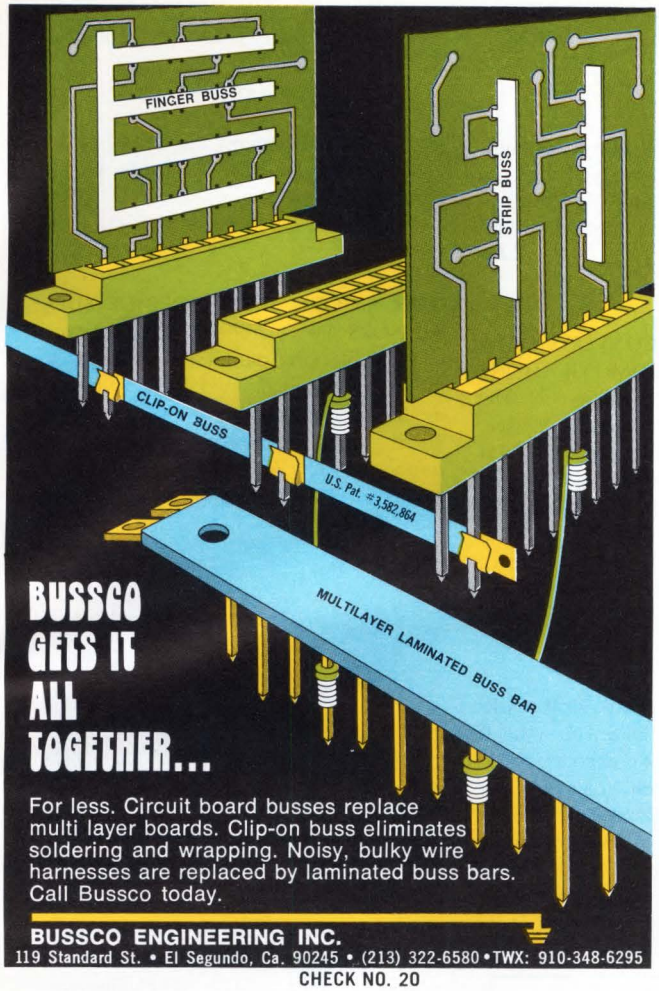
By contrast, the IR package is far more rugged and is more temperature stable due to the metal-ceramic construction and the greater inherent heat sinking capability. All-welded construction eliminates the need for solders.

In addition, the IR design allows a higher case temperature without the effects of thermal fatigue. A much lower operating temperature is required by conventional fuses.

Prices for the new fuses are competitive with conventional types. List price for the 130V, 100A version in small quantities is $3.50; delivery of all types is from stock.

Semiconductor Division
International Rectifier Corp.
233 Kansas
El Segundo, CA 90245.
Phone (213) 322-3331

266



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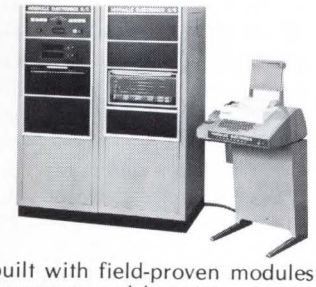

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By Sidney Weinberg

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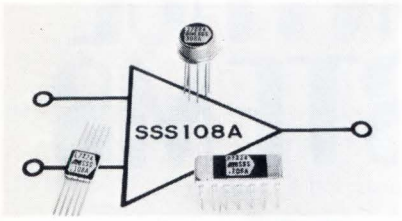


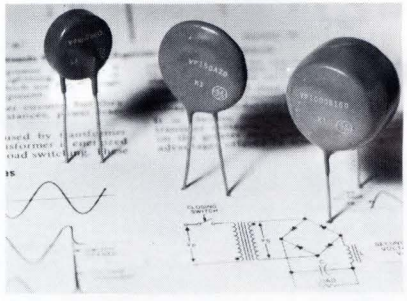
SUPER-BETA OP AMP FEATURES 2nA MAX. INPUT CURRENT. The SSS108A provides excellent performance in high-source resistance circuits because of the 200 pA max. offset current and 2.5 pA/°C max. offset current drift. Power supply current required is only 300 μA over the range of ±5V to ±20V. Prices for TO-99 devices at 100 pieces are from $2.95 to $19.95 each. Precision Monolithics, Inc., 1500 Space Park Dr., Santa Clara, CA 95050. Phone (408)246-9225. **225**

5,184-BIT STATIC CHARACTER GENERATOR PROVIDES 7X9 MATRIX OUTPUTS. Available in a 64 × 9 × 9 organization for use in vertical or raster scan displays and billboards, micro-programming applications, and code conversion. Model 2526 has TTL compatible inputs and outputs and requires +5V and −12V power supplies. Features include a 450 nsec typical access time. Signetics, 811 E. Arques Ave., Sunnyvale, CA 94086. Phone (408)739-7700. **226**

MOS/LSI SUBSYSTEM CONVERTS DATA FROM SERIAL COMMUNICATIONS LINKS to data processing equipment. The TMS6010 combines full transmit, receive, and format functions on a single MOS/LSI chip. Operation is from dc to 160 kHz. Immediately available in a 40-pin plastic dual-in-line package, it is priced at $15 in 250-piece quantities. Texas Instruments, Inc., 13500 N. Central Expressway, Dallas, TX 75222. Phone (214)238-2011. **227**

LED DRIVERS HAVE THICK-FILM CURRENT LIMITING RESISTORS. Four models are available: the 1001RL decoder/driver, the 1002RL quad latch (memory) decoder/driver, the 1003RL decade counter decoder/driver. The 1004RL includes counter, latch, decoder/driver and output limiting resistors. Prices range from $6 to $11 in standard plastic packages (1 to 24). SCS Microsystems, Inc., 1150 N.W. 70th St., Ft. Lauderdale, FL 33309. Phone (305)974-5400. **228**

DSAS SILICON SURGE-VOLTAGE SUPPRESSORS are controlled avalanche symmetrical blocking diodes connected back to back. Two all diffused P-N-P structure diodes are integrated on one silicon wafer. These surge suppressors feature μsec. response. Brown Boveri Corp., 1460 Livingston Ave., N. Brunswick, N J 08902. Phone (201)932-6066. **229**



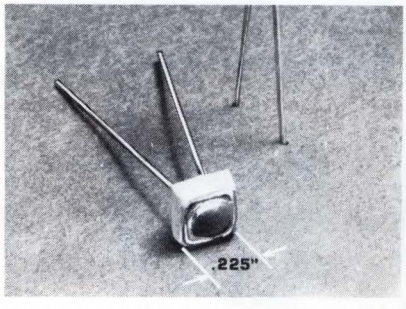
PRICES REDUCED ON MOV VARISTORS. The MOV offers significant advantages in voltage clamping and current handling over existing voltage suppression products. MOV varistors range in max. energy-handling capability from 10 Wsec., or joules, to 160 Wsec. Max. peak current rating is 1250A. General Electric, Semiconductor Products Dept., Electronics Park, Bldg. #7, Mail Drop 49, Syracuse, NY 13201. Phone (315)456-2021. **230**

MULTICHIP D/A CONVERTER IS MOUNTED IN A 16-PIN DIP. The unit includes monolithic switching networks, a precision thin film resistor network, and internal reference. Settling time is 3 μsec max. Power consumption is 600 mW max. and output voltage is 0 to −10V. Price is $39.00 in small quantities. Micro Networks Corp., 5 Barbara La., Worcester, MA 01602. Phone (617)753-4756. **231**

2048-BIT MOS RAM IN PRODUCTION. The AMS 6003 offers 360 nsec max access time and 595 nsec max cycle time; it features TTL-compatible inputs and incorporates address registers, chip-select registers and data output latches within the chip for easy memory-system implementation. Price is $20.48 each in orders of more than 250 pieces. Advanced Memory Systems, Inc., 1267 Hammerwood Ave., Sunnyvale, CA 94086. Phone (408)734-4330. **232**

TWO HIGH-GAIN TRANSISTORS FOR CLASS C VHF/UHF SERVICE. Silicon n-p-n overlay transistors feature high power gain: 6 dB min. The 40964 is especially useful as a frequency tripler in the 450-to-470-MHz band; the 40965 is intended for amplifier service in this band. Pricing in 1000-unit quantities is $1.20 for the 40964 and $1.08 for type 40965. RCA Solid State Div., Box 3200, Somerville, N J 08876. Phone (201)722-3200. **233**

AUDIO PREAMPS ADDED TO CONSUMER IC LINE. The LM381 has a total equivalent noise input of only 0.45 μV. The LM382 is similar to the LM381 except it has a built-in resistor network for NAB and RIAA equalization. Both the gain and equalization are selected by external pin connections. The LM381 sells for $4.95 and the LM382 for $2.25 each in quantities of 100. National Semiconductor Corp., 2900 Semiconductor Dr., Santa Clara, CA 95051. Phone (408)732-5000. **234**



8 AMP THYRISTORS OFFERED IN MINIATURE CERAMIC CELLS. The Cerma-cels™ are miniature ceramic cells containing an 8 Amp triac or SCR. They are available in 200V, 300V and 400V (V_{DROM}) ratings. The Cerma-cel combines the handling ease and thermal characteristic advantages of a packaged thyristor, but requires only slightly more space than direct chip mounting. Hutson Industries, 2019 W. Valley View La., Dallas, TX 75234. Phone (214)241-3511. **235**

ION IMPLANTED RECTIFIER FEATURES ULTRA-FAST RECOVERY. A 1A glass body, hermetically sealed rectifier featuring a forward voltage drop of less then 1/2V reverse recovery of 9 nsec max., and forward recovery of 1 nsec max., designated HSR-OA, is manufactured by an ion-implantation process which produces rectifiers with the fastest forward and reverse recoveries available at their current rating. Solid State Devices, Inc., 12741 Los Nitos Rd., Santa Fe Springs, CA 90670. Phone (213)698-3711. **236**

12 DIGIT MOS CALCULATOR CHIP DESIGNED FOR 5.5 to 7.5V OPERATION. The CT5002, has a current drain of typically 5 mA. The CT5002 has four functions and permits chain calculations. Multiplexed seven segment outputs will drive a variety of displays with a minimum of external parts. Cal-Tex Semiconductor, Inc., 3090 Alfred St., Santa Clara, CA 95050. Phone (418)247-7660. **237**

4-DIGIT, COUNTER/DISPLAY DECODER WITH BCD OUTPUTS. The 5007 is an ion-implanted, P-channel MOS four-decade synchronous counter with latches and multiplexing circuitry for BCD outputs. Prices for the MK 5007 P are $20.00 each in unit quantities and $11.75 at the 100-499 piece level. Mostek Corp., 1215 W. Crosby Rd., Carrollton, TX 75006. Phone (214) 242-0444. **238**

ECL TO TTL TRANSLATION EASED WITH INTERFACE FUNCTIONS. The MC10124, TTL in, ECL out, and the MC10125, ECL in, TTL out, are designed for use with the MECL 10,000 Series. MC1067/1267, TTL in, ECL out, and MC1068/1268 ECL in, TTL out interface with the MECL II Series. Motorola Semiconductor Products Inc., P.O. Box 20912, Phoenix, AZ 85036. Phone (602) 273-6900. **239**

SIX SCRs IN TO-5 CANS INTRODUCED. The 2N2322, 2N4212, IR5 and IR6 are all available with rated voltages of 25 to 400V; and the 2N1595 and 2N1595A, with rated voltage of 50 to 400V. Four of the types have sensitive gates: the 2N2322, 2N4212 and IR5, for example, require only 200 uA max. gate current to trigger at 25°C. Semiconductor Div., International Rectifier Corp., 233 Kansas St., El Segundo, CA 90245. Phone (213)678-6281. **240**

HIGH VOLTAGE, HIGH CURRENT TRANSISTORS OFFER FAST SWITCHING. The 2N6249, 50 and 51 feature a V_{CEO} (sus) of 350V and typical switching speed of 2 usec at 10A. They are manufactured using a double epitaxial process and hard solder construction in a copper TO-3 case. Prices in 100 lots or greater range from $4.74 to $7.14. Silicon Transistor Corp., KSC Way (Katrina Rd.), Chelmsford, MA 01824. Phone (617)774-0577. **241**

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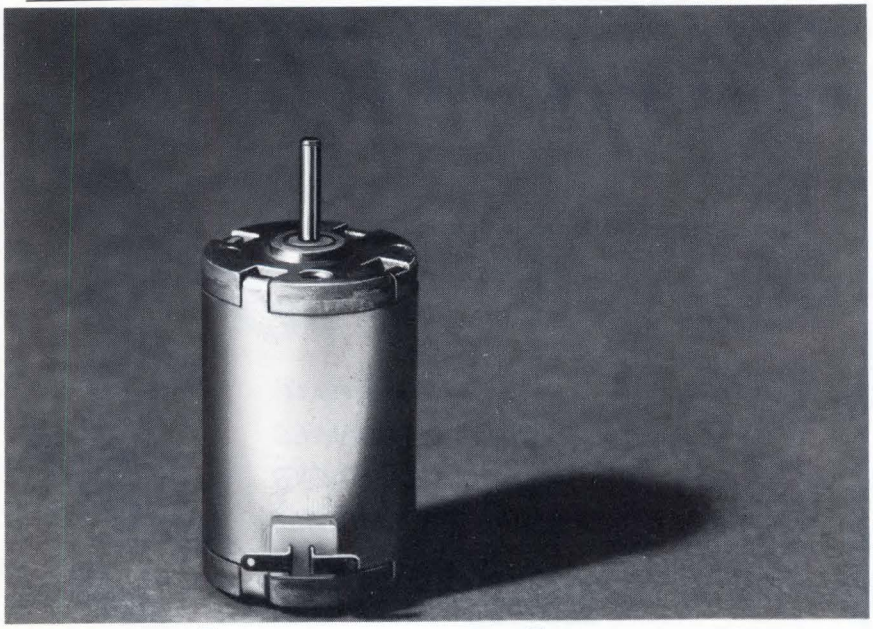

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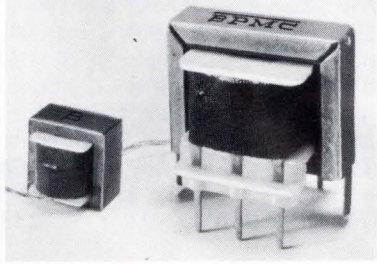

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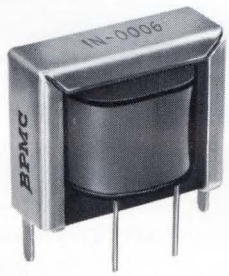

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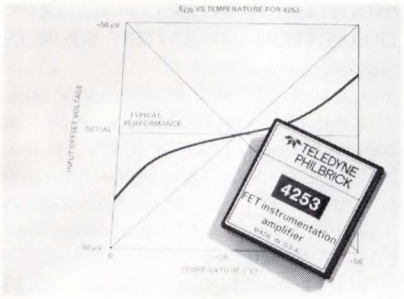


FET INSTRUMENTATION AMPLIFIER features guaranteed input offset drifts of 1 μV/°C. The Model 5253/01 (and 4253 with 2 μV°/C drift) precision amplifiers are designed to extract and accurately amplify small differential signals from large common mode voltages. The 4253 features single resistor gain selection. Priced at $67 and $115, respectively, in 25-piece quantity; the Models 4253 and 4253/01 are available from stock. Teledyne Philbrick, Allied Dr. at Rte. 128, Dedham, MA 02026. Phone (617)329-1600. **208**

ECONOMICALLY PRICED DC/DC VOLTAGE CONVERTER IS DESIGNED FOR DISPLAY USERS. The VC-523 model, featuring compact modular construction, operates from a 5V dc supply to provide an output over an adjustable range including 190 or 225V dc. The 190V output is intended for displays operating in standard dc applications. Load current is set at 15 mA max. Priced at $12.90 each in 1000 quantities. Sperry Information Displays Div., P. O. Box 3579, Scottsdale, AZ 85257. Phone (602)947-8371. **209**

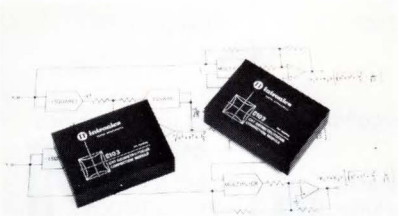
A/D CONVERTERS OFFER 13- AND 14-BIT RESOLUTION. The MP2913A and MS2914A provide conversions up to 13 bits or 14 bits, respectively, in 10 μsec, with linearity within 0.006%. The converters are housed in a 1-in. x 4-in. x 0.4-in. module and feature 7 ppm/°C gain and 3 ppm/°C differential linearity stability. External pins permit selection of four voltage input ranges. The MP2913A sells for $715 and the MP2914A cost $765. Analogic, Audubon Rd., Wakefield, MA 01880. Phone (617)246-0300. **210**

5V MODULAR POWER SUPPLY HAS 55% EFFICIENCY. Model 650A05 delivers 5V at 12A over the operating temperature range of −20°C to +40°C, 5V/10A at +50°C and 5V/8A at +71°C. It offers combined line and load regulation of 0.2%, operates from line frequencies of 47 to 500 Hz. Priced at $200 each. Trio Labs, Inc., Dupont St., Plainview, NY 11803. Phone (516)681-0400. **211**

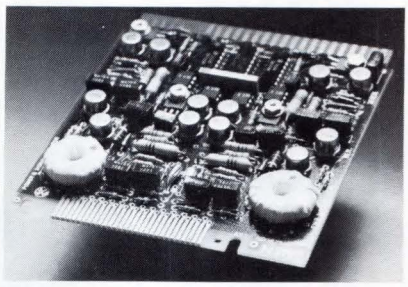
FOUR SIGNAL CONVERTERS PACKED ON SINGLE INTERFACE CARD. The card features four 5V dc to 115V ac signal converters in a standard size 4.5-in. × 4.5-in. card with CAMBION's 70-pin connector edge for easy incorporation into standard systems and intermixing with other CAMBION Cambi-Cards(R). Typical input requirements for the converters are 2.3V dc and 9.0 mA. Output is typically 115V ac at 7.5 mA. Cambridge Thermionic Corp., 445 Concord Ave., Cambridge, MA 02138. Phone (617)491-5400. **212**

HIGH PERFORMANCE DC AMPLIFIER IS LOW IN COST. The Model 550 dc amplifier from Ectron Corp. is a low-cost unit. Standard or optional capability includes 1μV/°C stability, dc to 80 kHz pass band, 100 mA output, 114 dB CMR, switch selectable filters, 10 direct reading gain steps from x1 to x1000, and gain vernier. Prices start at $135 for the fixed gain version. An additional $15 adds 10 selectable gain steps. Ectron Corp., 8133 Engineer Rd., San Diego, CA 92111. Phone (714)278-0600. **214**

PRECISION VOLTAGE REFERENCE IS DESIGNED FOR USE WITH ACCURATE A/D CONVERTERS AND COMPARATORS. The A-803 features a broad input voltage range of +15 to +25V dc and is preadjusted to an initial output voltage of 10V dc ±0.01%. Model A-803 is specified at 1.5 ppm/°C and the A-802 is specified at 3.5 ppm/°C stability over the full temperature range. Unit prices for the A-803 is $85 and A-802 is $65. Intech, 1220 Coleman Ave., Santa Clara, CA 95050. Phone (408) 244-0500. **213**



MODULES CORRECT FOR PINCUSHION DISTORTION IN PRECISION CRT DISPLAYS. Models are available for deflection angles in 5° increment up to 70°, with an accuracy of 0.02% at 20° to 0.2% at 60°. Model C102 features 10 mHz bandwidth with a gain temperature stability of 50 ppm/°C max. Model C103 is an economy version of the C102 with 500 kHz bandwidth. Prices are $395 (1-9) for the C102 and $245 (1-9) for the C103. Intronics, 57 Chapel St., Newton, MA 02158. Phone (617)332-7350. **216**



INDUSTRIAL LOGIC MODULE PROVIDES HIGH NOISE REJECTION. The NJ19 contains four digital-power isolators to provide +4 or +5V of isolated voltage which can be used as reference or regulated power. Additionally, four signal isolator circuits on the module isolate digital inputs from digital outputs. The NJ series modules use photo isolation to provide extremely high noise rejection and up to 1500V of ground isolation. Price is $150. Xerox Corp., 280 Park Ave., New York, NY 10017. Phone (212)972-1600. **217**

FSK MODEM MODULES USE SWITCHED ACTIVE RESONATOR CIRCUITRY. The technique eliminates many of the problems associated with phase-lock-loop circuits and requires a min. of external components. For a typical 300 bps 103 compatible modem utilizing the CH1211 demodulator, the CH1212 modulator and the CH1256 bandpass filter the modules occupy only 2.35 square in. of board space. Combined cost for the three modules in 100 quantity is $33.55. Cermetek, Inc., 660 National Ave., Mt. View, CA 94040. Phone (415) 969-9433. **218**

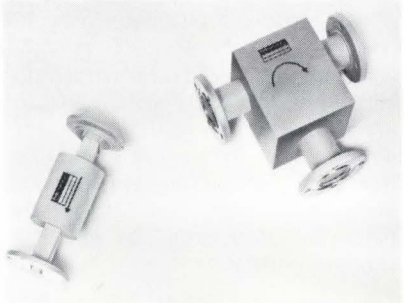
HIGH PERFORMANCE MICROWAVE AMPLIFIERS OFFER AN ORDER OF MAGNITUDE REDUCTION IN BOTH SIZES AND WEIGHT. Designated the UDP-2032 and UDP-4000 Series, the amplifiers cover the frequency ranges of 1-2 GHz and 2-4 GHz, respectively. The devices initially offered provide a minimum of 24 dB gain, 1 to 2 GHz (UDP-2-32) and over 10 mW (+11 dBm) linear output power from the UDP-4003. Prices start at $550. Avantek, Inc., 2981 Copper Rd., Santa Clara, CA 95051. Phone (408)739-6170. **219**

16-BIT A/D CONVERTER CARRIES A $895 PRICE TAG. The ADC-HR16B A/D converter is characterized by resolution of 16 binary bits with a linearity error of ±0.00015% and a remarkably low temperature coefficient of 5 ppm/°C Conversion time is 50 μsec. Overall accuracy is specified at ±0.005% of full scale with a long term stability of ±0.001%/year. Datel Systems, Inc., 1020 Turnpike St., Canton, MA 02021. Phone (617)828-6395. **220**

CIRCUITS

INDUSTRIAL DC TO DC CONVERTER OPERATES FROM 24V BATTERY SOURCES. Outputs are available in 5, 6, 12, 15, 24 and 28V dc at 20W. Efficiencies of up to 55% minimize heat dissipation and prolong battery life. Regulation is 0.01% for line, and 0.2% for load. Operating temperature is −20°C to +71°C. Six different models are available. Price is $165 each. Aaron-Davis Co., 1720 22nd St., Santa Monica, CA 90404. Phone (213)829-1834. **221**

RFI POWER LINE FILTERS PROVIDE POSITIVE CONTROL INTERFERENCE AT MODERATE COST. The K series filters are particularly suited where pulsed, continuous and/or intermittent RFI interference is present. Available in 6 case/termination styles and in current ratings of from 1 to 30 amps. The series is designed for operation from 115 to 250V ac 50 –400 Hz. Price ranges from $8.25 to $3.40. Corcom Inc., 2857 N. Halsted St., Chicago, Il 60657. Phone (312)327-6566. **222**



HIGH POWER FERRITE ISOLATORS AND CIRCULATORS cover the UHF through X-band frequency ranges. The new line includes the FCC-1100 Series High Power Coaxial Circulators, which achieve high power handling through the use of non-standard ferrite materials. Eleven standard models are available with average power handling capabilities to 10 kW and with peak powers to 500 kW. Merriman Industries, Inc., 41 Fairfield Pl., W. Caldwell, NJ 07006. Phone (201)228-3890. **223**

DOUBLE BALANCED MIC MIXER COVERS 12-18 GHz. Utilizing a patented balun configuration and mounted on a teflon-fiberglass board with beam lead Shottky diodes, the DM12-18 achieves low noise figure, (9 dB typical), good VSWR (2.5:1) and low IM distortion levels. The miniature unit occupies less than 2 cu. in. Priced at $595 in small quantities. RHG Electronics Laboratory, Inc., 94 Milbar Blvd., Farmingdale, NY 11735. Phone(516)694-3100. **224**

COMPUTER PRODUCTS

GRAPHICS COMPUTER TERMINAL OFFERS FULL UPPER & LOWER CASE. New features on the 4012 display terminal include a TTY-style keyboard with full ASCII capability, a bright graphic cursor to improve write-through capability, improved linearity and higher resolution plus the compatibility with all peripheral accessories of the 4010 family. $4950 with a basic communications interface. Information Display Products Div., Tektronix, Inc., P.O. Box 500, Beaverton, OR 97005. Phone (503) 644-0161. **197**

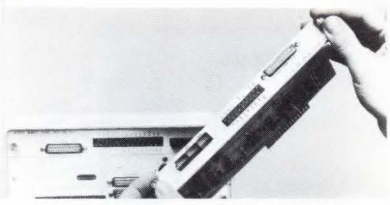
CASSETTE SYSTEM REPLACES PAPER TAPE IN GRI MINIS. A single Grisette II cassette can hold all GRI-99 computer library programs on one side and all computer diagnostics on the reverse. The full duplex version with both read and write units allows assembling and editing programs during software development. Phillips Type II cassettes are certified for 1600 bpi and can store up to 1 million characters. Data rate is 270 cps. $1000 for full duplex system including interface/controller and OS software. GRI Computer Corp., 320 Needham St., Newton, MA 02164. Phone (617) 969-0800. **198**

SC MEMORY SYSTEM SPORTS 125 NSEC ACCESS TIME. The RAM125 is available in configurations ranging from 128 × 8 up to 512 × 16. The SC system consists of memory modules plus support modules which contain memory address register, decoding and read/write amplifiers. All systems operate from ±5V and are supplied on a 4 × 5.5-in. or 7 × 5.5-in. pc card. System terminals are accessible through a 60-contact, double-edge connector. $384. Electronic Memories, 12621 Chadron Ave., Hawthorne, CA 90250. Phone (213) 644-9881. **199**

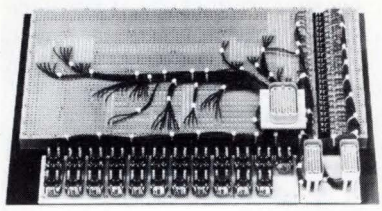
ADD-ON MEMORY FOR DATA GENERAL MINIS. Low-cost 4k and 8k × 16-bit add-on core memory boards are electrically and mechanically compatible with Data General's 1200 and Digital Computer Controls' D116 computers. 4k is priced at $2500 and 8k is $3900. Digital Computer Controls Inc., 12 Industrial Rd., Fairfield, NJ 07006. Phone (201) 227-4861. **200**

4800 BPS AUTOMATICALLY EQUALIZED MODEM FEATURES MOS CIRCUITRY. The ADS-448/IV operates over unconditioned or conditioned voice-grade telephone lines. The unit can be switched to 2400 bps when errors from deteriorating line conditions become intolerable. The modem is available as a compact, standalone unit or as a pc card in custom sizes. The unit features 2-channel multiplexing and 3 loopback test modes. American Data Systems, 8851 Mason Ave., Canoga Park, CA 91306. Phone (213) 882-0020. **201**

CARTRIDGE DISK SYSTEM STORES 10 MILLION BYTES ON LINE. Half of the data is stored on a front-loading single-disk cartridge, and half on a fixed disk which is permanently mounted in the drive. All is made removable by transferring it to and from the cartridge automatically. The 2004 doubles the capacity of previous systems with a price increase of less than 10%, and interfaces with most minis. $3395. Iomec Inc., 345 Mathew St., Santa Clara, CA 95050. Phone (408) 246-2950. **202**



TEST SET MONITORS DATA TRANSMISSION COMPONENTS. The Checktran data transmission test set tests and monitors multiplexers, modems, transmission facilities, individual multiplexed channels for computer and terminal equipments, and entire communications systems. It has many test features including a data rate selection technique from 45 to 4800 bps asynchronous up to 2 million bps synchronous. $1450. Computer Transmission Corp., 1508 Cotner Ave., Los Angeles, CA 90025. Phone (213) 477-5020. **203**



MATRIX BOARD SIMPLIFIES CUSTOM ASSEMBLIES. The programmer consists of an x-y matrix with two or more contact decks in the vertical plane. Interconnection between decks is made with shorting pins with selectively insulated sections, and by component-holding pins which connect components between contact points. The cordless program pin arrangement eliminates the need for patch cords. The assembly can include relays/or power switching. Sealectro Corp., 225 Hoyt St., Mamaroneck, NY 10543. **204**

DIGITAL PRINTERS FOR RECORDING MEASURING DATA. This new family of digital printers includes paper strip and programmable carriage printers, in bench type or rack-mountable versions, with 5 to 16 digits. Maximum speed is 4 lines or 64 cps. They accept 1 in 10 or BCD codes. All printers are equipped with an interrogation unit, permitting simultaneous print-out of all digits. $785. Traco Inc., 509 Rolling Hills Rd., Somerville, NJ 08876. Phone (201) 725-5333. **205**

CONTENTION CHANNEL EXPANDER HAS FULL CONTENTION. The CCE can now concentrate M channels to N interfaces. It can be used to concentrate modems, terminals and multiplexers on a first-come first-served basis to a given number of computer ports. The CCE connects two or more full-duplex channels to one or more full duplex RS-232 interface connectors including data, clock and control signals. $115/triad. Timeplex Inc., Box 202, 65 Oak St., Norwood, NJ 07648. Phone (201) 767-1650. **206**

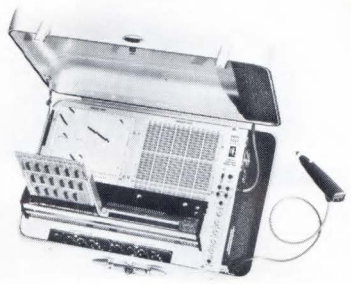
INTERFACE TO MATE CASSETTE SYSTEM TO PDP8, for both positive and negative buss machines. Software for the PDP8 family includes I/O drivers for each of the Mini-cette's 12 instructions. The Mini-cette 2000 digital cassette system includes self-correcting features (like read-after-write checking), CRCC check characters and dual threshold recording. At its 24 ips file read speed, it can read a 12k, 16-bit program into core in less than 10 sec. Cipher Data Products, Inc., 7655 Convoy Ct., San Diego, CA 92111. Phone (714) 277-8070. **207**

FET PROBE PROVIDES HIGH OSCILLOSCOPE PERFORMANCE. A dc-to-900 MHz, nonattenuating, low noise, FET probe lets you see faster and lower level signals. 3 pF input capacitance minimizes circuit loading. The probe is excellent for both 50Ω sampling and 1 MΩ conventional scopes (internally switchable). Plug-on 10X and 100X attenuators are available. The probe is designed for the TEKTRONIX 7904, 485, 7704A and 475 scopes. $375 Tektronix, Inc., P.O. Box 500, Beaverton, OR 97005. Phone (503) 644-0161. **170**

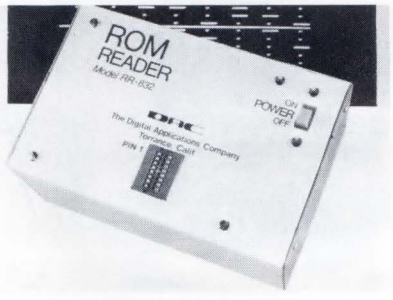
TWO-CHANNEL OSCILLOGRAPHIC RECORDER HAS 3 PLUG-INS. A choice of input plug-ins, a new ink system, and carbide tipped, stainless-steel pens and at least ten different combinations of signal conditioners can be used with Model 7402A. Three preamplifier plug-ins have sensitivities of: 1μV/div, 1mV/div, and 20 mV/div. Chart width is 50 mm, overshoot is less than 2%, and chart speeds are from 1 to 125 mm/sec. Basic price $1450. Hewlett Packard, 1501 Page Mill Rd., Palo Alto, CA 94304. Phone (415) 493-1501. **171**

TWO DIGITAL PANEL METERS. The low-cost series 2000B is smaller and faster at 30 readings/sec. than series 2000A and features buffered, isolated, and gated digital BCD outputs. Series 2000A will store a reading indefinitely, on external command, and feature autopolarity, ratio and 39.999 counts full scale. Reading rate is up to 20 readings/sec. with an error of ±0.01%. A 3-pole active filter attenuates all frequencies over 50 Hz by at least 50 dB. $280 for Series 2000B. Newport Lab., Inc., 630 E. Young St., Santa Ana, CA 92705. Phone (714) 540-4914. **172**

FET INPUT IN PORTABLE SCOPE INCREASES BATTERY OPERATING TIME. Operating time for the Phillips PM 3200 on the optional battery pack is extended from 4 1/2 to 5 1/2 hrs. Triggering is fully automatic. Sweep speed is selectable from 100 nsec to 0.5 sec/div. in 21 calibrated steps. Response is flat to 3 dB from dc to 10 MHz; sensitivity is 2 mV/div. The unit operates on 22 to 30V dc or of 100 to 125V or 200 to 250V ac at 40 to 400 Hz. Test & Measuring Instruments Inc., 224 Duffy Ave., Hicksville, NY 11802. Phone (516) 433-8800. **173**



DIGITAL LOGIC CARD TESTER IS PORTABLE. Model 200B features a hand-held high impedance probe with a four-digit display that shows logic transitions. Also on the probe are the start-test button, a level-set control, and indicators (LED) showing relative level and end-of-test. Overlay templates for the matrix panel permit rapid set-up of internal test circuitry. Four independent programmable power supplies provide −24 to +24V dc. $4495. Data Test Corp., 822 Challenge Dr., Concord, CA 94520. Phone (415) 689-3583. **174**



ROM READER CONVERTS SCOPE TO A DISPLAY UNIT. The model RR-832 allows viewing of the contents of an 8 x 32 (256-bit) ROM on any oscilloscope. ROM contents are displayed as an 8-bit horizontal by 32 word vertical pattern. A "zero" bit in is represented by a dot while a "one" bit is represented by a short line. In order to simplify identification of word addresses, every eight words are underscored on the display. $150. Digital Applications Co., 22513 S. Normandie Ave., Torrance, CA 90501. **175**

AUTOMATIC DIGITAL CAPACITANCE METER IS FAST AND ACCURATE. Model 275 provides automatic capacitance and dissipation measurement accuracies of typically 0.1% + 1 digit. The instrument's LEDs and 3 1/2 digit readout give instant verification of setting and C or D measurements, series or parallel. The display settles in 1 sec., and repetitive measurements are tracked at the rate of 4/sec. Electro Scientific Industries, 13900 N.W. Science Park Dr., Portland, OR 97229. Phone (503) 646-4141. **176**

LOGIC PROBE SELLS FOR UNDER $12. The LT-1 is a rugged, compact pencil type instrument used to determine logic levels. It operates from the dc supply of the system under test. Logic levels are detected by a LED indicator light. The LED is on at the (+) logic "1" level and off at the "0" level. The LT-1 is a high impedance device; therefore, there is no circuit loading. The frequency response is dc to 12 MHz. $11.95. EL Instruments Inc., 61 First St., Derby, CT 06418. Phone (203) 735-8774. **177**

HIGH-COST FEATURES ARE STANDARD ITEMS ON NEW DPMS. The 3 1/2 digit DPMs have suppressed or elevated reading, range-indicator lights, ratiometric reading, selectively blanked digits, special noise rejection, variable sample rate, two or more ranges, etc. available as standard additions to the basic DPM. A choice of terminal arrangements allow output for the operation of digital printers and other digital equipment. $143 for a basic bipolar DPM. Beede Electrical Instrument Co., Inc., Penacook, NH 03301. Phone (603) 753-6362. **178**

CURVE TRACER ALLOWS DEVICES TO BE TESTED IN-CIRCUIT. The LTC-905 features a horizontal length adjustment to 100V of sweep to enable use with all oscilloscopes. It checks for opens, shorts and leakages and tests such devices as transistors, UJTs, triacs, SCRs, zener diodes, FETs and MOSFETs—both depletion and enhancement mode types. $120. Leader Instruments Corp., 37-27 Twenty-Seventh St., Long Island City, NY 11101. Phone (212) 729-7410. **179**

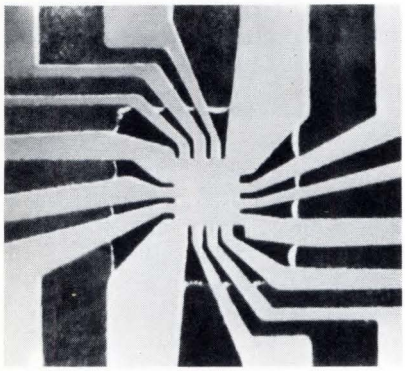
PHASE ANGLE STANDARD MEASURES AND GENERATES PHASE ANGLES. The 311/RT-1/717S can generate a precise phase shift, or measure phase angle. The full phase range from 0° to 360° is covered with an accuracy of 0.015 over the mid-frequency range. Operating frequency is from 30 Hz to 10 kHz. This instrument employs a unique "primary" concept where operation is not affected by changes in component values. $7800. Dytronics Co., Inc., 4800 Evanswood Dr., Columbus, OH 43229. **180**

WAVEFORM GENERATOR/PROGRAMMER DELIVERS COMPLEX WAVESHAPES. All the individual parameters whose values determine the exact shape of the final waveform can be independently selected. Model 175 allows independent selection of up to 4 inflection points and 2 values of either time (in pulse mode) or slope (in sweep mode) so that complex waveforms of up to 4 variable-length segments can be generated either singly or repetitively. $1650. Princeton Applied Research Corp., Box 2565, Princeton, N J 08540. Phone (609) 452-2111. **181**

SCOPE TRACER ELIMINATES CAMERA FOR REPETITIVE TRACES. A new clear plastic film with a 6 x 10 cm grid pattern on it and an adhesive backing allows trace records to be drawn in black, red and green using a normal single color oscilloscope. A direct positive record with high contrast results in excellent electrostatic copies as well as excellent reproduction by other techniques—e.g., offset printing. Kit price $11.75. JTEM, P.O. Box 211, Arcadia, CA 91006. **182**

RF CURRENT PROBES MEASURE RFI TO 1 GHZ. A special feature of these probes is their split, two-piece structure enabling them to be clamped around a conductor. Window diameters range from a maximum of four inches to as small as 3/4 inch. Models are available with RF current ratings as high as 1A, maximum power current as high as 350A and pulse current as high as 500A. Singer Instrumentation, 3211 S. LaCienega Blvd., Los Angeles, CA 90016. Phone (213) 870-2761. **183**

PROGRAMMABLE STANDARDS CALIBRATE DIGITAL AND ANALOG INSTRUMENTS. Series 300 models can be used for the rapid, precision checking and adjustment of 3, 4 and 4 1/2 digit ac and dc ammeters, voltmeters, multimeters and A/D converters, as well as a broad range of classic analog instruments. Voltage accuracy is 0.005% dc and 0.05% ac. Six voltage ranges are provided to 1000V, 6 current ranges to 10A, and 6 resistance values to 1 MΩ. Rotek Instrument Corp., 40 Guinan St., Waltham, MA 02154. Phone (617) 899-4611. **184**



LEAD FRAME ANNOUNCED FOR WIRELESS BONDING. A photoetched lead frame designed for flip chips and beam leads called Selectoframe eliminates the need for wire bonding between the pads of the chip and the fingers of the lead frame. Selectoframe is fabricated by joining two selective lead frames together with a proprietary brazing process. Plessey Inc., Materials Div., 2274 Mora Dr., Mt. View, CA 94040. Phone (415) 968-7215. **250**

THUMBWHEEL SWITCH IS EASILY INSTALLED. Designated the Series 25000, the new unit is snapped into a punched hole from the front of the instrument panel, eliminating close tolerance cut-outs, end brackets and excessive handling during installation. Currently available only in single-pole, 10-position configuration. The Digitran Co., 855 S. Arroyo Parkway, Pasadena, CA 91105. Phone (213) 449-3110. **252**

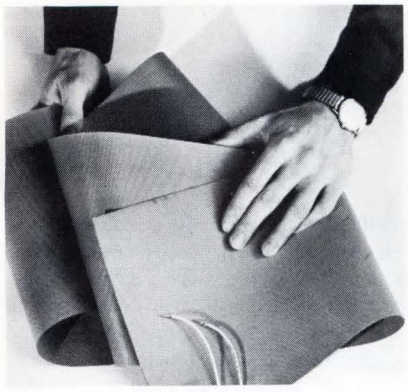
ACRYLIC-FIBERGLASS SLEEVING OFFERS UNIQUE PROPERTIES. Acryliglas 727N is a flexible sleeving with a thermally stable acrylic coating on a specially designed fiberglass base. The sleeving has a thermal life of over 30,000 hours at 155°C. Acryliglas 727N is available in all sizes, dielectric grades and colors. Natvar Corp., 211 Randolph Ave., Woodbridge, N J 07095. Phone (201) 388-8800. **253**

MINI-FRAME FOR INTEGRATED SOCKET STRIPS. This small, single bay mounting-frame assembly will accommodate up to six CAMBION Integrated Socket Strips, with 30 DIPS (14- or 16-pin). Each integrated socket has Wire-Wrap terminals and holds up to five dual-in-line packages with either 14 or 16 leads. A total of 4 strips can be used with this mounting. Cambridge Thermionic Corp., 445 Concord Ave., Cambridge, MA 02138. Phone (617) 491-5400. **254**

FREE GUN OFFERED TO INTRODUCE NEW NYLON CABLE TIES. To introduce its new line of WRAP-IT TIES, self-locking nylon cable ties, Richlok Corp. is offering a free LOCK N' SNIP tension fastening gun with initial orders for 25,000 ties. For free samples of the tie and additional information on the free gun offer, contact Richlok Corp., 5835 N. Tripp Ave., Chicago, IL 60646. Phone (312) 539-4061. **251**

DISCRETE RESISTOR NETWORKS IN DUAL-IN-LINE PACKAGES. Four standard configurations for pull-up or in-out functions combine up to 15 resistors in a package. Pricing depends on quantity and resistance values required. As an example, 1000, 14 pin pull-up networks with any of 20 standard resistance values cost 83¢ each. Electronics Products Div., Corning Glass Works, Corning, N Y 14830. Phone (607) 962-4444. **255**

PLASTIC OPTICAL MONOFIBERS AVAILABLE IN FIVE STANDARD DIAMETERS. Spool lengths range from 1000 to 100,000 ft. Standard nominal fiber diameters are 0.005 in., 0.010 in., 0.020 in., 0.040 in. and 0.060 in. Transmission range is from 400 to 1500 nm. Prices range from 1/10¢ to 10¢ per ft. in small quantities. Dolan-Jenner Industries, Inc., 200 Ingalls Ct., Melrose, MA 02176. Phone (617) 662-8200. **256**



FLEXIBLE HEATERS HAVE CONTINUOUS SERVICE TEMPERATURE OF 500°F. Manufactured for use in industrial and commercial application, these flexible blanket heaters can be cemented in place or clamped on. Sizes up to 35 ins. x 120 ins. are available. Wattage up to 28W per square inch can be supplied and single or 3-phase voltages, as required. Watlow Electric Mfg. Co., 12001 Lackland Rd., St. Louis, MO 63141. Phone (314) 878-4600. **257**

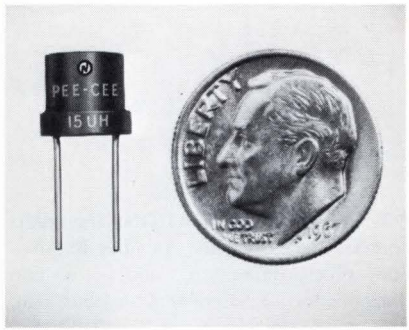
WORLD'S SMALLEST TWO CONTACT CONNECTORS. These units consist of a male plug and a female receptacle which have bodies that are less than 1/16 in. thick × 1/8 in. wide × 1/8 in. long, and 1/4 in. long respectively. The pins and sockets are gold plated brass. Prices are from $1.25 each in single quantities to $0.65 each in quantities of 1000. Microetch, Inc., 777 Henderson Blvd., Folcroft, PA 19032. Phone (215) 532-3388. **258**

SUPER FLEXIBLE FLAT SHIELDED CABLE ELIMINATES RADIATED INTERFERENCE. This cable has unique structure of flat conductors laminated between polyester vinyl film and jacketed with a solid copper shield and vinyl sheath. The Series 141 (single-side shield) and Series 142 (double-sides shielded) are both extremely flexible and are ideally suited to laying in ducts and raceways. Price: from 60¢ per ft., depending on quantity. Ansley Electronics Corp., Old Easton Rd., Doylestown, PA 18901. Phone (215) 345-1800. **259**

ELECTRODE PASTES FOR MONOLITHIC CAPACITORS provide a uniform electrode layer, resulting in higher capacitance and lower dissipation factors. There are no glass or other inorganic fluxes in these pastes. Metals contained in the pastes are Pd (#6006), Pt/Pd/Au (#6586) and Pd/Au (#6086). Electro-Science Labs., Inc., 1601 Sherman Ave., Pennsauken, N J 08110. Phone (609) 663-7777. **260**

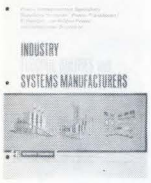
CERAMIC INSULATORS WITH MOLDED-IN-PLACE METAL MEMBERS. Ceram molded-in-metal components give electronic engineers considerably more latitude in component design and positioning of metal members. Also, they permit a hole pattern of much greater density then currently available and with exceptionally close member-to-member tolerances. Ceram Corp., El Cajon (San Diego), CA 92020. Phone (714) 449-4522. **261**

SUB-MINIATURE TRIMMER CAPACITORS are available with capacitance ranges from 1 to 25 pF and having Qs of >500 each at 100 MHz. These ceramic trimmer capacitors are for applications such as crystal oscillators and filters, tuning CATV amplifiers, as well as various broadband uses in communication and test equipment. Price is 47¢ each in large volume. Johanson Mfg. Corp., 400 Roackaway Valley Rd., Boonton, N J 07005. Phone (201) 334-2676. **262**



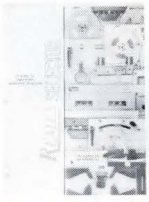
SHIELDED INDUCTORS COME IN 0.265 IN. DIA. PACKAGE. A subminiature shielded RF inductor, designated the "Pee Cee Ductor" is available for printed circuit applications. It is designed to meet MIL-C-15305D grade 1 Class B requirements. Prices range from $1.55 to $2.10. Nytronics Inc., Darlington Div., Orange St., Darlington, SC 29532. Phone (803) 393-5421. **263**

LITERATURE



POWER INSTRUMENTATION. The color-coded 24 page catalog includes information, specs, dimensions, and connection diagrams for the Scientific Columbus watt, var, power factor, current, voltage, frequency and phase angle transducer, in addition to its demand computer, temperature transducer, power test console, digiwatt wattmeters, and transducer calibrators. Scientific Columbus, a Unit of Esterline Corp., 1035 W. Third Ave., Columbus, OH 43212. **185**

CRT TERMINALS. A 2-color data sheet describes the application of the Series 200 video-display controller to industrial process and production control systems. Features include: software control of data and data format, display in English instead of abbreviations and mnemonics, black/white or color capability, multiple display operation using conventional TV sets or 525-line video monitors, and a built-in memory. Ann Arbor Terminals, Inc., 6107 Jackson Rd., Ann Arbor, MI 48103. **189**



PERIPHERALS GUIDE. This guide simplifies selection of Remex perforated tape and digital magnetic tape cassette systems. It provides basic technical data on perforated tape readers, spoolers, reader/spooler combinations as well as punch mechanisms, perforator systems and perforator/reader combinations. Also included is information about Remex digital magnetic tape cassette systems. Ex-Cell-O Corp., P.O. Box 386, Detroit, MI 48232. **193**

MAGNETIC TAPE DATA TERMINAL. The complete line of Teletype 4210 magnetic tape data terminals is described in a new four-page brochure. Of particular interest is the description of the new unattended automatic rewind and local print-out option. The brochure also includes a postage-paid card which enables the reader to order more technical information and a systems planning guide. Teletype Corp., 5555 Touhy Ave., Skokie, IL 60076. **186**

THERMAL DIGITAL PRINTER. A 2-page bulletin describes a newly announced TP-10 thermal digital printer and TP-10M plug-in print module. The brochure includes features, capabilities, paper, options, specifications and prices of both units. The TP-10 is a complete, high-performance, simple and compact instrumentation printer which accepts parallel data in BCD form. PPM, Inc., Subsidiary of Torq Engineered Products, Inc., 32 W. Monroe St., Bedford, OH 44146. **190**

RF WATTMETERS AND LOADS. An 8-page supplement to the 1971 general catalog lists over 30 new RF directional wattmeters, RF load resistors, and a 100W attenuator. Shown for the first time are 75Ω wattmeters for UHF-TV and 75Ω loads, in addition to the usual 50Ω equipment. Prices are included with equipment photos and performance specifications. General Catalog Supplement GCS-72, Bird Electronic Corp., 30303 Aurora Rd., Cleveland, OH 44139. **194**

INTERFACE FOR ALL MINI COMPUTERS. A six-page brochure explains how "Interfacing a Minicomputer to Your Process Is No Longer a Custom Engineering Problem." The company's concept of standard-type, plug-compatible process I/O interface and equipment is described featuring the entire family of real-time peripherals. Included is a compilation of condensed technical data and prices. Computer Products, P.O. Box 23849, Ft. Lauderdale, FL 33307. **187**

BELL & HOWELL SHORT FORM CATALOG describes representative examples of the company's extensive line of magnetic tape recorders/reproducers, transducers, recording oscillographs, computer peripherals and associated equipment. The 12-page color document contains photographs and brief, informative descriptions of the various products. Bell & Howell Electronics & Instruments Group, 360 Sierra Madre Villa Ave., Pasadena, CA 91109. **191**

DIGITAL VOLTAGE & TEMPERATURE MEASURING UNIT. A 4-page bulletin details the D-2400 two-range or two-function digital voltage or temperature measurement and display unit. Described are the device's interchangeable plug-in modules, unique cold junction reference and 40,000 count resolution (0.01 mV or 0.1° F or C sensitivities). Bulletin D-2400, Esterline Angus, a unit of Esterline Corp., P.O. Box 24000, Indianapolis, IN 46224. **195**

FAST RESPONSE EVENT RECORDERS. A new data sheet provides full details on 20, 40 and 60-channel stylus deflection event recorders. Recorder styli respond to signals in 3 msec and provide full deflection in 6 msec. A wide range of chart speeds are provided: from 3/8 iph to 3 ips. The data sheet discusses theory of operation, the various choices of chart drive and stylus actuation, and typical applications. Gulton Techni-Rite Electronics, Inc., Route #2, East Greenwich, RI 02818. **188**

DYNOGRAPH RECORDERS. Type R and Type RC Dynograph Recorders are described in a new four-page bulletin which gives complete operating specifications and price information. Type R dynograph is a high-sensitivity unit which can record simultaneously up to 24 analog signals and several event functions on a single permanent chart. Type RC dynograph is a medium-sensitivity system which can be expanded readily to Type R capability. Bulletin 5017A, Beckman Instruments, Inc., 3900 River Rd., Schiller Park, IL 60176. **192**

DUAL PROCESSOR. A four-page bulletin describes the Micro 1600D, a computer system consisting of two microprogrammable CPUs capable of simultaneously executing independent programs while sharing a common main memroy. The bulletin contains a general description, application information and a complete list of specifications. Photographs and diagrams illustrate functional characteristics, data flow and the physical packaging of the system. Microdata Corp., 644 E. Young St., Santa Ana, CA 92705. **196**

THE MINNESOTA TWINS

46 of these . . . 0.125 ctrs.

46 of these . . . 0.100 ctrs.

Here's a hot new idea in direct card connectors . . . our new Series 9 has 92 standard models: 0.100 or 0.125-inch centers, *any* number of dual positions from 5 to 50! Bifurcated dual contacts, 5 mounting options, .025 sq. wrap tails. Between-contact polarization even on the 0.100-inch size. And we won't freeze you out on delivery . . . or cost, they're all standard!

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DIVISION OF FABRI-TEK INC.

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Big Daddy ROM is here!

The EA 16K Read Only Memory

The World's biggest MOS ROM is in town and you can get it now. The EA4800, 16,384 bit ROM is designed for custom, high density microprogramming, high resolution character generation, and other big Read Only Memory tasks.

But the EA4800 is not just BIG, it also has many big benefits and is easy to use. For example, it's static, no clocks are necessary. Full address decoding is performed on the chip. The big ROM has two output enable controls, allowing wire-OR'd outputs, for ease of memory expansion, and organization as either 2048 x 8 or 4096 x 4. Maximum access time is 1.2 μsec and a .032 mW/bit power dissipation maximum lets your system operate at next to nothing. Works directly with TTL and operates on +5V and −12V supplies.

The EA4800 comes in either metal ceramic or low cost silicone, 24-pin Dip package. The price is a small $52.50 in 100 quantities in the silicone package.

We'll give you fast turn-around on custom patterns. Write or call your nearest EA representative or call us direct. Ask for the Big Daddy.

Big Daddy

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Stocking distributors: *Cramer, Computer Components, Burstein-Applebee Company.*

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5-DAY FREE TRIAL!

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Elite 1 features built-in wide range pulse generator, variable power supply, independent circuit monitor logic lights, isolated pushbuttons and toggle switch arrays. Plus universal component acceptance with SK-10 socket, unlimited fan in / fan out capability and common hook up wire interconnections. **Only $650.**

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GREAT MOMENTS

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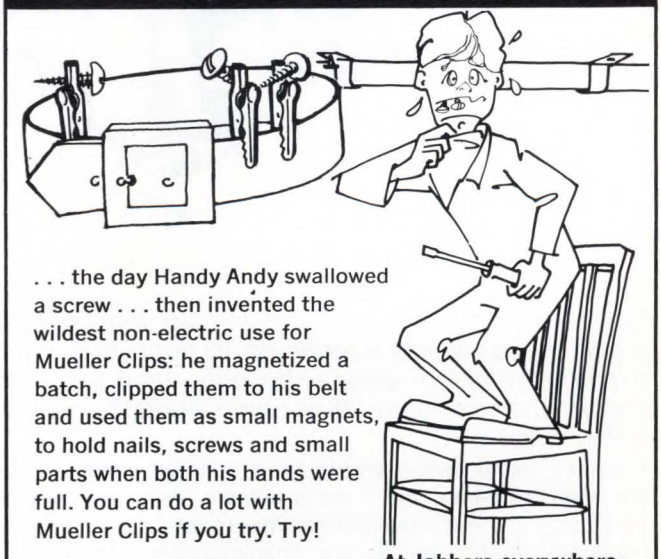

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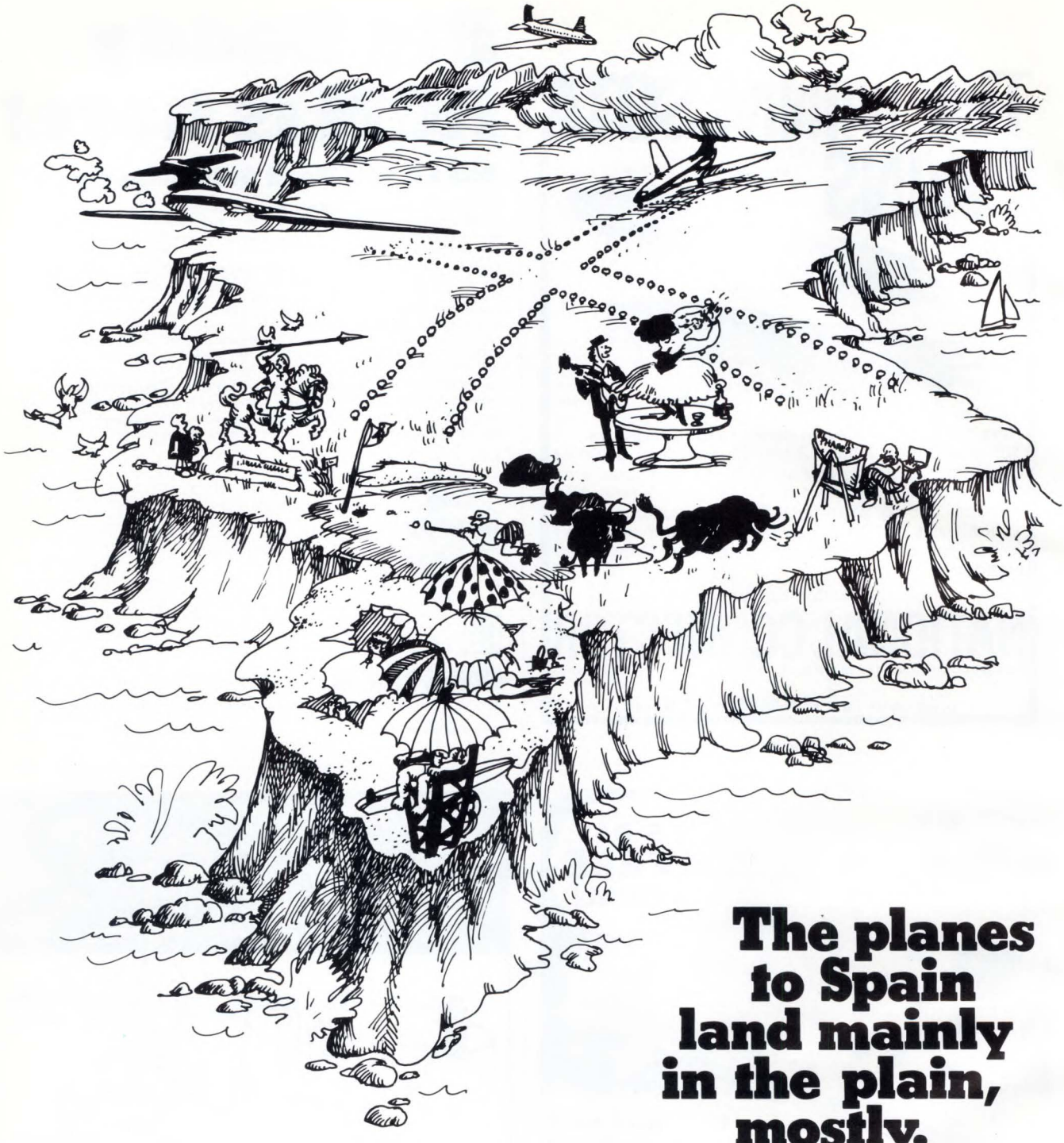

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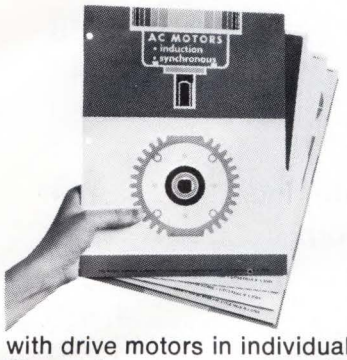
Everything you always wanted to know about Drive Motors.



Into these five booklets we've crammed 156 pages of the latest information on Kearfott's line of Drive Motors.

Kearfott, as you probably already know, is a primary supplier of drive motors. And has a reputation for quality, service and on-time delivery.

We can furnish you with drive motors in individual units or in packages to fit any of your aerospace or industrial applications. From counters to computers. From business machines to printers and tape readers.

Let's take a look at the type and range of motors we're talking about.

DC TACHOMETERS

Kearfott Tachometers are designed specifically for precision speed sensing and as rate generators to help velocity servos achieve fast response.

Features include: outputs to 100V dc/1000rpm; minimum ripple at high commutation frequency; high linearity; low friction torque.

These are ideal for computer tape transports where efficient data retrieval is a must. And for business machine and numerical control machine tools.

DC TORQUERS

You can get sizes 12 through 42, uncased for gimbal mount applications and cased for direct drive torque motor positioning.

Kearfott can also supply them with a variety of integral feedback elements such as potentiometers, synchros and tachometers—in a single housing.

You've a choice of standard design, inverted construction (inner member is magnetic and transfers power to an outer armature) and brushless Limited Rotation design.

DC MOTORS

These are Moving Coil Motors used for high-response DC servos such as High-Speed Printer and Capatan drives.

One of their unique features is that they need less cooling than equivalent competitive units. The reason: low internal impedance which allows a high cooling flow rate at low developed pressures.

Permanent magnet and wound-field types are available for standard aerospace and industrial applications, including high acceleration motors with integral tachometers for terminal printers.

AC MOTORS

Kearfott induction or synchronous motors of the hysterisis or reluctance type come in a broad range of frame sizes. And from sub-fractional power to 15 HP.

We can furnish motors that run on up to 440 volts ac, single, 2 or 3 phase. Induction motors that operate on 2, 4, 6, 8 or 12 pole design. And dual speed motors such as needed for driving memory discs in large computers.

You can also get: high-slip motors for aircraft requirements at 400 cps; synchronous motors for constant rotating speeds with varying loads; gear motors for extremely low speeds or speeds incompatible with the power supply frequency.

STEPPER MOTORS

If you want precision control—for example for small peripheral devices, small line printers and tape readers—Kearfott Steppers provide it via discreet steps and high slew rates. And in a wide choice of stepping rates and torque levels.

Typical Kearfott units have 15° stepping angles, compatible with all 24-tooth sprockets. They give high holding torque, high stepping speed and fast response.

Units with other step angles, such as 1.8°, 7.5°, 10°, 30°, 45° and 90° are readily available in frame sizes through 50.

But why not get all the details? Mail the coupon for our new booklets now. The Singer Company, Kearfott Division, 1150 McBride Avenue, Little Falls, N.J. 07424.

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ADVERTISERS' INDEX

Application Notes

"HOW TO GET BETTER TEMPERATURE CONTROL". Written for design engineers, this 64-pg. 1972 edition includes information on two- and three-mode control for dynamic heating processes where line voltages and heating load changes affect temperature control. It also contains information on overheat safety protection related to new OSHA requirements. Fenwal Inc., 400 Main St., Ashland, MA 01721. Phone (617) 881-2000. **242**

DATA LIBRARY CONTAINS SPECS FOR ALL EIA REGISTERED DEVICES. Book 1 and 2 complete data sheet specifications of all Motorola discrete semiconductors. The Reference Volume contains a technical description of all EIA-registered semiconductors made by the industry (regardless of manufacturer). The price is $6.50 for the basic set, $10.00 for the set and updatings. Motorola Semiconductor Products Inc., 5005 E. McDowell Rd., Phoenix, AZ 85008. Phone (602) 273-6900. **243**

CATALOG FEATURES EXACT REPLACEMENT FUSE AND CIRCUIT BREAKER ASSORTMENTS for every electronic equipment service requirement. Punched for easy reference use, the new two-color catalog "FCA" describes the convenient 2-in-1 assortment of eight popular circuit breakers and 30 of the most widely used fuses. Littelfuse, Inc., Dept. PR., 800 E. Northwest Highway, Des Plaines, IL 60016. Phone (312) 824-1188. **244**

CATALOG OF SWITCHES LISTS OVER 200 STANDARD TYPES of Snap-Action Switches, Matrix Selector Switches, Thumbwheel Switches and Keyboard Switches plus everything you need to know in order to specify or order them. Cherry Electrical Products Corp., P.O. Box 718, Waukegan, IL 60085. Phone (312) 689-7600. **245**

COST ANALYSIS OF DIP NETWORK vs DISCRETE RESISTORS presents statistical data for production quantities of 500 and 1000 assemblies and also includes the basic formulas for calculating other quantities. Technical Information Section, Helipot Div., Beckman Instruments, Inc., 2500 Harbor Blvd. Fullerton, CA 92634. Phone (714) 871-4848. **246**

BROCHURE ON VERSAWATT POWER TRANSISTORS ISSUED. A 12-pg. brochure "VERSAWATT—The Plastic Package for Power," PTV-427, discusses the performance, reliability, and long-life capability of VERSAWATT power transistors. The illustrations contained in the brochure show the internal structure of the basic package, lead-configuration, device performance, and production and testing facilities for VERSAWATT power transistors. RCA Solid State Div., Box 3200, Somerville, N J 08876. Phone (201) 722-3200. **247**

"WHAT'S NEW IN BREADBOARDING" IS AN 8-PG. BROCHURE depicting various breadboarding devices with supporting hardware and power supplies. 5 basic breadboard fixtures are described, each being an adaptation of the EL socket. All systems are DIP oriented and contacts are rated beyond 10,000 insertions. EL Instruments, Inc., 61 First St., Derby, CT 06418. Phone (203) 735-8775. **248**

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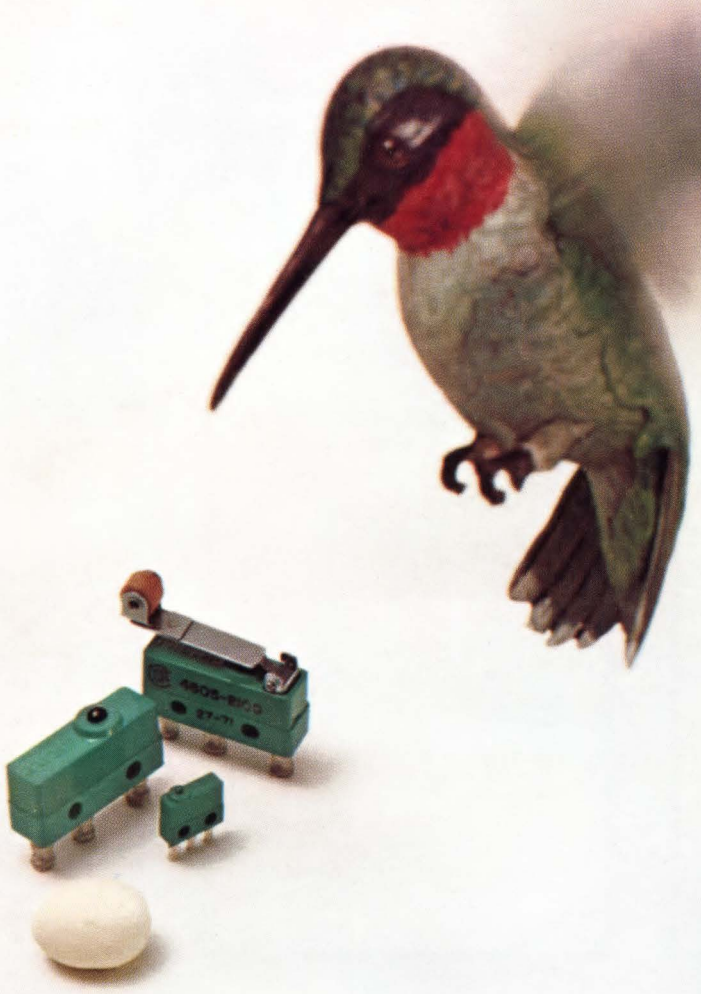

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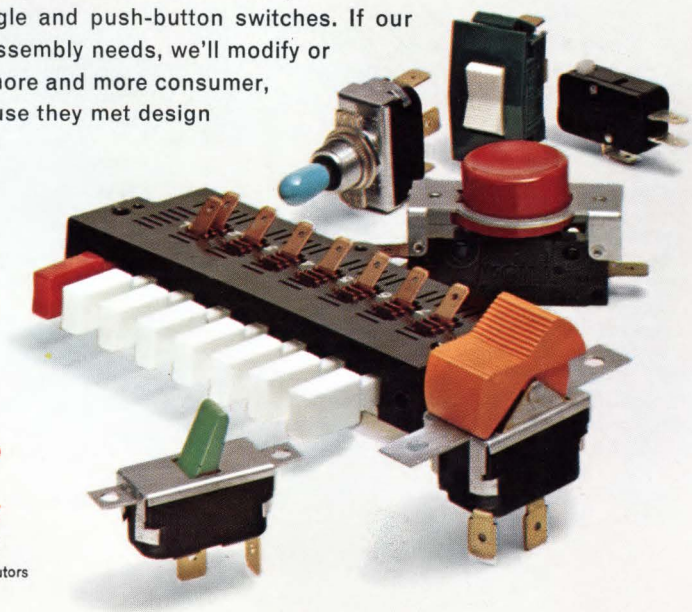

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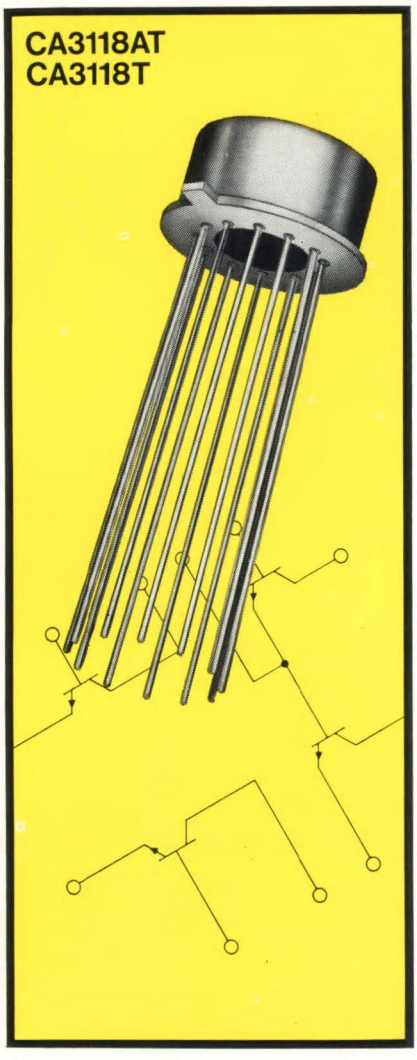

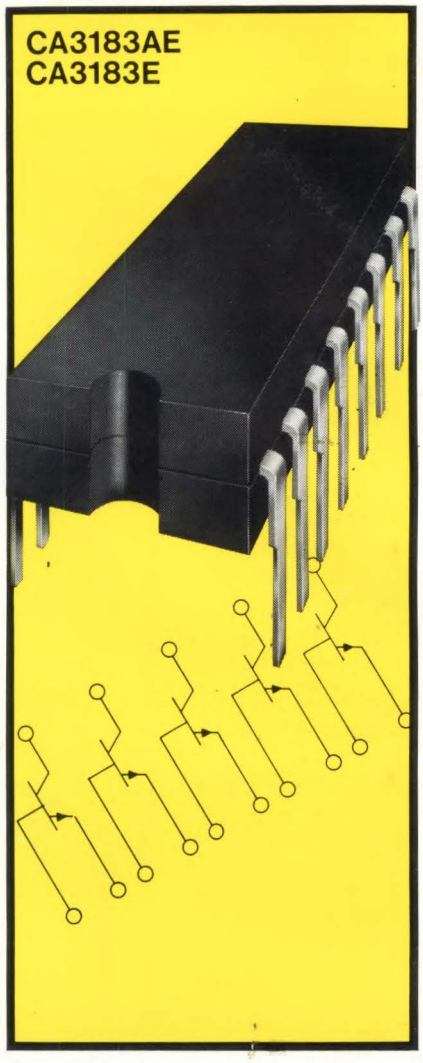

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