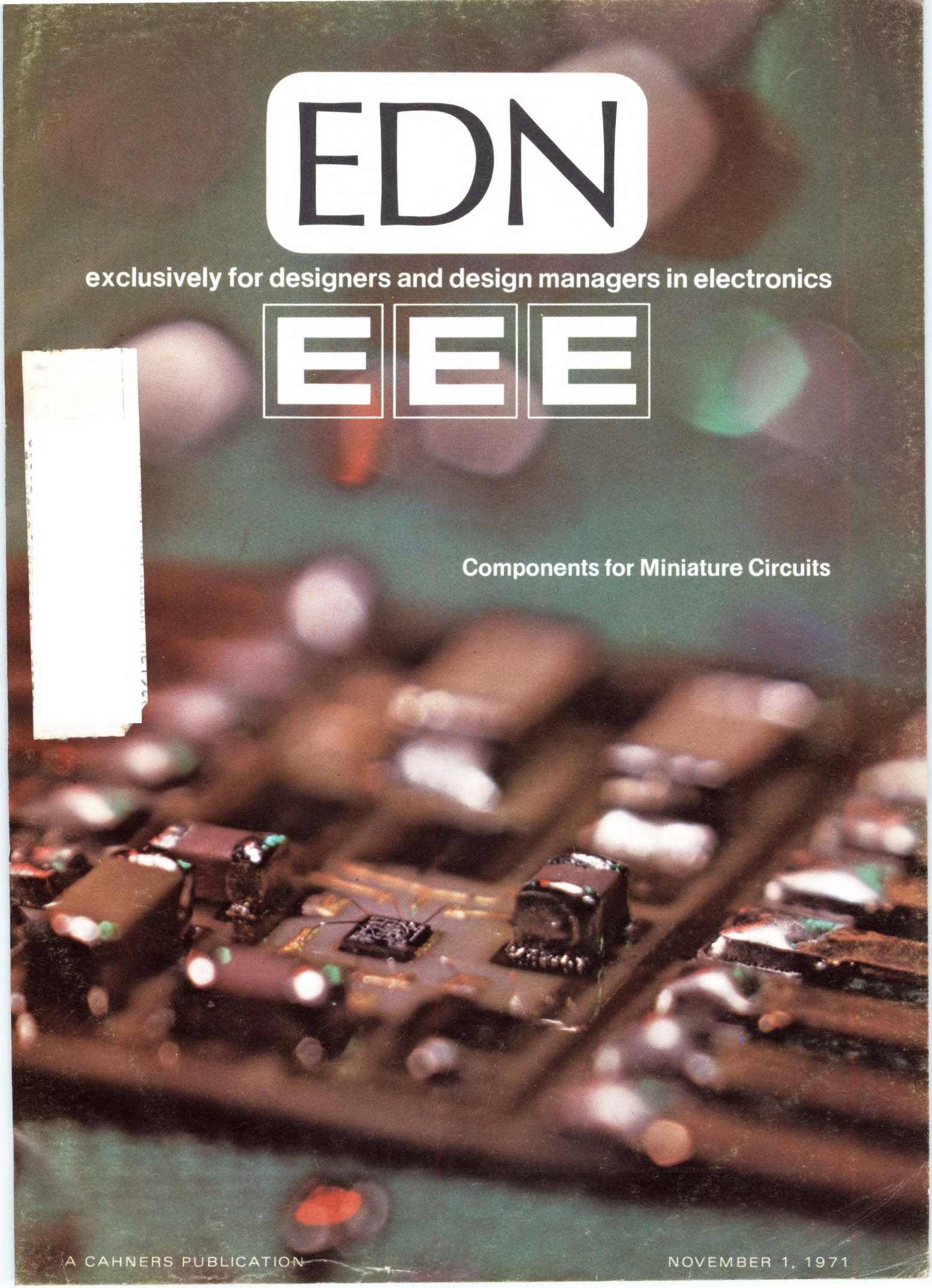
EDN

exclusively for designers and design managers in electronics

EEE

Components for Miniature Circuits



A CAHNERS PUBLICATION

NOVEMBER 1, 1971

Look at Acopian's new mini-module dc power supplies

Look at their size. Single output models (there are duals, too) are as small as 2.32″ x 1.82″ x 1.00″. And they can all be soldered directly into printed circuit boards.

Look at their performance. Load and line regulation is 0.02 to 0.1% depending on the model selected. Ripple is only 0.5 mv RMS. And Acopian's long experience in power supply technology assures high reliability.

Look at the choice of outputs. There are 58 different single output modules ranging from 1 to 28 volts, 40 ma to 500 ma. Duals are available in 406 different combinations of voltages. And these are **true** dual power supplies, with like or different outputs in each section that are electrically independent of each other. Perfect for powering operational amplifiers. Or for unbalanced loads.

Acopian mini-module power supplies

	Singles	Duals
Output Voltages (vdc):	1 to 28	1 to 28
Output Currents (ma):	40 to 500	40 to 250
Line and Load Regulation:	.02 to 0.1% depending on model	
Ripple:	0.5 mv RMS	
Ambient Temperature (without derating)	0 to 55°C	
Polarity:	outputs floating and isolated	

Look at their price. Single output models start at $39, duals at $58.

For a look at all the facts, write or call Acopian Corp., Easton, Pa. 18042. And just like Acopian's other 82,000 power supplies, every mini-module is shipped with a tag that looks like this . . .

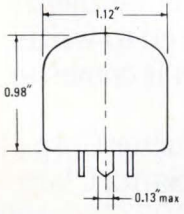
CIRCLE NO. 1

Amperex photosensitive devices...

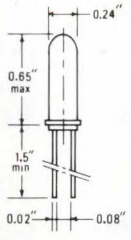
another facet of our electro-optics capability.

In addition to the well-known lines of Plumbicon* and vidicon TV camera tubes, X-ray image intensifiers and instrument cathode ray tubes, Amperex' total capability in electro-optics encompasses a broad line of photosensitive devices. Included are high-vacuum and gas-filled photo tubes covering a wide spectral range and a complete line of cadmium sulphide photoconductive cells.

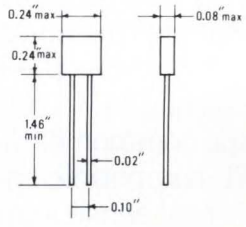
155UG: Typical and popular is the 155UG gas filled photo tube, sensitive to ultra-violet radiation. It has a peak spectral response at 220nm and only 10% response at 206nm and 250nm. It is intended for use as an on-off device in flame-failure and flame-detection circuits.



ORP66: The ORP66 cadmium sulphide photoconductive cell offers shock and vibration resistance and high sensitivity in a hermetically sealed envelope. It has wide spectral response, peaking at 630nm. It is intended for on-off as well as variable brightness control applications.



RPY58, RPY71: Examples of very inexpensive cadmium sulphide photoconductive devices are types RPY58 and RPY71, with peak spectral response at 550nm. Sensitivities are linear; 3 orders of magnitude in the RPY58; 4 orders of magnitude in the RPY71. Both of these devices are ideally suited for electronic control applications in toys, cameras, etc.



For more information on Amperex photosensitive devices, contact:
Electro-Optical Devices Division, Amperex Electronic Corp., Slatersville, R. I. 02876 Tel.: 401-762-3800

Amperex®

TOMORROW'S THINKING IN TODAY'S PRODUCTS

A NORTH AMERICAN PHILIPS COMPANY

*Reg. T.M. of N.V. Philips' of Holland

CIRCLE NO. 2

The RAM built by hindsight.

Being the first 1024-bit MOS RAM, the 1103 was quickly designed into many systems. (A big reason we wasted little time second sourcing it.)

At the same time, we (along with many others) felt that there was plenty of room for improvement in terms of cost and performance on an overall system level.

Hence, we're now building our very own 1024-bit MOS RAM, the vastly superior MM 5260.

Like the 1103, our MM 5260 comes with chip-select.

Unlike the 1103, the thoughtfully designed MM 5260 features a Tri-State logic common data I/O structure with TTL-compatible on-chip decoding and an internal sense amplifier. Plus precharge decoding to reduce system power dissipation significantly.

On a *system* level, the results speak for themselves: A power dissipation savings of almost 66% (two standard supplies versus three supplies); a 100% reduction in the number of overhead circuits; and a 200% savings in overhead costs. All without sacrificing system speed or performance.

Finally, the new MM 5260 comes in a 16-pin dual in-line package and is available for immediate delivery.

(Realizing the hard-core realities of phasing out an existing format, we will also continue to act as a volume supplier of the MM 1103.)

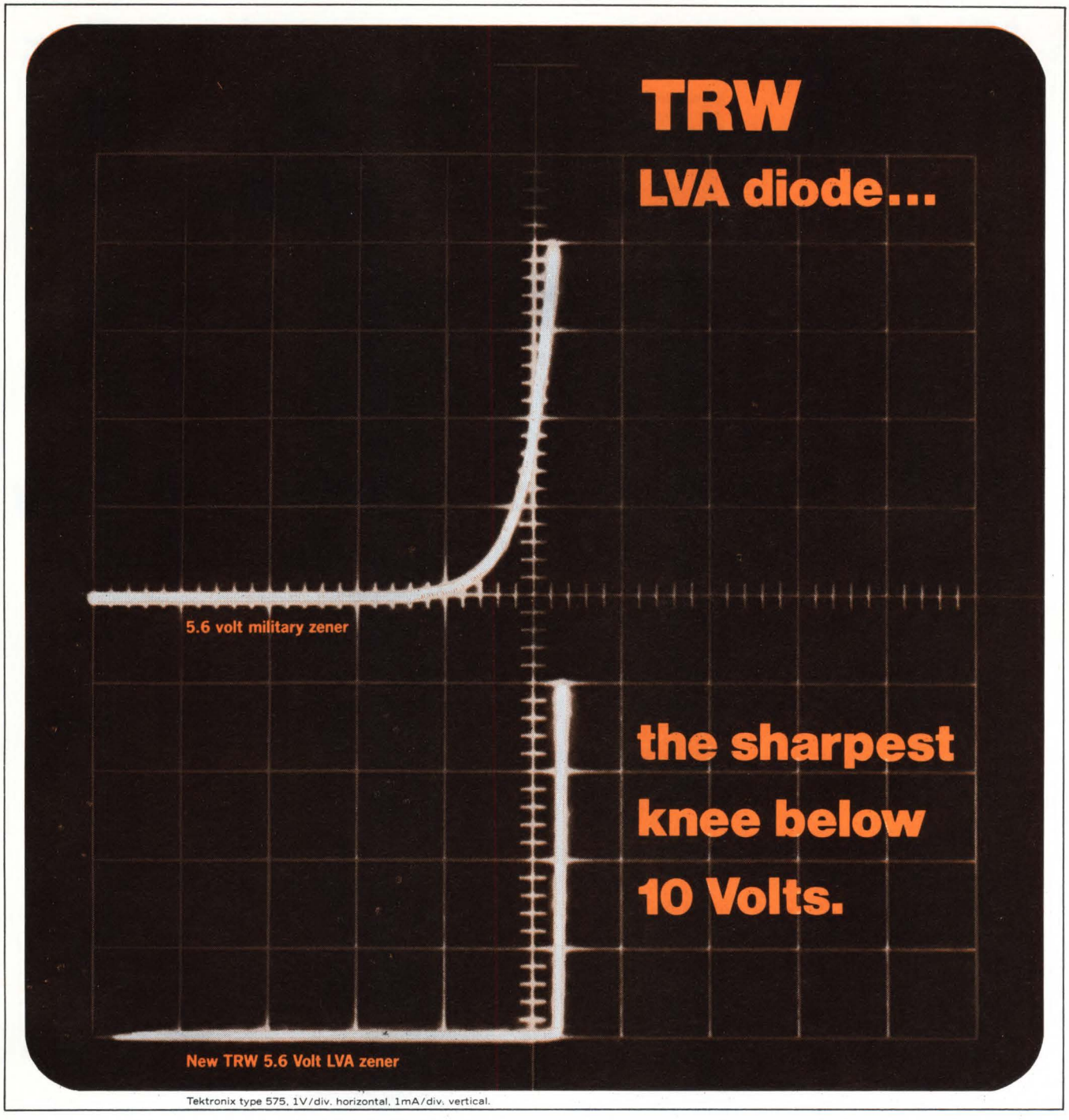
All of which means that there's now only one place you need to write, phone, TWX or cable when it comes to 1024-bit MOS RAMs:

National Semiconductor Corp., 2900 Semiconductor Dr., Santa Clara, California 95051. Phone (408) 732-5000. TWX: (910) 339-9240. Cable: NATSEMICON.

(Hot-off-the-drawingboard Dept.: In a blatant attempt to become the most respected name in RAMs, we will soon announce a couple of highly interesting 2048-bit MOS RAMs.)

National

CIRCLE NO. 3



Tektronix type 575, 1V/div. horizontal, 1mA/div. vertical.

The current saver.

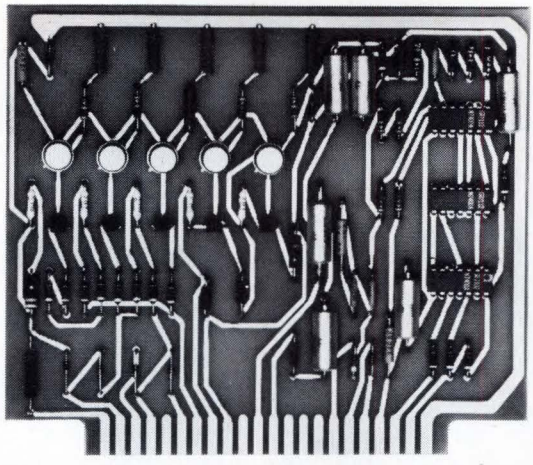
No other zener can approach TRW's LVA performance below 10 volts. Available for operation down to 4.3 volts, TRW LVA diodes minimize power consumption in portable-battery operated equipment. They're also ideal for instrumentation, where, as reference elements, they draw as little as 50 μAmps. TRW LVA's are available in various package configurations, including passivated chip form for hybrid-compatible packages. If you have a need for a low current voltage regulator or any other product that demands low current consumption, you should check out TRW LVA zeners. When it comes to current, they're really misers!

For product information and applications assistance write TRW Semiconductors, 14520 Aviation Blvd., Lawndale, California 90260. Phone (213) 679-4561. TWX 910-325-6206.

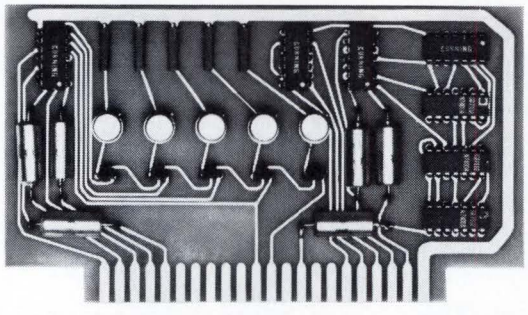
TRW®
SEMICONDUCTORS

CIRCLE NO. 4

IC's let you make your board smaller.



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



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

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

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

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

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

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

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

Write or call for complete technical specifications.

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

SPECIFICATIONS

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

CORDIP™ COMPONENT NETWORKS
From

CORNING
ELECTRONICS

CIRCLE NO. 5

NOVEMBER 1, 1971
VOLUME 16, NUMBER 21

EDN/EEE

EXCLUSIVELY
FOR DESIGNERS
AND DESIGN MANAGERS
IN ELECTRONICS

Cover

Cover photo by Ray Lewis, Art Director, illustrates how Allen Bradley saves space using minicomponents. For more on these tiny components, see p. 24.

SPEAKOUT—Richard Hein Speaks Out on Field Maintenance of Computers and Other Digital Systems. See article on p. 36.

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Circuit Design Award Entries

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Everybody wants your components business.

But we're doing 6 things to earn it.

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

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

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

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

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

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

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

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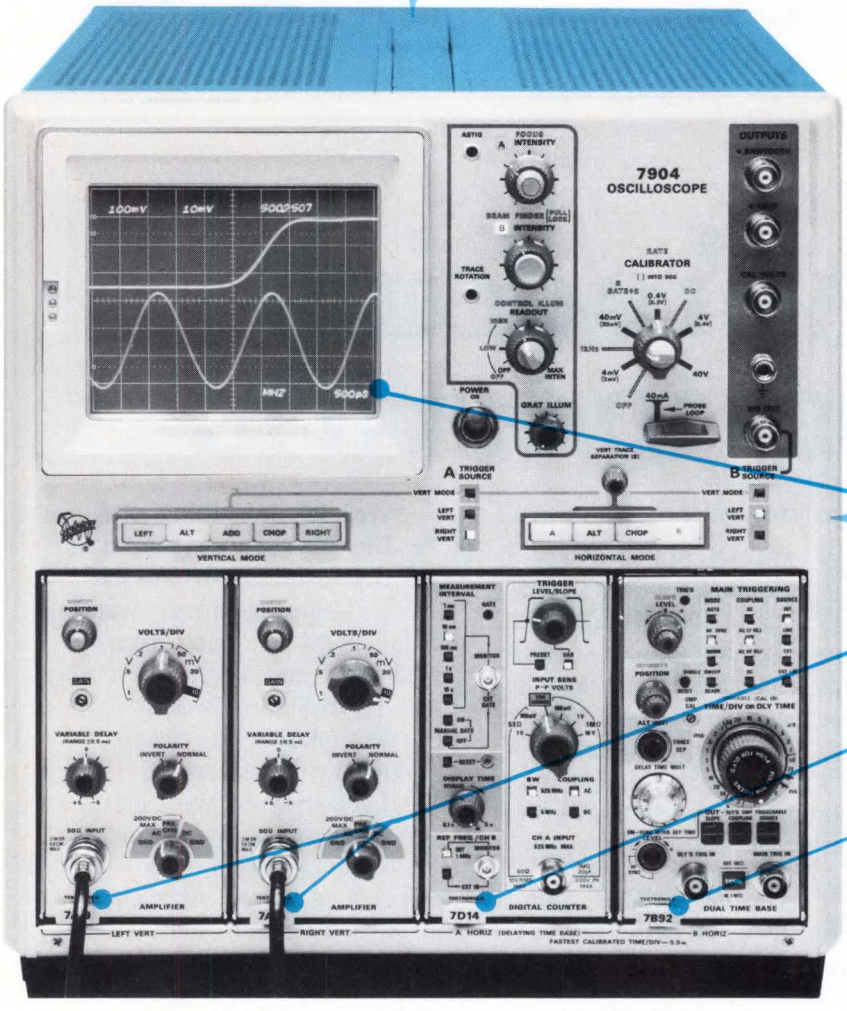
Resistors & Capacitors

for guys who can't stand failures

CIRCLE NO. 6

TEKTRONIX® 7900 FAMILY

1 GHz Direct-Access Oscilloscope



TEKTRONIX 7904

featuring extended performance or general purpose use, from one mainframe and a family of plug-ins.

Extended Performance — 20 kHz to 1 GHz

Plug in the 7A21N and install a simple vertical amplifier bypass to directly access the CRT. The bandwidth — 1 GHz, and risetime — 350 ps. Less than 4 V/cm driving signal required — single ended or differential. Sorry — no CRT READOUT — vertical amplifier bypassed.

General Purpose — DC to 500 MHz

Plug in the 7A19 — 500 MHz bandwidth at 10 mV/cm, 7B92 — delaying sweep rates to 500 ps/cm, 7D14 — direct counting to 525 MHz. As your applications and measurement requirements change, choose from 21 other plug-ins for: • sampling • TDR • spectrum analysis • curve tracing • digital multimeter • etc., etc. TEKTRONIX 7904 . . . A product of technical excellence.

For further information or a demonstration call your nearby TEKTRONIX Field Engineer or write: Tektronix, Inc., P.O. Box 500, Beaverton, Oregon 97005.

CIRCLE NO. 7

OR . . .

500 MHz real-time Oscilloscope System

- 8 x 10 cm display
  CRT READOUT
  9 cm/ns writing speed
- 7A19 Amplifier
  500 MHz @ 10 mV/cm
- 7D14 Digital Counter
  525 MHz direct counting
- 7B92 Dual Time Base
  500 ps delayed sweep

OR . . .

choose from 21 other compatible 7000-Series plug-ins for virtually any measurement

7904 Oscilloscope	**$2900**
7A19 Amplifier	**$500**
7A19 Amplifier, with variable delay	**$700**
7D14 Digital Counter	**$1400**
7B92 Dual Time Base	**$1400**
7A21N Direct Access	**$350**

U.S. Sales Prices FOB Beaverton, Oregon

Editorial

Science Is Not a Dirty Word

So much blame has been heaped onto science of late that its worth is in danger of being overlooked. It gets charged with causing all of our woes, as absurd as such an allegation really is. Why are some people suddenly turning against a former friend? Has science changed—or is the change within them?

If we try to get to the root of it, I think we'll conclude that the major point is a newly-found awareness of the bad effects of misusing scientific discoveries. In the past it was common to blindly assume that all scientific knowledge was inherently good for mankind—without regard as to how it was utilized. This lack of discrimination gave an opening that has been used by those who condemn all science for the evils caused by misapplying it.

Let's not permit this smear of science to continue. Instead, let's defend it for its true worth—and continue to do all we can to see that new scientific discoveries are put to constructive use. If we do, those who have condemned it may start to realize that science is still a valued friend—and we'll be back on the way toward a better world in which to live.

Does anyone honestly want mankind to return to an age when disease and suffering were looked on as "God's Will"; when it took weeks or even months for news to cross an ocean; when the only warning of a hurricane or tornado was the event itself? Of course they don't, so let's not permit science to be voted out for faults it doesn't possess.

Earle Dilatush

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Chances are you're paying up to 30% too much for this kind of breaker.

Unless you're already using Heinemann's new Series AM1.

It's our low-priced, direct replacement for AM12-type breakers that have been so popular everywhere.

But now you can save 17% on a single-pole model with auxiliary switch. Or 30% on a three-pole, 400-Hz model with auxiliary switch. Over comparable AM12s.

That ain't hay.

And AM1s are UL-recognized in any current rating up to 50 amp, at 240Vac or 65Vdc.

We offer you a bunch of options, too. Custom current ratings, choice of time-delay or non-time-delay response, special-function internal circuits. You can even get multipole models with all poles identical or with different voltage and current ratings, time-delay curves, and internal circuits for each pole.

If you've been using AM12-type breakers (incidentally, the most copied design in the world!), it's a cinch for you to work our AM1s right into your production. And you might even be able to lower your selling price. Or pocket some extra profits.

For all the details, write for Bulletin 3306. Heinemann Electric Company, 2626 Brunswick Pike, Trenton, N.J. 08602. Or Heinemann Electric (Europe) GmbH, 4 Düsseldorf, Jägerhofstrasse 29, Germany.

HEINEMANN

4975

CIRCLE NO. 10

NEW APPROACH TO MOS STANDARDS.

In old-fangled MOS, the goal is high-density real estate. Jam as many bits on a chip as possible, and let the chips fall where they may. That is, let the systems designer worry about how to put the devices to practical use in his circuit design.

In new-fangled MOS from Fairchild, our standard devices are designed to optimize your system by reducing problems, complexities—and costs. We call it OPTI-MOS.

By including, on the same chip, some of the required ancillary circuitry the other guys have not, we can give you optimum MOS: easier to use, costs less function-for-function, smaller and simpler. All our MOS Standards are optimized.

OPTI-MOS minimizes costs. Our MOS minimizes these critical systems cost factors: ▪ Labor and material costs associated with each IC printed circuit board, (often many times the cost of the IC itself). ▪ Package and assembly costs, which still dominate MOS/LSI manufacturing costs (lead count reduction is as important to MOS/LSI device costs as package count is to IC systems cost).

For example: 3258 OPTI-MOS Horizontal Scan Character Generator. This kind of generator usually requires an external row counter/decoder. This penalizes you and us: you need several ICs and we have to add 3 to 7 leads on the chip to accept the counter/decoder signals. Also, most character generators require a two-phase clock.

The 3258 OPTI-MOS changes all that. First, it's a static character generator. That saves 2 leads because it requires no clocks. Second, we've put the row counter/decoder right on the chip. Which saves an additional 2 to 6 leads (1 strobe input is still necessary). End result? Optimization: a 16-lead device that replaces a 24/28-lead device plus several ICs. Our costs are reduced. And so are yours.

3329 OPTI-MOS Silicon Gate Shift Register minimizes your clock power requirements: 1/6 the clock power per bit is all that's needed. That's because of our inherently lower clock capacitance and lower voltage swing requirement. You can use simpler—and fewer—clock drivers. And it simplifies solutions to the ringing problems found in any high-speed shift register operation.

3513 OPTI-MOS ROM is truly TTL-compatible. You no longer need input pullup resistors to "directly" drive the MOS device. Which means you can get rated TTL fanout without additional TTL devices. Because we've put a special Schmitt trigger buffer right on the chip, it acts essentially like an open circuit to the TTL driver. Fanout remains as rated, circuits are simplified, TTL-compatibility is real.

How to OPTI-MOS your system (and save yourself a lot of aggravation): Call or write. We have a data package on our OPTI-MOS. And a variety of MOS Standards available. Like these:

OPTI-MOS SILICON GATE PRODUCT LINE	
All products in this family operate from +5, Ground, and −12 volt supplies. Using the inherent speed and density improvements of Silicon Gate, all devices have been designed for 2MHz operation, elevating MOS system speeds into the realm of DTL.	
Character Generators (All are Static Devices):	
3255	16 Characters, 5 x 7 font, vertical scan, single space, 16-pin DIP.
3256	16 Characters, 5 x 7 font, vertical scan, double space, 16-pin DIP.
3257	64 Characters, 5 x 7 font, vertical scan, 24-pin DIP.
3258	64 Characters, 5 x 7 font, horizontal scan, 16-pin DIP.
ROM's (All are Static Devices):	
3512	2048 Bits (256 x 8), TTL I/O.
3513	2560 Bits (256 x 10), TTL I/O.
3514	4096 Bits (512 x 8), TTL I/O.
Shift Registers:	
3325	Quad 64-Bit, multiplexed I/O.
3329	512 Bit dynamic 2 MHz register; only 0.09 pf per bit clock capacitance, TTL I/O.
3330	480 Bit . . . (same as 3329)
3331	500 Bit . . . (same as 3329)
3383	256 Bit register with on-chip recirculate gating, 2MHz, TTL I/O.
RAM's	
3532	512 Bit fully decoded static RAM.

Fairchild makes advanced products to uniform standards throughout the world.

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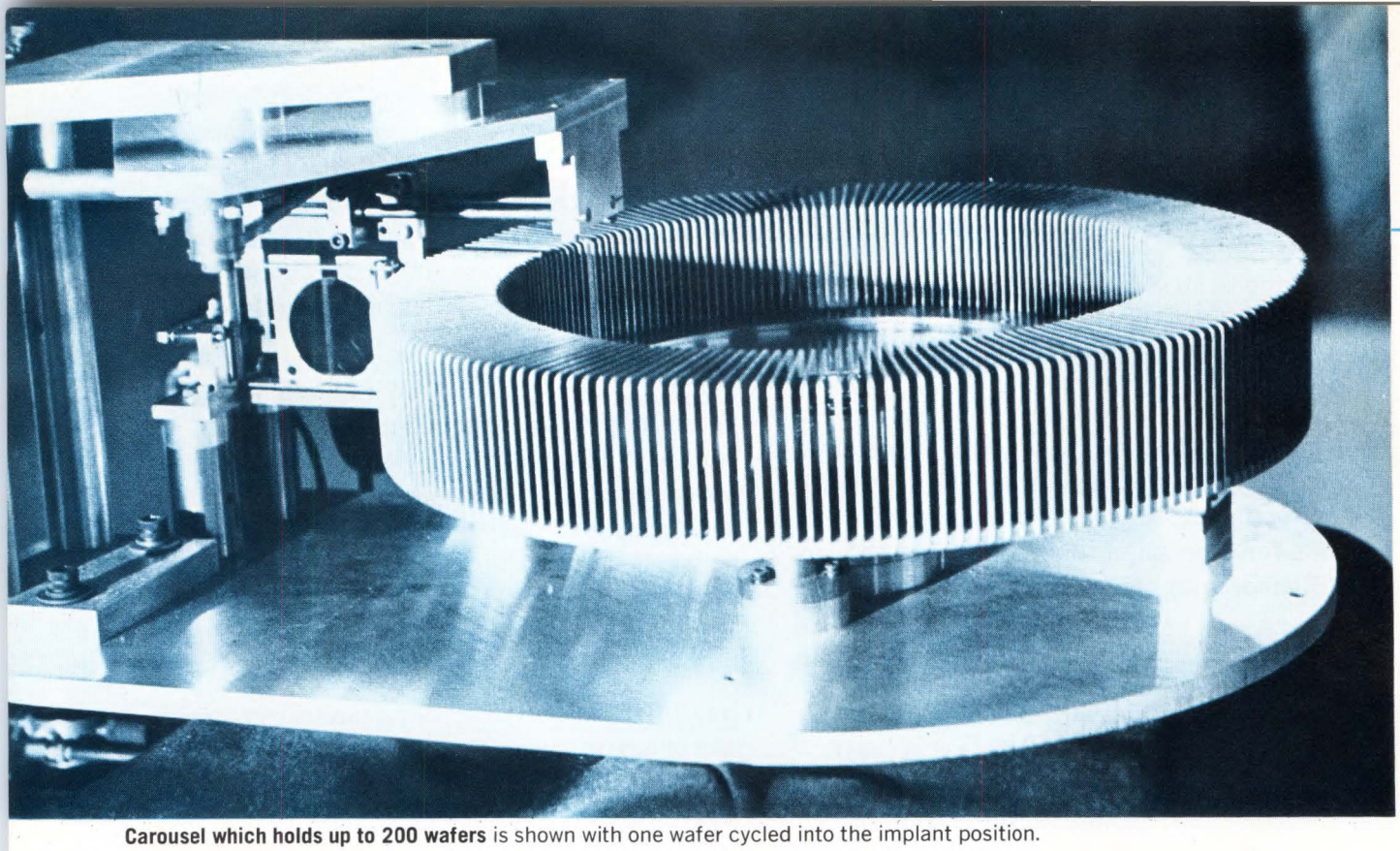
CIRCLE NO. 11



Carousel which holds up to 200 wafers is shown with one wafer cycled into the implant position.

Ion Implantation Gets a Boost

Ion implantation is an extremely valuable processing tool for making MOS devices. However until now it has not achieved its potential because of the lack of simple, compact batch-processing equipment.

The situation is expected to change now with the introduction by Extrion Corporation, Peabody, Mass., of a new second-generation automatic machine. This is a 150 keV unit that can process up to 200 wafers an hour, which is double the previous high of 100 per hour claimed by Mostek.

The key to the high capacity of this machine is its end station, or implanting chamber, in which is located a carousel that holds all 200 wafers. As shown, the carousel looks and operates like one used for a slide projector. When one wafer is set into its implant position, the ion beam, which was previously in a holding position away from the implant area, is deflected onto the wafer. The entire surface of the wafer is then scanned much like a TV raster scan, both in the 'x' plane, and in the 'y' plane for a preset time, depending on the implanting dosage needed.

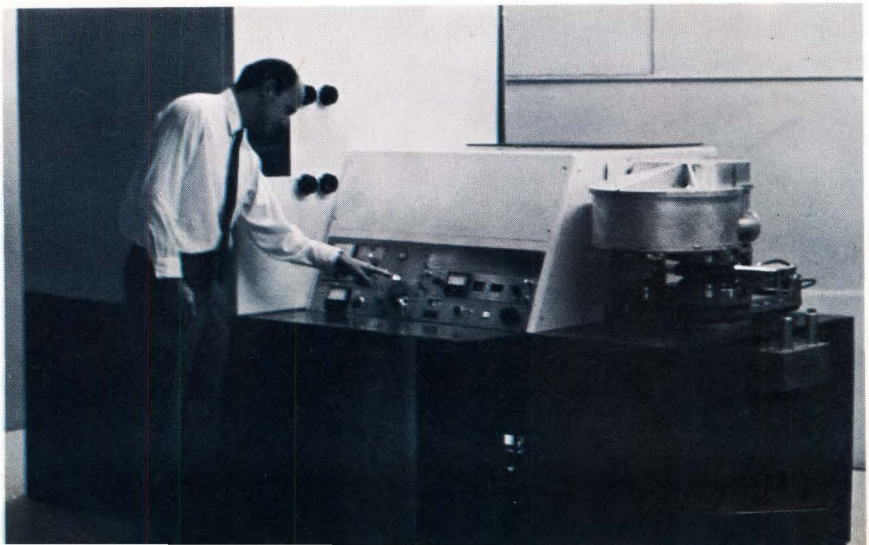
This method gives doping uniformity of better than 2% from point to point on the wafer. At a typical dose level (10^{13} boron ions/sq. cm and 10μA beam intensity), it takes about 5 seconds to implant a 2-inch wafer.

When the accumulated dose level has reached a preset value as monitored by a current integrator, the ion beam is switched away from the implant area and the wafer is cycled back into the carousel. Electronic switching is used to move the ion beam on and off the wafer to prevent any non-uniformity in doping. The carousel is then cycled to move the next wafer into position. While all this is going on, another carousel is loaded and made ready to replace the one being implanted.

This machine is built specifically for industrial production; that is, it can be operated by non-skilled personnel and be maintained by technicians whose skills should already be present in a semiconductor manufacturing facility. Reliability is enhanced by the fact that the normal maintenance cycle is extended by more than an order of magnitude over earlier machines that were originally designed for lab use.

Envisioned for the future is a continuous implanting process where wafers will move in a line through the implanting chamber by utilizing vacuum locks. A third-generation computer-controlled machine with beam currents approaching 1 mA is expected from Extrion within a year. Ion implantation of bipolar devices will then be technically and commercially feasible.

The 150 keV machine shown is 5 ft wide by 10 ft long by 7 ft high—smaller than any other equivalent unit.



Experimental Printer Uses Acousto-Optic Devices

Laser light, ultrasonics and photographic paper have been combined by Zenith's acousto-optic research group to produce an experimental printer capable of printing over 100,000 characters per second.

The key to this high printing rate is, of course, the absence of moving mechanical parts except for the paper drive. In principle, the system is analogous to CRT readouts. A beam (laser) scans horizontally at a rate determined by a deflecting force (ultrasonic laser scanner). Information is coded on the beam by a modulator and is presented visually on dry-processed photographic paper.

In place of vertical scanning, the primary laser beam is divided into seven beams in the vertical plane prior to modulation. Paper is moved mechanically to allow repeated scans of the seven-beam fan.

Acousto-optic principles used by Zenith in other experimental systems (see EDN/EEE Sept. 1, 1971, "Acoustic Microscope Magnifies Onion Skin") are used in this printer to achieve fast writing speeds.

At a recent demonstration of the developmental printer at the Electro-Optical Systems Design Conference in New York, news reports were taken direct from the wire of United Press International and printed in a format 132 characters wide.

In the demonstration unit, which does not utilize the speed capabilities of the system, the input signals from the news wire are fed to a converter that changes the Teletype line code to an ASCII code. This signal is then processed through a seven-frequency generator and fed to the modulator that turns the seven beams on and off according to the incoming signal.

Scanning of the seven beams is done simultaneously in the cascade scanning system. Here acousto-optic techniques are used to deflect the laser beams. An ultrasonic transducer produces a sound wave in a glass block diffracting most of the light at an angle determined by the sound frequency. By varying the sound frequency in a predetermined manner, the beams are made to scan in the horizontal plane at the desired rate.

The scanning beams are directed to a moving sheet of red-sensitive photographic paper. After being dry processed, the sheet emerges from the printer with a hard copy printout of the news from the UPI wire.

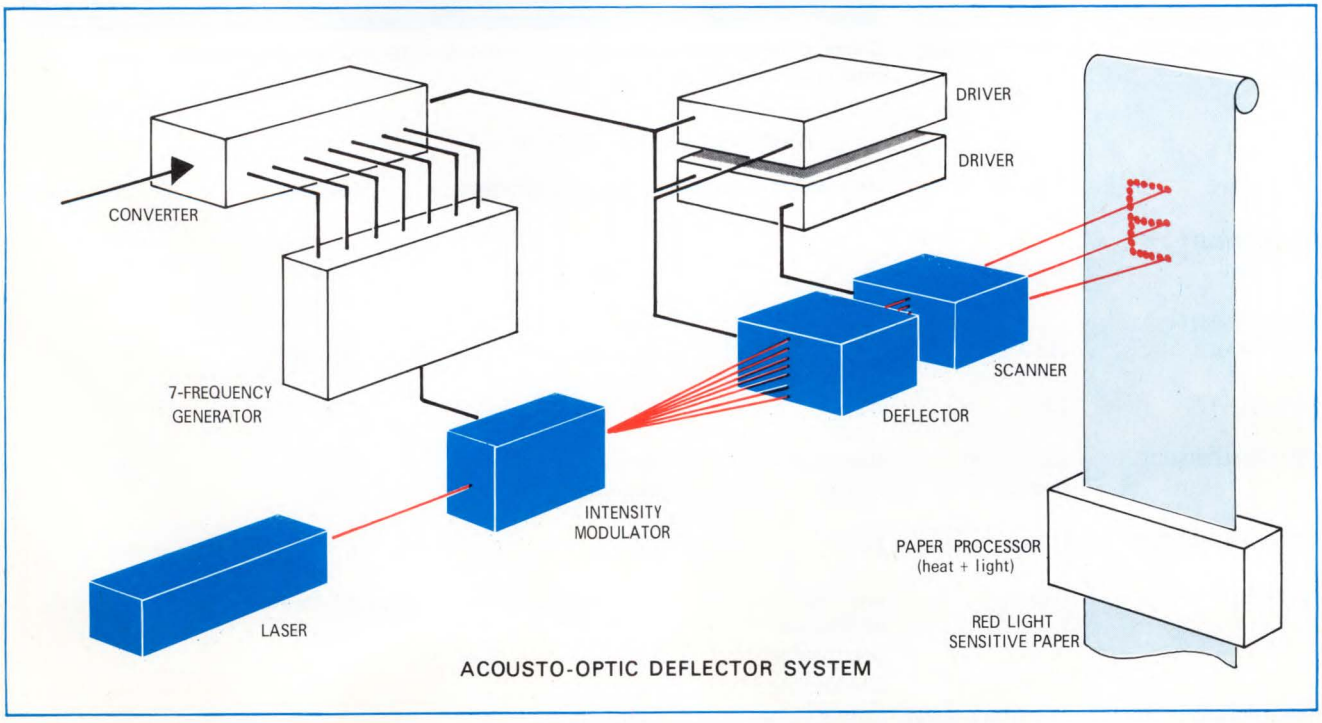
With printing rate capabilities over 100,000 characters per second, the system looks very attractive for direct printing of a computer output.

Scan width can easily be adjusted so that printout can be done on microfilm, microfiche or on a large sheet.

In addition to greater speed than mechanical printers, the all-electronic method with microfilm would be less expensive, simpler and would make handling of readout much easier.

Zenith developed the printer to demonstrate the capabilities of recently developed acousto-optical devices which include the M-40R acousto-optic intensity modulator introduced in 1970, the D-70R laser deflector brought out early in 1971 and the Cascade 800 laser scanner just introduced this fall.

Zenith Radio Corp., 1900 N. Austin Ave., Chicago, IL 60639.



ACOUSTO-OPTIC DEFLECTOR SYSTEM

Long-Life Lithium Battery on Horizon

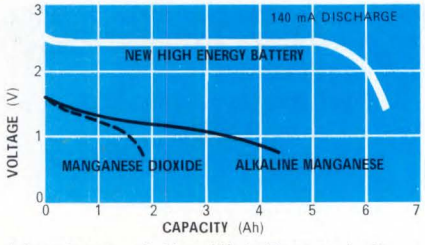
Designers and users of battery powered equipment will be interested in the recent development of a High-Energy primary battery by National Panasonic, Matsushita Electric Co., Ltd., Kadoma, Osaka, Japan.

Working voltage of the new battery is 2.6V per cell and energy density is reported to be four to five times greater than conventional manganese batteries, on a volume basis. These features combined with a shelf life of one year and a flat discharge curve add up to a substantial improvement in battery performance.

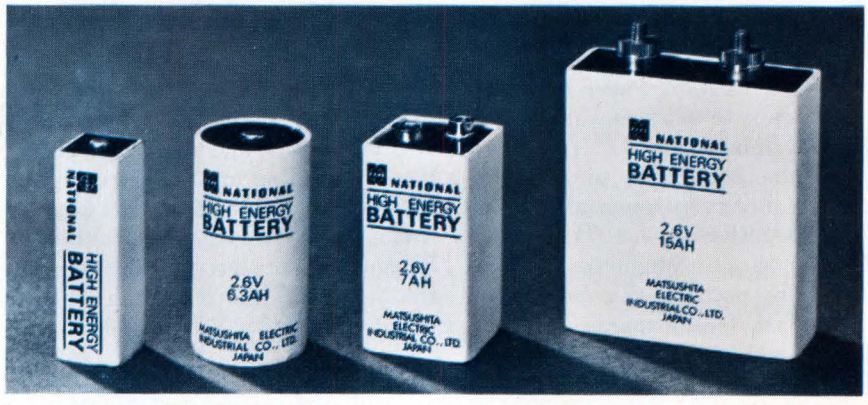
A new combination of materials is the key to this advance in battery technology. The negative electrode is made of lithium. Solid polycarbonmonofluoride is used for the positive electrode and the electrolyte is an organic material. Lithium and organic electrolyte systems have been studied by others, and used in special cases prior to this development, but limited shelf life has always been a disadvantage. The breakthrough in shelf life was accomplished by using a solid polycarbonmonofluoride electrode. This material is chemically and thermally stable, but shows high activity in electrochemical reaction. Consisting of carbon and fluorine combined in the ratio of one to one, it provides the high fluorine content required.

In use, the positive electrode is converted into conductive carbon while fluorine combines with lithium to produce lithium fluoride. There are no side reactions to produce gas or cause metal corrosion, therefore efficiency is high and the battery is almost free of voltage decrease during use. Case material is either aluminum or nickel-coated iron that is hermetically sealed to prevent electrolyte leakage.

Prices for these batteries have not been established, but will be in the range between alkaline-manganese and mercury batteries. Initial production units will be available in Japan next year in the sizes shown. Export details have not yet been worked out. Patents are being applied for in Japan and other countries.



Advantages of the High-Energy battery over conventional types include higher voltage, longer life and flatter discharge curve.



C-size, Square types equivalent to C- and AA-size and rectangular types will be available on a sample basis next year.

BATTERY COMPARISON

BATTERY TYPE	LITHIUM	MANGANESE DIOXIDE	ALKALINE MANGANESE	MERCURY	SILVER OXIDE
ENERGY DENSITY (Wh/kg):	470--320	80--20	100--50	110--90	120--80
ENERGY DENSITY (Wh/liter):	620--500	150--40	230--140	400--300	350--300
VOLTAGE (V):	2.6	1.5	1.5	1.34	1.25
POSITIVE ELECTRODE:	Carbonmono-fluoride	Manganese dioxide	Manganese dioxide	Mercury oxide	Silver oxide
NEGATIVE ELECTRODE:	Lithium	Zinc	Zinc	Zinc	Zinc
ELECTROLYTE:	Organic	Ammonium chloride and zinc chloride aqueous solution	Caustic potash or caustic soda aqueous solution		

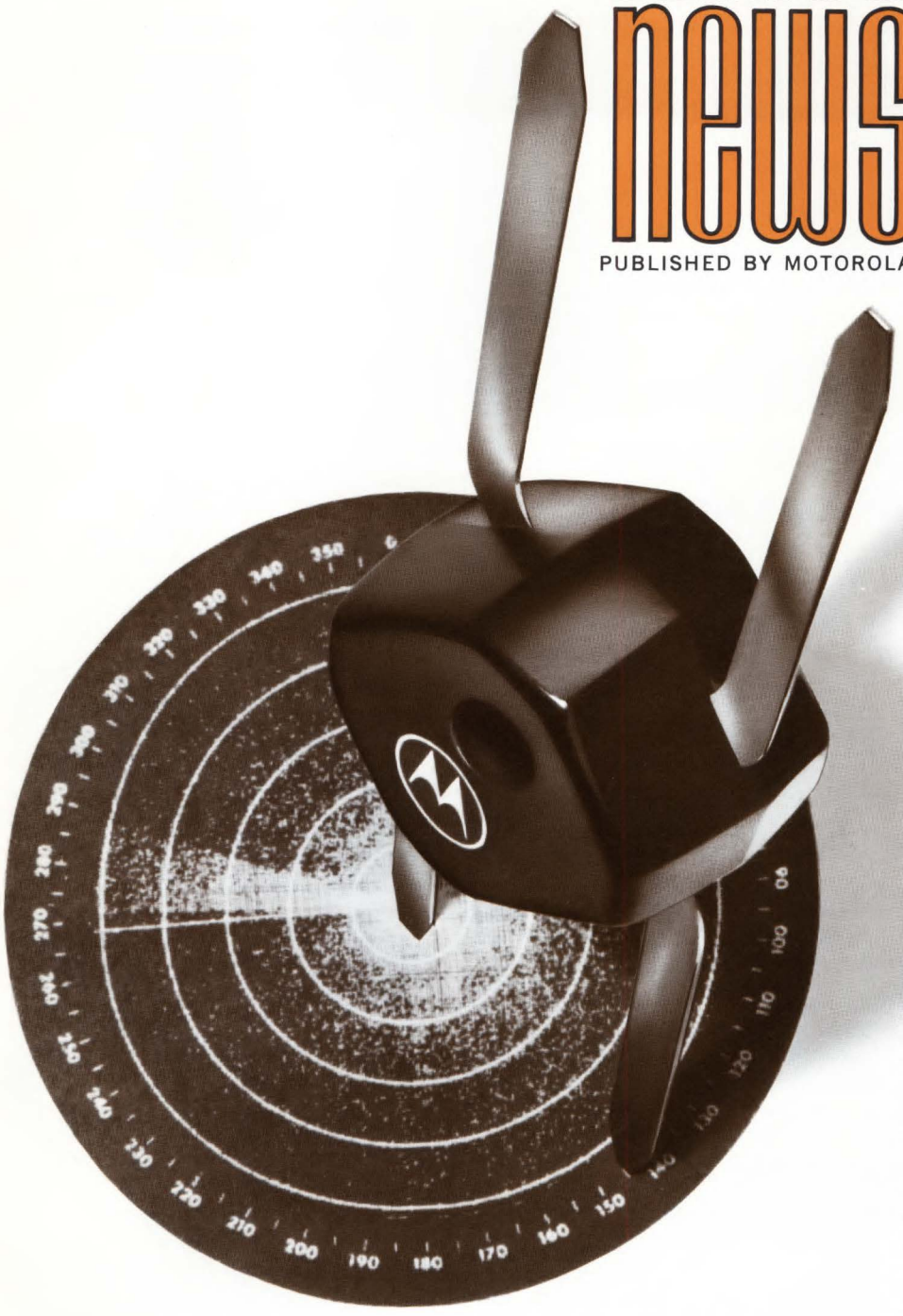
Energy density of the lithium battery is significantly higher than conventional batteries.

No. 13-71

SEMICONDUCTOR

newsbriefs

PUBLISHED BY MOTOROLA SEMICONDUCTOR PRODUCTS INC.



1 GHz, N-Channel, Dual-Gate MOSFET Features Low Distortion

Introduced at the Chicago IEEE Spring Conference in its development stage, the revolutionary, state-of-the-art MPF1000 is now in production.

Designed for UHF and low microwave frequency amplifier applications, this new silicon, depletion-mode, N-channel dual-gate MOSFET displays exceptionally low distortion characteristics. Use the MPF1000 and your cross-modulation problems will be significantly reduced.

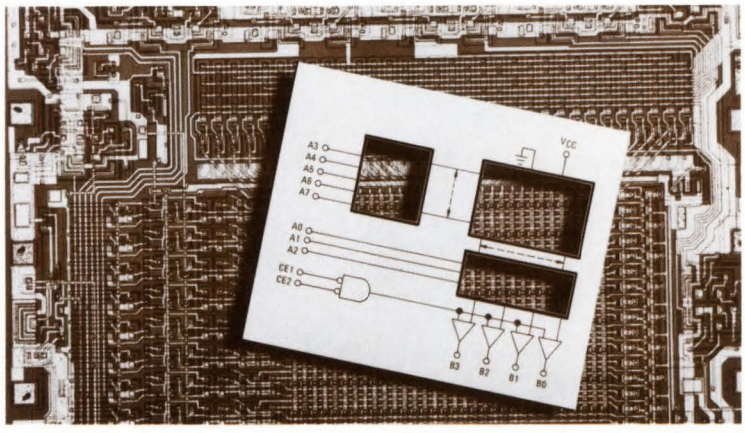
For details, circle 21

The key to the MPF1000's eye-opening combination of low price and 1 GHz frequency capability lies in its new 4-lead plastic package – the MICRO-H. Parasitics were minimized to obtain good high-frequency characteristics and the cost breakthrough came by taking a leaf from the TO-92 book – assembly and encapsulation on high-volume stripline facilities.

MPF1000 also features silicon nitride passivation for excellent long-term stability and has diode protected gates. It has (@ 1 GHz) a power gain of 7 dB (min) and a noise figure of 7 dB. Typical output capacitance of the new MOSFET is 2.5 pF.

Evaluate this exciting transistor now. Its performance is sure to roll back a design boundary or two. And to help you realize the greatest benefit from the MPF1000 in your designs, our friendly MOSFET product marketing group is ready to help, either directly or by arranging for applications assistance. If you've an idea for using this device that you'd like to discuss – particularly in tuning the UHF band – why not give them a call at Code 602/273-4164.

The 1000-up price of the MPF1000 is a surprising 80¢ – low enough for you to evaluate, innovate, and use!



To develop custom functions for your system — fast — call on Motorola's MCM-4004 or MCM-4006 1024-bit read-only memories. Your look-up tables, micro-programs and code translators are just a truth table away.

1024-Bit ROMs Simplify System Micro-Programming

When your system needs the advantages of custom micro-programming, code translation, or look-up table functions and you are fighting time plus development cost, Motorola's MCM4004 or MCM4006 1024-Bit ROMs can solve your problem. Just supply your truth table/output option requirement and the final processing step is then completed — the net result is a custom function less developmental program cost and time.

The basic organization of both memories is 256 four-bit words. By removing appropriate emitter connections on the pre-ohmic mask, each bit can be programmed to meet specific logic requirements. Both devices offer optional 2.0 kilohm pullup resistors on the four outputs. The open collector output option is provided by removing pre-ohmic connections to the 2.0 kilohm resistors. The open collector option allows several memories to be wire-ORed to form large arrays.

The MCM4006 features an address time of 40 ns (typ) and chip select time of 20 ns (typ) with standard TTL input loading of 1.6 mA. The MCM4004 offers reduced input loading (0.1 mA typ) for large systems. Typical MCM4004 address time is 50 ns and typical chip select time is 25 ns.

The devices are supplied in 16-pin white ceramic dual-in-line packages (MCM4004AL, MCM4006AL) or black ceramic (MCM4004L, MCM-4006L). 100-up price for either package is $17.50 and the mask set-up charge is a low $600 per program with reduced costs for additional masks. Contact your local Motorola representative for ordering information — the option and savings are yours!

For details, circle 22

Differential Wideband Video Amplifier Has The Speed For Today's Digital Systems

Recently added to Motorola's linear IC lineup, MC1733 is an excellent general purpose video amplifier. But you'll find it also has the specs for use in magnetic tape or file systems, high speed thin-film or plated wire memory, and pulse amplifier applications. And it can handle video applications as well as directly replace other 733 types.

Essentially a wideband amplifier providing differential input and output with gain fixed at 10, 100, or 400, the MC-1733 also features gain adjustable from 10 to 400 with the addition of a single external resistor. It's the MC1733's bandwidth though, typically 120 MHz at $A_{vd} = 10$, that gives it the speed needed in today's digital systems. Rise time is just 2.5 ns (typ) and the propagation delay is a good 3.6 ns typical, both measured at $A_{vd} = 10$.

Four variations are available at prices which make them top values. In 100-up quantities, the full temperature range (−55 to +125°C) MC1733G (TO-5) and MC1733L (TO-16) are $5.75. The 0 to +75°C MC1733CG and CL are only $2.85.

Your Motorola distributor or factory representative will cheerfully serve your product needs.

For details, circle 23

New Capacitive-Coupled Sense Amp Speeds Up Low-Level Sensing

Designers concerned with the detection of signals from plated-wire and thin-film memories and with other low-level sensing applications will find Motorola's MC1544 ac-coupled four-channel sense amplifier "made to order." The device consists of four input channels with decoding selection, two stages of gain employing capacitive coupling, and an MTTL compatible output gate.

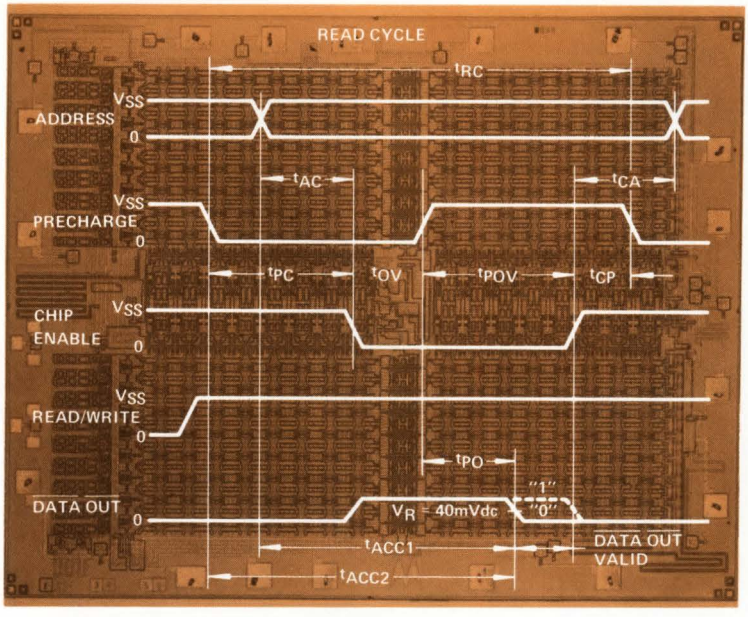
The MC1544 allows fuller utilization of the speed capabilities of plated-wire memories by reducing access times. Older sensing devices such as dc-coupled sense amplifiers were affected by the slow decay of transient signals induced by switching the word current on and off during read cycles. The capacitive coupling of the MC1544 can sense the plated-wire output pulses before the transients have fully decayed, resulting in faster cycle times and better noise immunity.

Fast, high-gain sense amp — MC1544 — has level-restoring circuit to maintain TTL levels on its output at the highest repetition rate.

Additional MC1544 features include a unique dc level restore circuit on capacitors that eliminates repetition rate problems and helps achieve a typical propagation delay of 18 ns, wired-OR output capability, and a strobe-gated output to inhibit undesirable signals.

Both the −55 to +125°C version, the MC1544L, and MC1444L, the 0 to +75°C version (supplied in 16-pin dual in-line ceramic) are at your nearby Motorola distributor. They are 100-up priced at $9.00 (MC1544L) and $8.00 (MC1444L). Evaluate now and speed up your sensing capability.

For details, circle 24



Motorola's latest RAM — the MCM-2372L — employs silicon-gate P-channel enhancement mode devices in a single monolithic structure and uses MOS gate capacitance for information storage.

Silicon Gate 1024-Bit Dynamic RAM Expands Motorola MOS Memory Line

Now, Motorola offers another of the industry's popular 1024-bit MOS Random Access Memories. The MCM2372L Silicon Gate P-MOS, fully decoded, 1024-bit by one word RAM joins the workhorse MCM1173L in Motorola's MOS line, marking the first time both the 6001 and 1103 type RAMs became available from a single major manufacturer. The MCM2372 is faster and provides a smaller package for minimizing board size while the MCM1173 offers considerably lower power dissipation. Evaluate your requirements and take your choice.

Access time for the MCM2372L is only 300 ns and the write cycle time is a comparably quick 480 ns. Read cycle time is 540 ns. Overall system speed should be approximately 25% better than in a system utilizing MCM1173's. Refresh time with the MCM2372L is 2 ms (max). System expansion is assisted by a chip enable input for address expansion and wired-OR output capability for memory expansion.

In any sizable system the number of boards required is a significant consideration. The 18-pin, 300 mil width ceramic package of the MCM2372L helps keep the total down.

The total bond size is significantly smaller than possible with either the 600 mil wide, 24 pin MCM1173L or the 400 mil wide MCM1172. (The MCM1172L is a 22 pin version of the MCM1173L.)

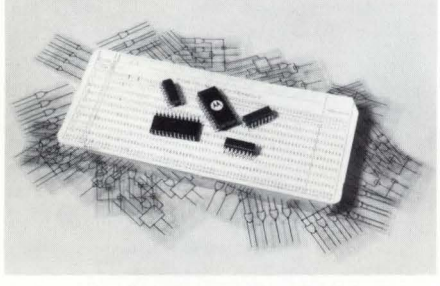
Now you can choose either of the industry's most popular MOS RAMs . . . from your Motorola distributor. In 100-up quantities, the MCM2372L — $35.00.

For details, circle 25

MECL 10,000 Improves Systems 10 New Ways

Motorola's high-speed, low power MECL 10,000 family has expanded again with the addition of *ten new functions!* Included are eight gates, a line receiver, and a dual latch.

MECL 10,000 uses techniques such as on-chip collector and emitter dotting to bring you devices that perform multiple functions in virtually single-gate delays. Open emitter outputs and Hi-Z inputs let you select the optimum termination method for your system.



Computer functions, 2.0 ns speed, relatively slow rise and fall times and line driving capability — that's MECL 10,000.

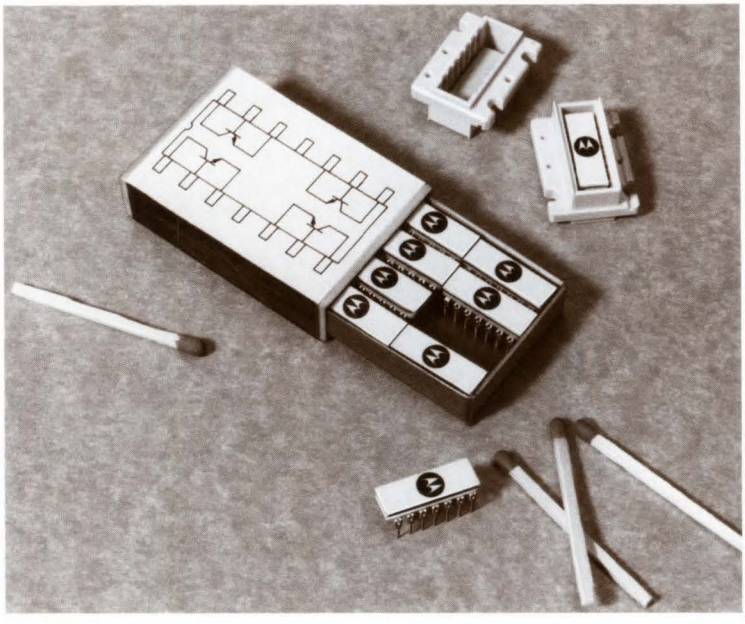
Of particular interest is the MC-10101 Strobed Quad OR/NOR Gate, for distributing 4 bits of parallel information on or off card. With both OR and NOR outputs available, 4 twisted-pair lines may be driven at data rates up to 100 megabits/second. Use its single strobe input to gate the data on or off in just 2 ns. And to reduce system package count just apply the MC10105 Triple 2-3-2 OR/NOR Gate. This versatile logic element typically manipulates Boolean functions in 2 ns.

The MC10115 Quad Line Receiver is recommended for MOS to MECL interfacing and for translating from MOS 1103 type memory to MECL. And the MC10117 is the first available emitter-coupled logic gate performing the powerful OR-AND/OR-AND-INVERT function — in just 2.4 ns. It's a natural for data multiplexing and data distribution.

Check the table for the function you need and call your local Motorola representative for evaluation devices today. Evaluation eliminates the alternatives!

Device Type	Description	Unit Price (100-Up)
MC10101	Strobed Quad OR/NOR Gate	$2.00
MC10102	Quad 2-Input NOR Gate	2.00
MC10105	Triple 2-3-2 OR/NOR Gate	2.00
MC10106	Triple 4-3-3 NOR Gate	2.00
MC10107	Triple 2-Input Exclusive OR/Exclusive NOR Gate	2.50
MC10115	Quad Line Receiver	2.00
MC10117	Dual 2-Wide OR-AND/OR-AND-INVERT Gate	2.50
MC10118	Dual 2-Wide 3-Input OR-AND Gate	2.50
MC10121	4-Wide OR-AND/OR-AND-INVERT Gate	2.50
MC10130	Dual Latch	5.00

For details, circle 26



Motorola's quads nestle four silicon Annular devices in one hermetic dual in-line ceramic package to save space and weight in your challenging designs.

Quad Transistors— Match Savings In Space With Lower Assembly Costs

Benefit from quad savings!

Choose from 17 new quad transistors and extirpate your design problems!

Check the application breadth of these new introductions:

8 general-purpose devices
2 high-speed switches
1 memory driver
6 high-gain amplifiers

and – there are more to come!

These exciting new quads house four devices in one, hermetic, TO-116 outline, dual in-line ceramic package. One that features a fine-leak rate less than 10^{-7} cc/s and is designed to permit standard PC board layout and take advantage of automatic insertion equipment.

All 17 utilize Motorola's Annular construction that eliminates channeling in the semiconductor bulk material, a field relief electrode (equipotential ring) that stabilizes the transistor surface, and the epitaxial structure that makes ultra-high speed and low collector resistance possible. Result? Stable, reliable transistors that perform!

For details, circle 27

Quad Device #	Function	Similar to Discrete Device #	100-999 Price
MHQ2221	NPN General Purpose	2N2221	$2.61
MHQ2222	NPN General Purpose	2N2222	2.85
MHQ2906	PNP General Purpose	2N2906	2.61
MHQ2907A	PNP General Purpose	2N2907A	2.85
MHQ3250	PNP General Purpose	2N3250	2.85
MHQ3251A	PNP General Purpose	2N3251A	3.09
MHQ2369	NPN High Speed Switch	2N2369	2.37
MHQ3546	PNP High Speed Switch	2N3546	4.60
MHQ3798	PNP Low Noise, High Gain Amp.	2N3798	3.32
MHQ3799	PNP Low Noise, High Gain Amp.	2N3799	3.66
MHQ2483	NPN Low Noise, High Gain Amp.	2N2483	3.32
MHQ2484	NPN Low Noise, High Gain Amp.	2N2484	3.66
MHQ3467	PNP Memory Driver	2N3467	3.05
MHQ6001	NPN/PNP Complementary Pair General Purpose	2N2221/ 2N2906	2.70
MHQ6002	NPN/PNP Complementary Pair General Purpose	2N2222/ 2N2907	3.04
MHQ6100	NPN/PNP Complementary Pair High Gain Amp.	2N2483/ 2N3798	2.70
MHQ6100A	NPN/PNP Complementary Pair High Gain Amp.	2N2484/ 2N3799	3.04

Six Amp Rectifier Bridges Show 200 ns Recovery Time

Encountering stubborn, high-frequency rectification design problems?

Soak them awhile in Motorola's latest problem solvent . . . 5 new molded-assembly rectifier bridges.

Designated MDA952FR-1 thru -5, the bridges are fabricated of individual, hermetically-sealed, fast-recovery rectifiers that are interconnected and encapsulated in molded assemblies. They're for use in applications requiring an output current of 6 amps and they're available in peak reverse voltage ratings of 50 to 400 V. Recovery time of 200 ns (max) provides a high operating efficiency at 250 kHz, or higher.

The new fast-recovery bridges are designed for use in high-frequency power supplies, circuit isolation and high-frequency inverter applications in both industrial and computer areas. The principal advantages provided by fast-recovery over standard devices are the reduction of power losses by improvement in rectification efficiency, and increased switching speed.

The MDA952FR series of molded-assembly bridges can rectify 6 amps of your single-phase power at peak reverse voltages up to 400.

Another advantage is the definite cost savings that come from buying the pre-assembled rectifier bridge and eliminating the time and labor you'd invest in assembling the 4 individual diodes. Then there's the fact that the hermetically sealed individual rectifier cells are again sealed *within* Motorola Case 113 that brings you a compact, corrosion-resistant assembly with readily-solderable terminals.

If you're still thinking competition in the face of these advantages, do like the MDA952FRs . . . switch fast!

For details, circle 28

MDA952FR Device	$V_{RM(wkg)}$	Price 100-up
—1	50	$4.85
—2	100	5.00
—3	200	5.50
—4	300	6.00
—5	400	7.25

Now You Need All This For Reliable, Economical, Zero-Point Power Control

Glassivated Triacs With Industry-Assured Specs . . .

Glassivation — Triac technology pioneered and introduced by Motorola over two years ago — now brings you 32 full-wave Triacs that offer you the widest choice of mechanical and electrical features available . . . *plus* performance characteristics registered to standard, EIA specifications!

Motorola 2N-Triacs, for your bidirectional power control applications.

Glassivation advantages are great: sealed, passivated junctions; intimate, void-free bonds between chip and glass; high commutating dv/dt (typically 5 V/μs). And it's standard, no-extra-cost on *all* Motorola Triacs!

Use them in your ac motor speed, light and heat controls, solid-state circuit breakers, power switches, and welders . . . and for EMI-less zero-voltage switching with the new MFC8070.

Rugged and capable up to 600 V of blocking voltage, the metal Triacs offer utmost flexibility in packaging/mounting with 3-lead, stud, pressfit and isolated stud cases, furnishing the option of mounting "hot" or isolated cathodes to the same heat sink.

4 A Triacs are available in plastic THERMOPAD packages; 10 A units in larger THERMOPAD or metal ELF packages. THERMOPAD units assure low thermal resistance via the industry's shortest plastic-device chip-to-heat sink thermal path. Typical trigger currents range from 6 to 25 mA and holding current is 6 mA. The metal ELF provides design flexibility and mounting ease combined with ruggedness and reliability.

The 30 A Triacs have: 250 A peak surge current protection, low as 10 mA typical holding and gating currents and big power-handling capability for rugged industrial/military applications! And thermal resistance is only 1 °C/W.

Triac Series	I_T (RMS) A	V_{DRM} V	I_{TSM} A	Price 100-up	Package Style
2N6068-75	4	25-600	30	$0.56-2.10	Plastic (case 77)
2N6151-56	10	200-600	100	1.15-1.75	Plastic (case 90)
2N6139-50	10	200-600	100	1.64-2.22	3-lead, stud, isolated stud
2N6157-65	30	200-600	250	2.74-5.00	Stud, pressfit, isolated stud

For details, circle 29

Zero Voltage Switch That Eliminates Electromagnetic Interference

Some integrated circuit zero voltage switches offer premium features, but at premium prices. Others are cheap, but lack some desirable features. Motorola's new monolithic MFC8070 zero voltage switch offers the best of both worlds . . .

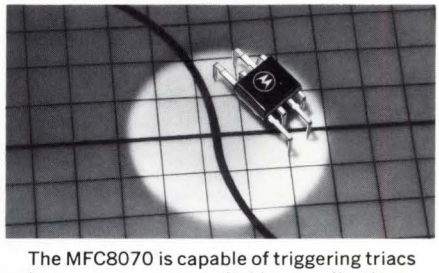
Now you can operate Triacs and SCRs in half or full-wave ac power control applications and forget about EMI. Use the economical MFC8070 in heater, valve, and photo controls, on-off power controls, threshold detectors, and relay drivers, flasher controls . . . anywhere EMI-less, zero-crossing thyristor triggering is needed.

One key MFC8070 feature is a differential amplifier front end that provides two sensor inputs — the only available switch that has more than one. With the MFC8070 you con monitor a voltage band and obtain full proportional control. Another benefit is internal protection against shorted or open sensor inputs — no need for concern that a sensor will be accidentally disconnected, turning power fully on.

MFC8070 also provides built-in voltage regulation for direct ac line operations. Its peak output current is 50 mA (min) with an excellent output pulse width of 70 μs typical.

The MFC8070 is recommended for use with these 4-mode, switching triacs: 2N6151-53, 2N6139-44, 2N6148-50, and 2N6157-6165.

For economy, the unit is supplied in an 8-pin, staggered-lead package that will dissipate a full watt at $T_A = 25$ °C.



The MFC8070 is capable of triggering triacs in your ac power switching applications.

In 1000-up quantities, its price is $1.75. Get the best of two worlds!

For details, circle 30

EPICAP Tuning Diode Series Offers Broad VHF/UHF Design Flexibility

Motorola has added a new 30-volt VVC series to its tuning diode line-up. Packaged in the low-inductance MINI-L plastic case, the new series is comprised of BB105 A, B and G silicon EPICAP diodes.

The diodes are designed for UHF and VHF tuning and AFC, as well as general frequency control and tuning applications. Their addition to the industry's broadest line provides you with an even greater latitude of device choice and increased design flexibility.

BB105B is used in UHF tuners and other UHF and microwave applications, and the BB105A and G are primarily used as VHF and AFC diodes. This new VVC series features a typical break-down voltage of 40 V, specified minimum Q values (@ f = 100 MHz and $C_T = 9$ pF) of 225 for both the BB105A and B, and 150 for BB105G.

The series also displays a controlled and uniform tuning ratio. C_3/C_{25} is typically 4.9 and min/max values are specified for each device. Where required, the capacitance of all diodes in a set or group can (on request) be matched to within ±1.5% or 0.1 pF, whichever is greater, along the entire specified tuning range.

Part of Motorola's high-volume, stripline production efficiencies are passed on to you in these 1000-up prices: BB105A — 70¢, BB105B — 75¢, and BB105G — 52¢.

For details, circle 31

NEW PRODUCTS BRIEFS

N-CHANNEL J-FET OPERATES GROUNDED-GATE

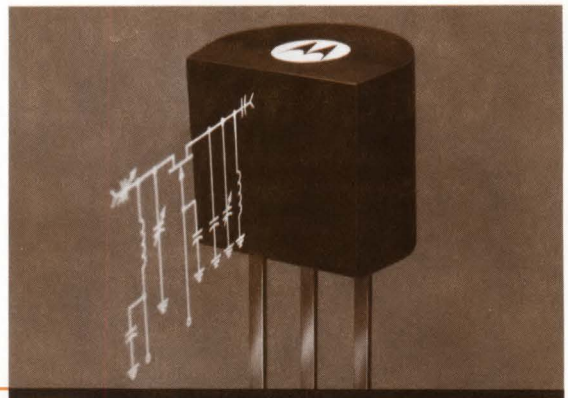
— For Low Noise, Large Signal Handling

Motorola's latest silicon N-channel, junction field effect transistor — MPF820 — is a state-of-the-art device designed and specified for grounded-gate operation. In this mode, it has excellent large-signal handling capability for your low-noise RF amplifier applications. The MPF820 can provide a nearly optimum antenna match using no input tuned circuit. Stable, non-shielded RF tuners can be constructed with the new device.

The MPF820 features a low noise figure of less than 4.0 dB (max) and a high gain of 18 mmhos (typ), both measured at 100 MHz.

Encapsulated in Motorola's proven, TO-92 plastic package, the 1000-up price of MPF820 is a low 48¢. And it's in good supply. Get yours now!

For details, circle 32



FIRST HTL NIXIE DRIVER

— MC676 Features "Glow-Free" Operation, CMOS Compatibility

Motorola is the first in the industry to offer a Nixie®-driver in high threshold logic — the MC676P, L monolithic BCD-to-Decimal Decoder/Driver.

MC676 is the industry's first high threshold logic driver — designed for use with gas-filled, cold-cathode indicator tubes and other devices requiring high-voltage drivers. The new IC offers 70 V output breakdown voltage (min) over the −30 to +75°C temperature range.

Glow-free operation is made possible principally by the MC676's high output voltage capability. Some devices can't handle the high Nixie voltage and force the tube itself to do so causing unwanted glow.

Operating from a 15-volt power supply, MC676 has an input loading factor of 1 and dissipates 380 mW (typ). Like all Motorola MHTL logic, it has a noise immunity nearly 50% of the supply voltage and is compatible with CMOS.

The new Nixie-driver is supplied in the 16-pin, plastic, dual in-line package (MC676P in case 612) for $4.85 and in the 16-pin, dual in-line ceramic package (MC676L in Case 620) for $7.95. Both prices are in 1000-up quantities.

®Trademark of the Burroughs Corp.

For details, circle 33

TRUTH TABLE

INPUT				OUTPUT									
D	C	B	A	9	8	7	6	5	4	3	2	1	0
0	0	0	0	1	1	1	1	1	1	1	1	1	0
0	0	0	1	1	1	1	1	1	1	1	1	0	1
0	0	1	0	1	1	1	1	1	1	1	0	1	1
0	0	1	1	1	1	1	1	1	1	0	1	1	1
0	1	0	0	1	1	1	1	1	0	1	1	1	1
0	1	0	1	1	1	1	1	0	1	1	1	1	1
0	1	1	0	1	1	1	1	0	1	1	1	1	1
0	1	1	1	1	1	1	1	0	1	1	1	1	1
1	0	0	0	1	0	1	1	1	1	1	1	1	1
1	0	0	1	0	1	1	1	1	1	1	1	1	1
1	0	1	0	1	1	1	1	1	1	1	1	1	1
1	0	1	1	1	1	1	1	1	1	1	1	1	1
1	1	0	0	1	1	1	1	1	1	1	1	1	1
1	1	0	1	1	1	1	1	1	1	1	1	1	1
1	1	1	0	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1	1	1

RF POWER AMPLIFIER

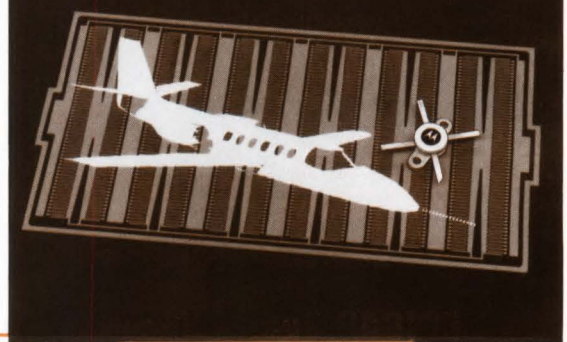
— Offers 100 W, 150 MHz Class C Output

28 V aircraft radio and military ECM equipment will be the better for this new RF device offering 100 W PEP @ 150 MHz and Balanced Emitter Technology construction for ruggedness. In a BET transistor many independent emitters, each with its own nichrome resistor, protect the device against destructive external factors such as load mismatch and detuning.

Packaged in the thermally-conductive, easily-mounted flange case, the new 2N6166 device provides 6 dB power gain at 100 watts power output. Opposed emitter packaging lowers lead inductance and improves broadband capability.

The new data sheet shows all the specs you need for "worst-case" designs: impedance parameters, efficiency, power-out vs. frequency, leakage, etc. Send for yours!

For details, circle 34



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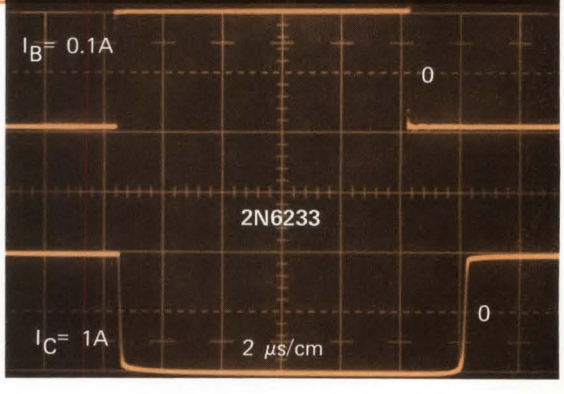
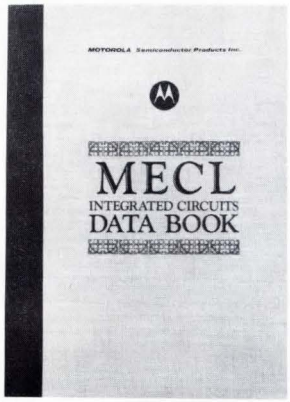
Switches in microseconds . . . offers very high switching efficiency . . . performs at 325 V sustaining voltage! It's called the 2N6233-35 series silicon power device and it's available now for your high-efficiency inverter designs. In the rise and fall portions of the switching cycle where losses in efficiency normally occur, this device doesn't dally. Rise and fall times are both 0.5 μs (max.) at I_c = 1.0 A. Originally qualified for use in the Safeguard program, the family also offers 0.5 V saturation voltage for additional efficiency, 20 MHz f_T and 5 A continuous current capability. Power dissipation measures out at 50 W and h_{FE} ranges from 25 to 120 at 1 A. The series is packaged in the hermetic, space-saving TO-66 case.

For details, circle 35



NEWS BREAKS

Microelectronics Book Gets Second Satellite – MECL Data Book Achieves Orbit



Incorporating information on all products in Motorola's emitter-coupled logic families, the MECL Data Book is successfully launched. Second in a series that will soon see data for each of Motorola's major IC product lines published under its own cover, the new book presents complete specifications, family and system characteristics and applications information for Motorola's four series of emitter-coupled digital integrated circuits: MECL 10,000, MECL III MC1600, MECL II MC1000/MC1200, and MECL MC300/MC350.

The MECL Data Book is tabbed for quick access to the section of interest. Each section includes full specific information on all currently available devices in a logic series plus general family characteristics such as propagation delay, fan-out, current drain and operating frequency. Helpful system design data is given including: power dissipation, worst-case noise margin, trade-off in characteristics for variation in temperature and supply voltage, clock distribution and system layout rules.

Designers involved in TTL systems will find the recently published MTTL Data Book just as helpful as its MECL counterpart. Keep the product information in your technical library complete and up-to-date. Use the handy order form to obtain your copies of these useful books.

2N404/A PNP Germanium Switching Transistor Now JAN-Qualified

The rugged and dependable 2N404/A – popular PNP Germanium switching transistors, with the proven reliability of the Motorola Mesa system of manufacturing germanium products – have received JAN qualification under MIL-S-19500/20C.

Designed for medium-speed saturated switching principally in military computer, and telephone applications, the JAN2N404/A feature a low collector-emitter saturation voltage of 0.2 Vdc (max) @ I_C = 24 mAdc, and high emitter-base breakdown voltages of 12 Vdc (min) for the JAN2N404 and 25 Vdc (min) for the JAN2N404A, both @ I_E = 20 μAdc.

Compared to alloy devices, JAN2N404/A offer more stable betas and lower leakages, plus greater mechanical strength (due to bonding the die to the header). The devices are packaged in the TO-5 metal can. (Corresponding "MM" commercial versions – the MM404 and MM404A – are available in the smaller, space-saving TO-18 package.) 100-up prices are only 29¢ for JAN2N404 and 45¢ for JAN2N404A.

For details, circle 36

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NEWS BREAKS

Prices Slashed From 25 To 60% On Current-Limiter Diodes!

As Motorola's production efficiencies go up, prices on its entire 37-device line of current-limiter diodes come down!

Price cuts affecting the thirty-two 600 mW devices of the 1N5283 thru 1N5314 series average between 25 to 50% off regular prices. The series holds current constant up to 100 V and provides current from 0.22 to 4.7 mA at ±10% tolerance.

The new prices listed for the 5-device MCL1300 thru MCL1304 series represent savings up to 60% off the old prices. The series provides currents of 0.5 ±3.0 mA and 1.0, 2.0, 3.0 and 4.0 mA at ±0.6 mA respectively with voltages up to 75 V.

Current-Regulator Diode Prices

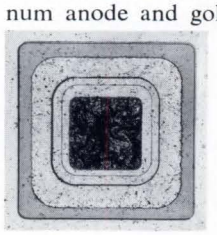
Device Nos.	1-24 Price NEW	1-24 Price (OLD)	25-99 Price NEW	25-99 Price (OLD)	100-999 Price NEW	100-999 Price (OLD)
1N5283 thru 1N5286	$3.30	(4.45)	$2.80	(3.90)	$2.20	(2.95)
1N5287 thru 1N5310	$2.30	(4.45)	$2.05	(3.90)	$1.55	(2.95)
1N5311 thru 1N5314	$3.30	(4.45)	$2.80	(3.90)	$2.20	(2.95)
MCL1300 thru MCL1304	$1.80	(4.45)	$1.60	(3.90)	$1.20	(2.95)

For details, circle 37

120 Zener Chips Now Available

Motorola is making 120 silicon zener diode chips available as "standards." The devices are for use in compact and high performance circuits that are beyond the present state of monolithic production capability — in a word — hybrids.

Standard chip size is 25 mils square with an aluminum anode and gold backing. Larger chips (60, 90 and 120 mils square) with different metalization to handle higher power requirements are available on special order.



All chips are available in ±10% and ±5% tolerance and feature silicon-oxide passivated junctions that provide greater reliability than devices that are subject to contamination from exposed junctions. They are compatible with all standard wire and die bonding techniques used in hybrid circuits.

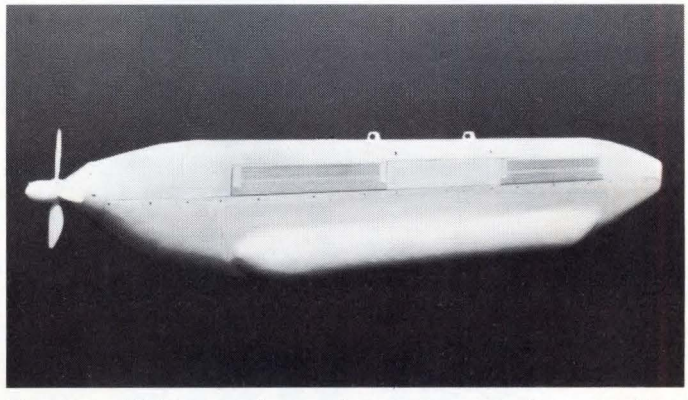
These zener chips are available for a wide voltage range — from 2.4 through 200 volts in the "A," or high-level series, and from 1.8 to 200 volts in the "B," or low-level series. Limits on four electrical parameters are assured by testing.

The 100-up prices for the MZC2.4A10 thru MAC-200A10 high-level series range from only $1.26 to 2.00 and, for the MZC1.8B10 thru MZC200B10 low-level series, from $1.20 to 2.30.

For details, circle 38

AiResearch electronic cooling systems are built into the F-14.

We have designed and built complete electronic cooling systems for hundreds of airborne applications—both on board and pod mounted. In fact, a Garrett AiResearch built electronic cooling system is on board the Grumman F-14 air-superiority fighter. □ Whatever your specific airborne electronic cooling requirement, come to Garrett AiResearch for total system optimization.



Garrett AiResearch enclosures are also cooling the pod mounted ALQ-76 and ALQ-99 electronic countermeasures systems. The enclosure in the ALQ-99 pod (shown above) for the EA-6B utilizes surface heat exchangers as the ultimate heat sink.

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CIRCLE NO. 12

Everything you always wanted to know about hybrids but were afraid to ask.

Now it can be told.

The inside story on Hughes hybrids. From the people who are doing it all.

The Thin Film/Thick Film Hybrid Integrated Circuits Book.

In it you'll find all kinds of Hughes hybrid stories: the simple, the complex. Everything from simple resistor networks to LSI hybrid circuits.

Along with information how Hughes designs, develops, builds, tests and guarantees the total hybrid package.

And some revealing facts on Hughes hybrids that are being used in very high places: missile systems like STANDARD ARM, PHOENIX, MAVERICK, and AGENA; aircraft like E-2C, DC-10, S-3A, F-14 and F-15.

It's what you need to know about hybrids.

And just so there's no mistake, it's illustrated.

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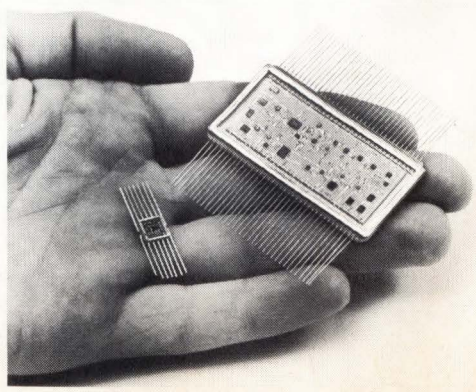
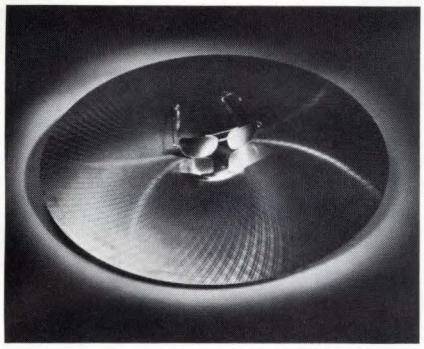


CIRCLE NO. 13

Big Target Is Hard to Miss



Sylvania Emissive Products of Exeter, N. H. recently produced a vacuum hot-pressed target that is believed to be the largest one-piece sputtering target ever produced for the semiconductor industry. Largest targets previously produced have been 12 inches in diam. Although the initial target is chromium, all conventional materials used by the semiconductor industry – boron, silicon nitride, aluminum oxide, silicon-oxide gold, etc. – can be produced now that the process has been perfected. A unique feature of this type of target is that it is vacuum hot pressed thereby reducing subsequent outgassing problems in the sputtering chamber. Its big advantage is that it increases throughput of devices per sputtering cycle.

Sufficient Electric Vehicle Market to Support an Industry, Study Shows

A sufficient market exists in this country to support a new electric vehicle industry now, irrespective of environmental pressure and benefits.

That is one of the major conclusions of a recently released study comparing performance capabilities of electric vehicles with use patterns of standard vehicles operating today, according to George M. Hartley, president of Cooper Development Association Inc., and H. J. Young, executive secretary of the Electrical Vehicle Council, joint sponsors of the research program.

"Careful statistical analysis shows there is a sufficient potential market to support an electric vehicle industry. But no one to date has put together a total business concept, including market data and financial justifications," reported Mr. Hartley. "This study represents significant progress in that direction."

"The environmental advantages of electric transportation – cleanliness, quietness and ease of operation – are attractions that can no longer be ignored, but the market for on-the-road electric vehicles is significant even ignoring these benefits," Mr. Young said.

More than a million passenger cars currently in use in both the cities and the suburbs could function as electrics – considering the actual use patterns of these cars. Needs of people using these cars could be fulfilled with a four-passenger electric auto with a top speed of 60 mph and a daily driving range of 60 miles. This is within existing technological capabilities.

In the light delivery truck area, more than a quarter million vehicles in operation today also could function as electrics. Such trucks have a 1000-pound payload, make five stops per mile and have a daily range of 40 miles at a cruising speed of 40 mph. This, too, is well within existing capabilities.

By 1975, the state-of-the-art could permit a five-passenger car with a range of 100 miles and a top speed of 75 mph. If use patterns remain the same that would mean 25 million people might as well be riding electrics.

In this country, electric vehicles are presently used extensively in industry and for leisure-time transportation. Recent advances in battery technology have made it possible for electric cars and trucks to be manufactured for limited-range, special purpose uses. In England, some 60,000 electric vehicles are in use on the roads, largely as delivery trucks and vans.

(Continued)

Design Briefs

A report on the study—"The Potential Market for On-the-Road Electric Vehicles"—is available. Requests should be addressed to Copper Development Association Inc., 405 Lexington Ave., New York, NY 10017, or Electric Vehicle Council, 90 Park Ave., New York, NY 10016.

Blood Pressure By Ear

One of NASA's Biomedical Application Teams (BATEAMS) has utilized aerospace technology to help solve the problem of determining human blood pressure when conventional methods aren't feasible.

For some critically ill patients, repeated blood pressure checks using the arm cuff or a catheter inserted into a blood vessel prove impossible. Blood pressure measurements, however, provide an early detection of physiological shock which is sometimes irreversible and fatal.

In seeking a solution to the problem, the National Cancer Institute's Leukemia Service sought the aid of the BATEAM associated with the Research Triangle Institute, Raleigh, N.C.

The answer was found in an Ames Research Center development of the early 1960s. A sensor called an ear oximeter had been used to study rapid acceleration effects on patients in a centrifuge. Operating on an absorption principle, the sensor measures the oxygen content of blood circulating in the ear. Since the onset of shock is accompanied by a reduction in both the amount of blood and the oxygen content of blood flowing through the ear, the sensor can be used to detect blood pressure changes and set off an alarm.

NASA has eight special teams charged with identifying individual problems and preparing solutions based on aerospace technology. Four of the teams are BATEAM concentrating on biomedical activities, and four concentrate on environmental problems.

For swept RF measurements of both magnitude and phase, Try this test lab.

HP's 8407A Network Analyzer makes quick RF measurements, 100 kHz to 110 MHz with ease, accuracy and thoroughness. Inadequacies of alternate techniques have been eliminated and swept measurements over a wide dynamic range are now possible.

We're talking about full characterization — both magnitude and phase — of filters, amplifiers, attenuators, transistors, antennas, and any other RF components, devices or networks you can name. And you can check them at any stage of design, development or production.

The system consists of:

- 8601A Generator/Sweeper, a precision swept source, 0.1 to 110 MHz, with flat output, a highly linear sweep and low residual FM.
- 8407A Network Analyzer mainframe with 8412A Phase-Magnitude Display unit for CRT presentation of test results.
- Accessory coax devices and probes to monitor the unknown's responses to the swept test signal.

For coaxial work: 11652A Reflection-Transmission Kit with all the accessories you'll need: precision power splitter, high directivity flat coupler, termination and matched cables. Just hook up — make high accuracy swept measurements of complex transmissions and reflection coefficients simply and quickly.

For circuit work: 11654A Passive Probe Kit with high impedance voltage probes and dividers plus current probes. You can measure circuit and device performance without disturbing their behavior. And using voltage and current probes simultaneously, you can make swept impedance measurements with 10,000:1 dynamic range.

Dynamic measurement range is greater than 100 dB, and you can see 80 dB in one viewing of the 8412's CRT. And you can see phase response at the same time with 360° phase range. The system also provides 0.05 dB magnitude and 0.2° phase resolution.

The 8407A is a narrow-band detector that tracks the sweeping test signal. Tracking provides these unique benefits:

1. Wide dynamic range and high sensitivity — make high-gain/high-loss measurements on sensitive networks and devices.
2. Accurate measurements — free from errors encountered in broadband detection methods resulting from harmonics and other spurious signals.

The 8407A RF mainframe costs $2950; 8412A Display, $1575; 11652A Reflection-Transmission kit (for coax), $325; 11654A Passive Probe kit, $400; 8601A Generator/Sweeper (general purpose precision swept source, useful for many applications), $2250.

You can get the full story by phoning your local HP engineer and asking for a demonstration. He'll also be glad to give you Application Note 121-1, a comprehensive description of what this system can do for you; plus Application Note 121-2 which describes how to make wide dynamic range impedance measurements on a swept-frequency basis. Or write to Hewlett-Packard, Palo Alto, California 94304; Europe: 1217 Meyrin-Geneva, Switzerland.

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NETWORK ANALYZERS

CIRCLE NO. 16

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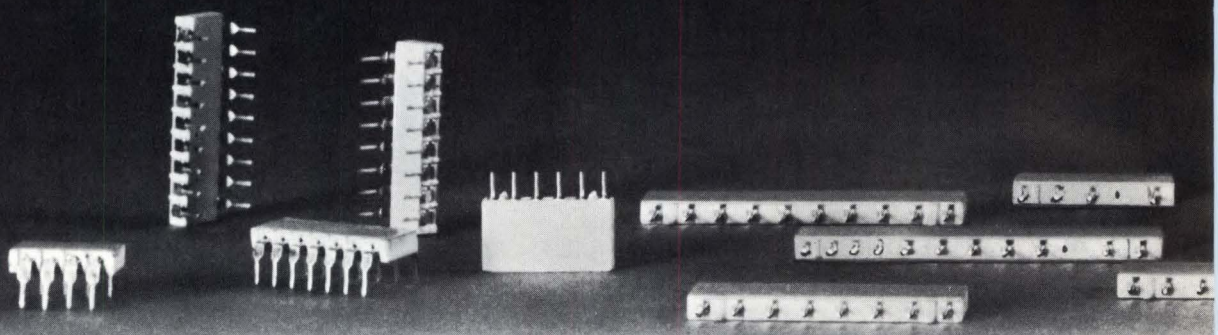

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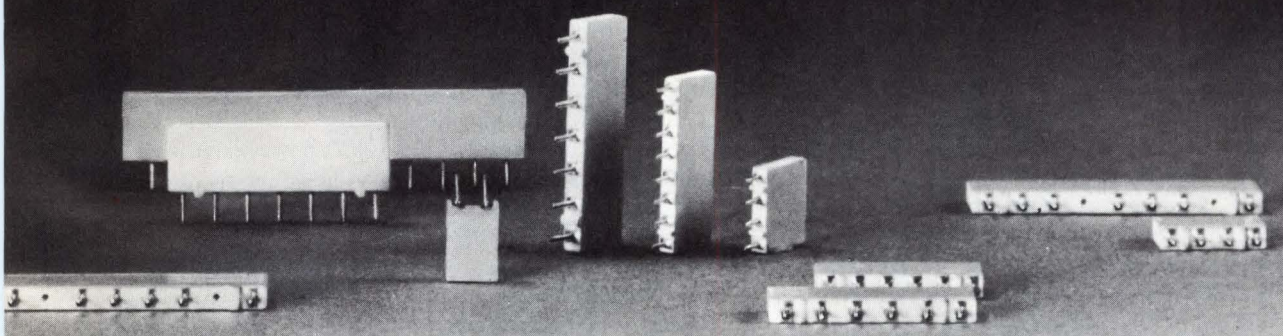

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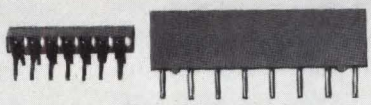


ACTUAL SIZE

CTS CORPORATION *Elkhart, Indiana*

A world leader in cermet and variable resistor technology.

CIRCLE NO. 17

HOW SMALL IS SMALL?

Thick-film or thin-film? Laser or abrasive trim? Flip-chip or beam lead?—These are a few of the trade-offs interwoven within the minicomponent evolution.

HARRY HOWARD, Senior Editor

To keep up with the IC trend, component manufacturers have reduced size and cost with improved reliability. Today's generation of electronic circuits makes use of monolithic arrays that use either hybrid or large-chip processing techniques. Each has its merits depending on the specific application.

Generally, manufacturing procedures remain unchanged—prototype to final test—but advancing into this new generation of components requires the upgrading of many traditional operations. Automation for handling micro-operations, materials interface and complex-array testing requires improvement.

Size reduction necessitates a choice between thick and thin films. As in any good design, one must take advantage of all materials in the proper combination to reduce cost and improve reliability. Small components also mean a reevaluation of the mechanical design and how to handle and assemble the component in the production phase of operation. Sometimes an overlooked aspect of the manufacturing operation is the interconnection between the chip and the packaging medium. Operator intervention still accounts for a major source of defects, and the need for advances within this area should not be ignored.

Finally, as in any manufacturing operation, the last step is testing. In the past, discrete components made partition testing a rather straightforward operation. Now, combining circuits of large scale arrays on various media makes isolation and testing infinitely complex. In many cases, these operations must be automated because manual testing would be time limited.

Thick or Thin

The controversy over thick or thin film can be just a waste of time and energy. If one examines it objectively, the choice is usually based on a finite number of factors. Once these factors are isolated, the choice is generally resolved. For example, thin-film devices are used where precision geometrical control is a must—such as in microwave applications.

Thin films have been used for several years and their technical characteristics are widely understood. Several materials are used to develop passive components—the popular materials are tantalum oxide and nichrome. Sputtering techniques are used to deposit the tantalum and then it is wet anodized to the desired sheet resistivity. Advantages of this technology are excellent stability and temperature coefficient characteristics, predictable resistor values and that the process can be automated. However, tantalum oxide is difficult to etch: it reacts with its own oxide in excess of 300°C and it reacts with aluminum. The 300°C temperature constraint inhibits the use of eutectic die attach techniques.

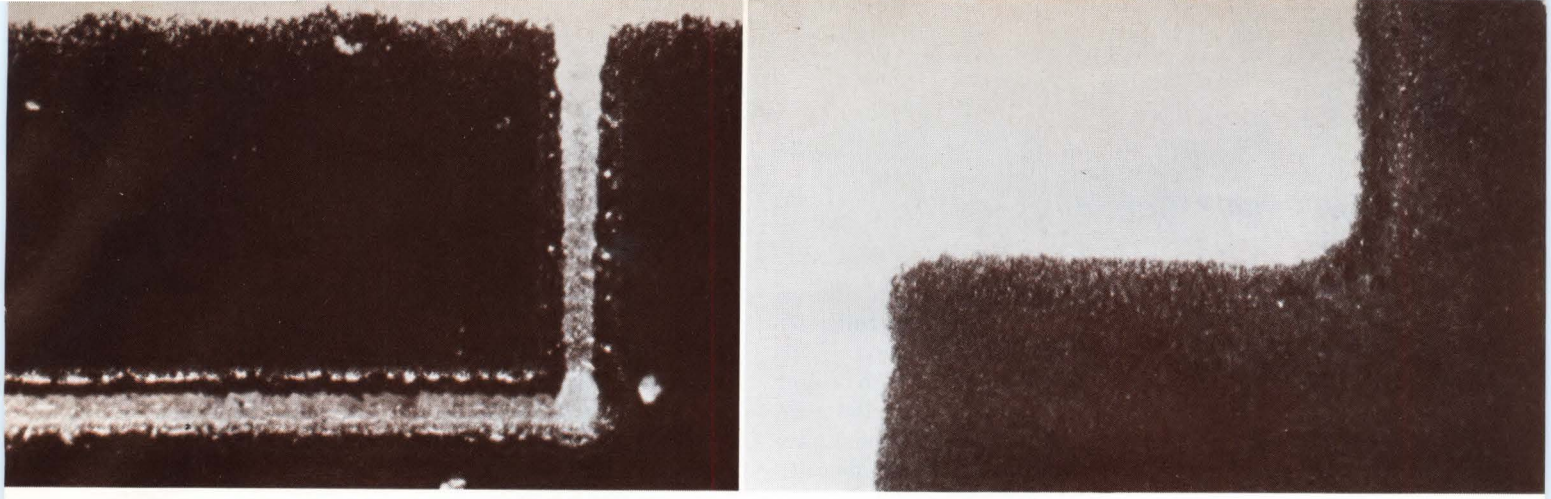
Nichrome is etchable, has controllable TCR, is easy to deposit, it's rugged and laser trimming can be used. However, the disadvantages are that it makes good ohmic contact to NiCr (nickel chromide) difficult, it is very thin when deposited and it has a low sheet permence. Because of nichrome's ability to withstand die bond temperature without changing, however, it is the popular choice. For example, this die attach technique is necessary to produce power hydrids.

Thick film for hybrid construction follows thin films. Thick film endeared itself to volume production users because of its automation potential—and because it provides an easy approach for selling additional functions. In addition, it offers fair quality resistors at a reasonable price, ruggedness and functional trim and low-level technological requirements. On the negative side, thick film depends on resistive ink, is not adaptable to small volume orders, is large in size as compared to thin-film components and does not permit die bonding large numbers of active devices using SiAu eutectic methods.

Resistor inks are important and the number of different inks used should be kept to a minimum. In fact, it is common to use three different inks on a single substrate. Each ink requires a separate mask and screening operation—another increase in manufacturing cost. On the other hand, one material requires a large substrate area for a typical value in a typical circuit.

Next to conductor inks, another functional material for thick-film technology is resistor pastes. In principal, any mixture of metal powders and glass forms a resistor after firing. However, controlling the resistor properties can be extremely difficult.

Thick-film materials that are commercially available include a platinum-based system, ruthenium oxide, thallium oxide and various palladium-silver bases. The palladium-silver base is the most popular and the oldest. Palladium-oxide formed during firing determines the final resistor properties. The addition of



Laser (left) and air/sand abrade magnified 80X (*MOTOROLA SEMICONDUCTOR PRODUCTS INC.*).

silver optimizes or enhances such parameters as temperature coefficient, drift and noise. The glass serves as a bonding medium and it too affects temperature coefficient.

Resistor materials are available in the range from 1Ω to 1 MΩ/square mil. Inks of the same resistor family can be blended to form intermediate values. By adding semiconductor oxides, the temperature coefficient will be reduced. For special applications, the paste supplier usually modifies the basic resistor properties. Available commercial inks are a compromise of the various properties.

Glass used in these systems is either lead or zinc borosilicate. The melting point is chosen to reach a desired metal-to-metal oxide equilibrium. For example, glass used in the palladium system has a lower melting point than in the ruthenium system. The expansion coefficient affects the TCR, thus complex glass material is used. Particle size is another factor that will affect both sheet resistance and TCR.

Abnormal design situations demand unusual solutions. Among these, IC compatibility may require one type of film even though another exhibits superior properties. Packaging constraints and environment are also very important factors for consideration.

Abrasive or Laser

Abrasive and laser trimming are similar in that the material is removed to increase the resistor value. Abrasive trimming equipment consists of a set of nozzles, any size or shape, positioned over the resistor to be trimmed. Aluminum oxide powder, usually 27 micron, is propelled at the resistor and the material is removed. The operation is continuously monitored throughout until the proper value is attained, then the abrasive flow is stopped.

Tolerances as low as ±0.5% can be realized with abrasive trimming. In this process, the tools never come in contact with the substrate, thus no shock, vibration or heat is introduced. This process can be easily automated and high production rates are practical. There is no damage to the substrate, because the pressure of the abrasive can be adjusted to prevent the removal of substrate material. There is the problem of removing the abrasive material from the substrate, but this is readily achieved with a vacuum cleaner set up. Another problem is overspray of the abrasive powder which could hit a neighboring resistor. This can be controlled only by careful layout of the resistors on a substrate.

The laser process uses a focused laser beam to accomplish the task of trimming. Resistor material in the path of the beam is vaporized, leaving an exposed substrate. Thus, the resistor area that is not required is merely isolated from the conductive path. There are a variety of laser systems—the most common types are YAG (yttrium-aluminum-garnet) and CO_2 (carbon dioxide).

Theory behind the laser trim path shape and location becomes complex because of such variables as the resistor tolerance, size, aspect ratio, sheet resistivity and power requirement. The objective of laser trimming is to move the beam as rapidly as possible, to remove the resistive material, to achieve the final resistance value and to maintain power requirements. Thus, beam positioning speed is optimized through different trim patterns such as straight trims, multiple straight trims and "L" trims. Based on all of these required variables, laser trimming lends itself to computer control.

Laser trimming offers some advantages over abrasive techniques because the trimming can be performed on glazed resistors without altering the glaze. In laser trimming, narrow trim paths are possible. Laser-trimmed resistors seem to maintain identical characteristics to the basic resistive material and abrasive units exhibit higher drift and noise parameters. However, the capital investment for a laser system is large and can only be justified for large production requirements.

What Are Capacitors Made Of?

A thick-film capacitor is essentially a screened dielectric layer between two printed conductors. Mixtures of glass and ferroelectric materials are commonly used. For hybrid design, there are basically two types of capacitors—single and multilayer.

Single-layer devices have the advantage of being available in almost any size or shape and can be manufactured in either an opposed electrode configuration or in a flip-chip form with both electrodes on the same side. The multilayer device has an electrode configuration that lends itself to bonding. Because of the multilayer concept, it exhibits high capacitance.

(*Continued*)

One major problem that exists with thick-film capacitors is the difference in thermal expansion between the titanate materials used and the alumina substrate. To reduce the problem, glass with a high softening temperature is used thus reducing the average expansion coefficient. Also the titanate must have fine particles to overcome the stresses at the glass-titanate interface.

Another important item is the conductor material of the electrodes—such materials are seldom interchangeable. Any variations are clearly attributable to the differences in concentration and composition of glass frits and other fluxes used in the conductors rather than to interaction between the metals themselves.

Environmental Protection

Materials for environmental protection of chip components contain inorganic compounds in an organic vehicle system. For maximum protection, the entire film is covered, including the portion overlapping the termination. Resistor trimming can be accomplished through the fired encapsulant. The YAG laser system will not disturb the encapsulation but the CO_2 scheme melts it without exposing the resistive material.

In order to minimize the effects on the underlying resistor films, a low temperature glaze that will not crack under stress is employed. Not all properties can be realized and compromises must be considered. Generally, high-lead glasses are used. Material such as zirconium oxide is added to control the expansion. Other materials, including refractory compounds, are added to make the glaze opaque and resistant to cracks.

Firing the encapsulant can alter the component characteristics, thus care must be taken. Properly fired films are translucent and exhibit a slightly matted or dull surface.

Final Connection

Selecting the lead material is important. This material should have an expansion coefficient that closely matches alumina (6.4×10^{-3}/°C). Commonly used materials are copper, nickel, solder (60-40), Kovar and Ceramvar. A common practice is to gold plate the lead material for ease of wire bonding and to provide protection from oxidation.

Copper leads are usually soldered directly to the thick-film paste conductor. Pull strength of a 50 by 50 mil solder pad is just a few pounds. Also copper pins are swaggered into holes in the substrate. These pin diameters are kept to less than 40 mil to prevent cracking during exposure to heat.

Epoxies are a popular adhesive and exhibit excellent characteristics up to 200°C. To achieve these advantages, however, acid-anhydride-cured rather than amine-cured materials ar used. When conductive epoxies are needed, silver or gold is added to assure good electrical and thermal conductivity, but at a sacrifice in the mechanical properties of the adhesive. For nonconductive adhesives, the epoxies are frequently composed of silica or a form of talc. When the epoxy must exhibit both insulating and thermal properties, a combination of these materials as well as a glass filled epoxy is used.

Around the Circuit

When the proper vendor is selected, it is conceivable that all that is required is the capability to piece the components together. Multichip approach offers many outstanding features and among them, all components are commercially available—be they passive or active. Also, there is a high degree of repairability where chips can be removed and replaced within a reasonable turnaround time. Some manufacturers who are involved in the development of passive minicomponents include:

RESISTORS

Airco Speer Electronics is involved with both thick-film and thin-film technology. Their thick-film line consists of a cermet resistance composition fired on a ceramic substrate with pretinned wraparound palladium-gold termination. For example, a 100 MΩ, 400V resistor comes on a 50 by 150 mil chip. Average TCR for this series is <200 ppm/°C. Of further interest is their high-voltage divider—also thick film. These units are operated at 2000V, exhibit 1000 MΩ/square

From left to right, thin-film (75-mil chip) and two thick-film networks (*AIRCO SPEER ELECTRONICS*).

Comparison of terminations following solder dipping (*VITRAMON, INC.*).

inch and are on a 0.1- by 0.75-inch chip.

In the thin-film area, a thin film of stabilized nichrome alloy is the resistive alloy element. It is deposited on a substrate of either glass or passivated silicon. Gold termination pads provide for wire-bond connection. All resistors are on a 75-mil square chip and laser trimmed to ±0.05% tolerance.

Allen-Bradley Co. combines high-purity alumina substrate, specially formulated paste and volume production facilities to supply passive networks to complement ICs. Among these are pull-up resistors for TTL circuits, terminating networks with and without capacitors for ECL devices and a family of pad attenuators as well as R/2R ladders and summing networks for IC converters. The majority of these units are available and compatible in 14- or 16-pin DIPs.

Production quantities of laser adjusted cermet networks are available with resistor absolute tolerances of ±0.5%, TCR of ±100 PPM/°C and TCR tracking well below ±50 PPM/°C. Up to 26 resistors are mounted within a 16-pin DIP.

Both cermet and thin-film products are available in unencapsulated forms for users desiring to attach chip devices onto a substrate. These unpackaged networks come with or without leads and with or without conformal coating. Allen-Bradley's thin-film networks consist of a unique chromium cobalt technology used to assure tight precision for critical requirements.

Centralab Electronics Div., a pioneer in thick-film technology, uses laser adjusting techniques to reduce resistor size, a special lead-frame material for increased power handling capabilities and automated testing. Available resistor networks provide up to 24 resistors/package in a 14-pin DIP and 28 resistors/package in a 16-pin DIP. The RC networks include multilayer ceramic chip capacitors. Available range of resistance to 10Ω to 10 MΩ, and the capacitor's range is 5 pF to 1 mF. Substrate material used is 95% alumina ceramic with palladium gold as the conductive ink.

Corning Glass Works recently introduced a packaging concept for resistor-capacitor-diode networks called CORDIP. The components (Glass-K ceramic chip capacitors, C-style glass-tin-oxide resistors) are inserted into prepunched epoxy subboards—round holes for resistors, square for capacitors. Once inserted, the interconnections are made. A lead frame is press fitted to one side of the subboard and the unit is given the typical protective DIP coating. Basically, this work is custom, but it provides flexible RC network designs at a low cost. For example, in 1000-package quantities, 14-pin CORDIP containing thirteen 5% resistors cost about $0.85 each. A unit containing nine 5% resistors and two 10% capacitors costs about $1.80. Up to 16 components can be inserted in a 14-pin DIP, while the 16-pin version holds as many as 23. Resistance range is 10Ω to 150kΩ with resistance ratios greater than 15,000:1. Resistance temperature coefficients are 50, 100 and 150 PPM/°C from −55 to 125°C. Tolerances are 1, 2, 5 or 10%. Capacitance range is 10 to 10,000 pF with 50V ratings.

CTS Corporation's major involvement is monolithic resistor networks in a DIP, including 8-, 14-, 16- and 18-pin modules. Having up to 2W capabilities, these modules feature 0.1-inch lead spacing and standard ±5% tolerance. The resistor material used is cermet with alumina substrate. CTS feels that these resistor networks offer the following advantages:

—Automatic insertion capabilities reducing overall cost.

—Improved utilization of PC board space as compared to discrete resistors.

—Elimination of external interconnect increasing reliability.

(Continued)

How Small? (Cont'd)

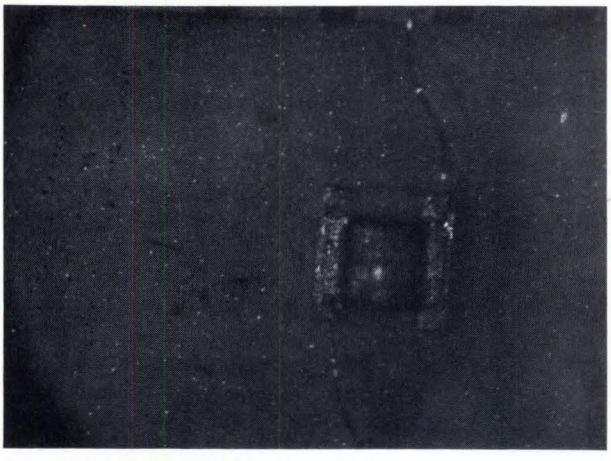
—Improved matching and tracking capabilities, difficult to attain with discrete components.

Eltec Instruments Inc. saw a need for tiny resistors less than 0.1 inch in length with values of 1000 MΩ and capable of operating in vacuum, cryogenic and high-shock environments. Using thick film, they developed a semiconductive glass resistor.

Usually small amounts of glass are used as a binder to cement conductor and resistor particles together and to a substrate. By contrast, a small amount of inorganic impurities are added to the glass, thus changing an insulator to a controlled semiconductor—the basis for Eltec's design.

Both chip and lead configurations employ semiconductor mixtures fired at a high temperature onto a ceramic rod or wafer—overlapping the leads and terminals.

This integral design with broad interface areas lowers noise, reduces thermal effects and insures structural integrity. The conductive glass forms a thin continuous nonspiraled bulk coating that covers the entire surface area between terminals. High glass content seals the element to some degree. Lead types are further sealed with a hard tightly crosslinked epoxy recommended for use in vacuum and cryogenic



Only 50 by 50 mils, this thick-film chip resistor dissipates 3W of power (*MINI-SYSTEMS, INC.*).

environments. Except for the epoxy sealant on lead models, no other organic materials are used that might outgas in high vacuums. The gold-plated nickel leads on conventional models are solderable or weldable. Based on this approach, Eltec offers four standard values—1.5×10^8, 1.5×10^9, 1.5×10^{10} and $1.5 \times 10^{11}\Omega$. Tolerance of these units is ±25%.

Hycomp Inc. combines proprietary design and production techniques to manufacture 12-bit R-2R resistance networks in large quantities. Based on thin-film technology, these networks exhibit 1 PPM/°C tracking characteristics on a single 100 by 150 mil chip. Significant bit accuracy is 0.012% maximum at −55 to 125°C.

The basic construction consists of a thin layer of nichrome deposited on a glass substrate in a narrow line configuration to obtain high resistor density. Aluminum is used to interconnect conductors; thermocompression gold bonding and aluminum ultrasonic wire bonding make interconnections to package leads.

Available packages include flat packs and DIPs of both hermetic and nonhermetic varieties. Standard models range from the full 12-bit in 16-pin flat pack for military applications to an economical 8-bit network in epoxy DIPs for commercial applications. These networks also have two temperature tracking resistors that can be used in series or parallel for operational amplifier applications.

KDI Pyrofilm Corp.'s thick-film chip resistors have a value range of 100Ω to 1 MΩ with 1 to 20% tolerances. The alumina chips are diced to provide for more uniform edges and improved size tolerances. For improved reliability, the resistance elements are away from the side edge of the chips.

Micro Networks Corp. elucidates on the topic of thin-film technology—their approach for developing thin-film nickel-chromium resistor networks. The most popular technologies are tantalum and nichrome. However, nichrome yields the temperature characteristics necessary for the full mil range of operation.

Trimming is one of the significant considerations in selecting a thin-film manufacturer. How the trimming is achieved is not important, but the ability to trim various configurations, functionally trim and achieve the required tight absolute values is critical. Thus, the state-of-the-art relies on the ability to trim various configurations (trimming a closed-loop configuration is an example), tight tolerances of ±0.01% and functional trimming.

Combining trimming considerations with advance processing techniques, Micro Networks produces—in production quantities—resistor ladder networks of up to 13-bit accuracy with TC tracking of 1 PPM/°C. The basic systems consist of thin-film nickel chromium with gold interconnect patterns and gold bonding pads. Gold wire bonded to the pads and package leads yields a monometallic bonding system for high reliability. In addition, resistor matching is 0.01% with a network accuracy of 0.0006%.

Mini-Systems, Inc. (MSI) specializes in the design and production of precision thick-film chip resistors. Technology involved includes:

—Ruthenium-based materials fired at 1000°C providing an inherently stable resistivity.

—Gold paste used for end-metallization for material compatibility and bonding simplification.

—Glass insulation preventing solder bridging and value changes during attachment.

Two versions of resistor geometries are available: gold end terminations for wire-bond assembly techniques and a flip-chip (FLIP-R) that has solder tinned end terminations and glass coated resistor bodies.

One of MSI's feature devices is a 35 by 35 mil chip that covers the resistance range from 1 to 10 MΩ with 1% tolerance. For power work, they have chip resistors for high-voltage application (up to 10 kV) which handle 10W of power on a heat sink. Another chip is a 50 by 50 mil unit capable of 3W operation.

Motorola Semiconductor is involved in both beam-lead and thin-film technology. The beam-lead resistor chips are mainly for microwave applications. They are comprised of nichrome film deposit on a glass substrate. Die substrate dimensions are 50 by 50 by 3 mils, and for the beam, 5 by 20 by 0.3 mils.

In the unencapsulated thin-film line, two versions are available—ordinary chip resistors (5 and 10%) and a multitap chip (10%). These chips have gold-alloy backing that is suitable for eutectic bonding directly to a metallized substrate or that may be bonded to a Kovar or ceramic tab, then attached to the substrate with epoxy adhesive or other suitable methods. Electrical connection from the aluminum bonding pads to the other circuit elements is achieved with conventional wire bonding techniques.

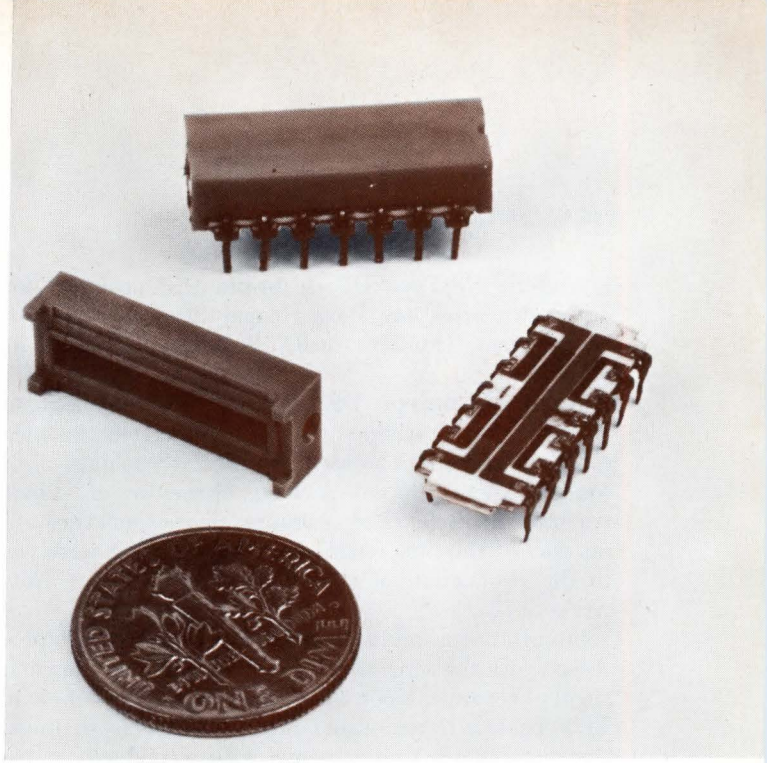
RCL Electronics Inc. uses either thick- or thin-film technology in developing their resistor ladder or summing networks. Absolute resistor tolerances are available to ±0.002% with ratio tolerances to ±0.001%. The ac resistance match at frequency is defined by the user. In ac converter networks, capacitance is matched to 0.01 ρF with a shielded network. Temperature coefficient match and tracking between resistors are within ±1 PPM/°C from 0 to 85°C. The networks are packaged in either a "Coffin" type or the standard 14-pin DIP.

Stettner-Trush Inc. has developed a carbon-film resistor for substrate mounting in a hearing aid. Two versions are available—a subminiature type with axial leads and a capless unit with solder-coated axial wire leads. The resistance range for 0.035W resistors is 10Ω to 4.7 MΩ.

Vishay Resistor Products has an unusual approach that uses a proprietary bulk metal film and an ultrafine photoetching process. Conventional methods for deposition are not used, and the proprietary alloys is approximately 10 times thicker than the conventional evaporated films. A variety of resistive patterns are photoetched so that the resistance is adjustable to a standard tolerance of 0.01 to 0.005% (special order). Shelf stability for these components is 25 PPM/year.

In the construction of these resistors, flexible ribbon leads welded to the resistive element provide permanent contact, and wire leads (terminals) are then welded to the ribbon. To retain the resistance within a specific tolerance, a flexible silicone rubber coating isolates the resistive element from external thermal and mechanical stresses. Moisture-sealing epoxy filling and a molded epoxy case complete the final encapsulation.

In resistor networks, a unique process of depositing bulk metal film on glass yields a matched set of resistors that is up to eight times smaller than equivalent networks. For example, 10k/20k voltage divider in a 0.565- by 0.520- by 0.150-inch package exhibits 2 PPM/°C and ±0.01% ratio tolerance. In addition, Vishay offers R/2R 12-bit ladder networks made up of discrete dual chip resistors and mounted in a 1- by 1- by 0.25-inch package. Accuracy of these devices is ±0.012% over the −55 to 125°C temperature range.



An unusual concept in PC trimmers is the TRN—a trimmer/resistor network in a DIP (*AMPHENOL CONTROLS DIV.*).

TRIMMERS

Allen-Bradley is following the pronounced trend apparent in pots and trimmers—miniaturization. Panel space is shrinking and so is PC board real estate. Obviously, this means smaller pots and trimmers. In the latter part of 1970, Allen-Bradley introduced four pots for panel mounting that fulfilled present and future requirements.

First and foremost was the Series 70 MOD POT—only 5/8-inch square. Employing an unusual modular concept (four modules can be combined into one), the user can select the exact function required for mounting in limited panel space. In addition to having cermet or hot-molded composition tracks, several types of switches, vernier operation, concentric shafts and various sizes of bushing and shafts are also available.

Three pots fulfill the high-power requirements. Type CQ, 0.5 inch in diam, has a cermet resistance track and handles 0.5W at 125°C. Another cermet device, Type SP (only 3/8 inch) handles 1W at 70°C and a third unit, Type CJ (1-5/32 inches in diam) handles 5W at 70°C. Resistance values for the latter unit are up to 5 MΩ—upper limit for wire-wound is approximately 100 kΩ. In the trimmer category, Allen-Brad-

(Continued)

ley offers the Type DP—a 14-pin DIP designed for automatic insertion. Power capabilities for this 20-turn cermet trimmer are 0.75W at 25°C or 0.5W at 85°C.

Amphenol Controls Div. designers felt that because trimmers and resistors exhibit similar technologies and always seem to be used together, it was natural to combine them into one package. Screening of cermet resistance tracks and vacuum deposition through masks of Film-Met resistance tracks lend themselves to the production of the "Trimming Resistive Networks" (TRN).

Simultaneous multiple network substrates are processed with the screening of an array of patterns on one sheet of ceramic. Upon completing this operation, four TRN bases are separated along scribed score lines. The substrate is first screened with a conductor paste to form the trimmer's commutator and the termination pads for all resistors and trimmer elements. After the substrate is furnace-fired to fix the conductors, the cermet resistor and trimmer elements are screened and fired.

Another key feature is the cover. This assembly contains the O-ring, the lead screw and the carrier assembly that bridges the resistance element and the commutator strip. After assembling these parts into the cover, thermosetting seals are placed around cover, base and under the base to strengthen the terminals. Seal joints are fixed when the unit is assembled and fired in the oven. The final package is physically compatible with DIP integrated circuits.

Available resistance values range from 10Ω to 1 MΩ with ±10% tolerance (±1% special). Power rating is 0.75W at 40°C and the TCR is ±100 PPM/°C (±50 PPM/°C special). With the entire trimmer/resistor network in one package, all resistors operate at the same ambient temperature—an attractive feature for this device.

CTS Corp. offers two series of DIP devices—Series 125 and 760. The 125 Series rectilinear cermet trimmer (TO-116 pin configuration) was designed for ease of mechanical handling, is a low profile unit, and is compatible with DIP automatic insertion equipment. Rated for 0.75W at 25°C (0.5W at 85°C), these 20-turn trimmers span the 50Ω through 500 kΩ resistance range at a tolerance of ±20%.

The 760 Series, a cermet resistor module, comes in a variety of packaging configurations including 8-, 14-, 16- and 18-pin modules. Up to 17 resistors are in the 18-pin unit and power capabilities range up to 2W at 70°C. Standard resistance range is 50Ω through 100 kΩ with ±5% tolerance (±1% special).

Vishay Resistor Products makes use of bulk metal film set on glass to create a trimmer having the combined specifications of both wirewounds and nonwirewounds. Three models—1201, 1202 and 1203—span the resistance range of 2Ω to 20 kΩ. The 25-turn trimmers have multifingered wipers on redundant paths for eliminating the catastrophic failure mode of wirewound units and the wandering outputs of the cermets.

CAPACITORS

Allen-Bradley's activities not only involve resistors, but they make multilayer chip capacitors for the hybrid designers as well. The Type MB capacitors are available in 10 sizes including the standard EIA and MIL sizes with capacitance values ranging to 1 μF. These monolithic ceramic chips come in NPO (GOG), stable (X-7R), semistable (X-7S) and Hi-K (X7) materials with silver terminals—and with optional solder coat. Termination systems are unique and have been designed to minimize or eliminate the silver leaching or robbing problem that is common with many ceramic chip capacitors.

American Lava Corp. produces miniature capacitors for hybrid circuits in both the single layer ("diced" capacitor) and multilayer varieties. These capacitors are available in all temperature compensating (NPO to N5600 PPM/°C) and high dielectric constant (up to K8000) A1SiMag dielectric compositions.

Smallest capacitor is a diced chip measuring 0.02-inch square maximum with values up to 100 pF. These components are fabricated from thin sections of ceramic dielectric materials, metallized and diced to capacitance. The electrode material is either silver or palladium-silver (migration resistant).

Multilayer capacitors are fabricated by an exclusive process that insures a strong bond of the high-quality A1SiMag thin strong ceramic dielectric and electrode layers. Edge termination is solderable silver. Capacitance range is from 0.001 to 0.22 mF.

Corning Glass Works has been producing glass ceramic Glass-K chip capacitors for several years. These components pack up to 90 $\mu F/inch^3$. Glass-K chips have fired-on solderable silver as the standard termination. Glass-ceramic capacitors are also obtainable in standard axial-lead (encased) configurations.

Dionics Inc. manufactures MOS capacitor chips that are 20 to 45 mils square and 6 mils thick. Inherent advantages of the MOS capacitor chips are small size, greater high-temperature stability and lower dissipation factor. They can be bonded using conventional production techniques.

In this series, there are six different geometries of single and dual units that span the 0.5 to 220 pF capacity range. Working voltages are 25 to 75V.

The chips are gold backed, permitting conventional eutectic die bonding. Aluminum bonding pads on the chip surface permit wire bonding. Dionics also offers custom arrays with multiple capacitors within each chip. Any of the chips may be ordered in probed, uncut sliced form.

Mini-Systems, Inc. (MSI) is primarily a resistor manufacturer, but they do produce a single-sided capacitor chip. The capacitor and electrodes are on the same side and isolated from the chip bottom. The advantage is that no metallization is required on the substrate to accept the capacitor and there is no need to provide insulation for the chip if it is to be attached to a conductive circuit. Present capacitance range is from 2 to 500 pF, and 1000 pF appears to be feasible.

Monolithic Dielectrics, Inc. has a capacitor that contains varying units of capacitance in a monolithic structure. Values are in the 50 to 100 pF range, and there are 11 units in an approximate geometry of 0.55 by 0.05 by 0.03 inch. These components are aimed for delay line applications.

The following methods were described for attaching their chip capacitors:

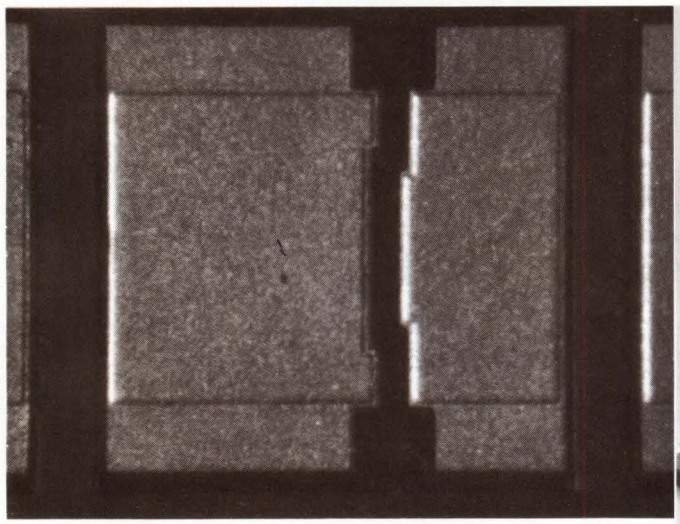
Soldering—Dipping and paste/preforms are the common approaches. For dipping, the chip terminations and substrate pads are pretinned. The entire board containing the chips is gradually heated until the solder melts or reflows to effect the connection. Required temperature is 400 to 500°F. In paste/preforms, it is recommended that the solder paste be screen printed on the substrate. Best results are obtained if the chips are solder dipped prior to attaching.

Ultrasonic Bonding—This cold bonding technique is adaptable to the joining of dissimilar metals and sections of different thicknesses. A transducer tip vibrating at about 60 kHz, applying pressure to the surfaces to be joined, produces the ultrasonic bond. The force of the scrubbing action causes molecular mingling of the surfaces in contact, thus forming a bond. Usually, there is some type of preform material placed between the chip and conductor interface.

Thermocompression Bonding—This technique is a heat bond. The chip is placed in position, the surface on which it is placed is heated and a pressure is ap-

(Continued)

Chip capacitors come in all shapes and sizes. A few examples are: (A) MOS (*DIONICS INC.*), (B) ceramic (*USCC/CENTRALAB*), (C) beam-lead (*TEXAS INSTRUMENTS INCORPORATED*) and (D) tantalum (*UNION CARBIDE CORP.*).



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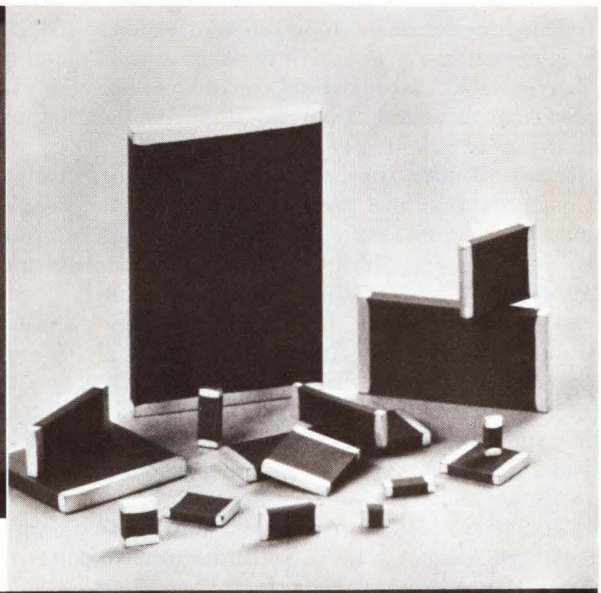

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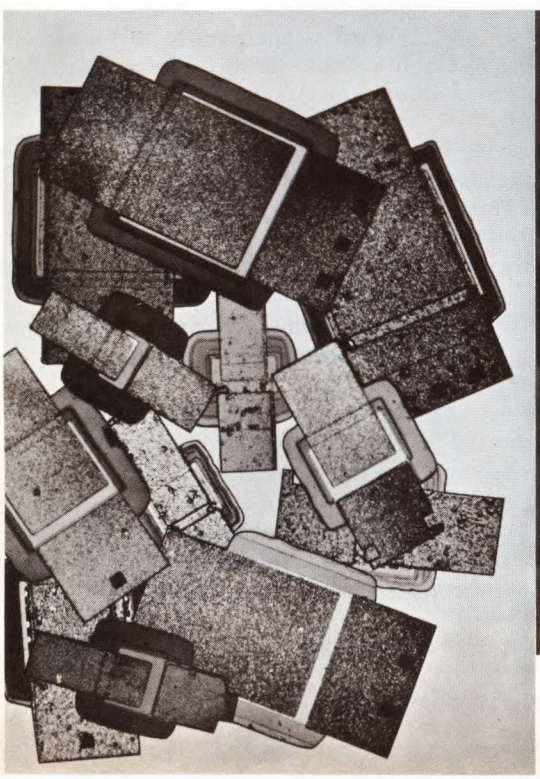


C

D

plied to the chip top—similar to semiconductor die attachment. In some instances a preform material such as AuSn is used at the substrate chip interface. Required temperature ranges from 375 to 400°C.

Conductive Epoxy—A small quantity of conductive epoxy is placed on the substrate where the end termination of the chip makes contact after the chip is placed. Required temperature varies from room to 300°F, depending on the epoxy.

Nonconductive Epoxy—Electrical connections between chip and conductor are completed using either gold or aluminum wire bonding techniques. Required temperature varies from room to 300°F, depending on the epoxy.

Motorola Semiconductor's activities involve unencapsulated thin-film capacitors. These chips have gold-alloy backing suitable for eutectic bonding directly to a metallized substrate. Also, they may be bonded to Kovar or ceramic tab and then attached to the substrate with epoxy adhesive or other suitable method. Conventional wire-bonding techniques provide the electrical connection from the aluminum bonding pad to the other circuits.

Stettner-Trush Inc. produces tantalum-electrolytic capacitors that are used on substrates for hearing aids. Capacitone range is from 0.01 to 10 μF with rated voltages of 1.5 to 20V dc. These tiny components operate within the −55 to 85°C temperature range.

Texas Instruments Incorporated offers a dozen beam-lead capacitors (maximum length of 35 mils) that are designed especially for microwave applications. A special metallization process yields negligible insertion losses. A combination of vacuum deposition and electroplating is employed to attach the electrodes to the top and bottom of the chip.

The MD400 Series uses silicon dioxide to minimize dielectric losses, and these units are unpolarized. Capacitance values range from 0.57 to 12 pF.

Capacitors in the MD401 family are polarized and tantalum oxide (higher dielectric constant) is used to achieve higher capacitance. Range of values is from 7.5 to 155 pF. Both series feature 50V maximum working voltage and ±20% tolerance.

U.S. Capacitor Corp. (USCC) designers view the ceramic capacitor chip as the workhorse in hybrid circuits. Dimensions range from 0.05 by 0.05 inch and up with capacitance values to 1.5 μF readily available in "W" characteristic dielectric. Terminations of silver and gold alloys offer a variety of bonding techniques.

A USCC spokesman feels that the present emphasis is switching from further miniaturization of components to the reduction of unit price. Recent advancements in fabrication and processing have permitted USCC to make the unit price of $0.03 (production quantities) a reality for popular sizes such as 0.10 by 0.05 inch. Efforts are underway towards accomplishing production automation while improving yields and minimizing labor costs—a goal that has long eluded ceramic capacitor manufacturers.

Union Carbide Corp. manufactures a complete line of hybrid-compatible Kemet chip capacitors, including both ceramic and tantalum styles. Both incorporate high-temperature copper terminations developed by Union Carbide that render the chips immune to damage from reflow soldering.

The ceramic chips are available in six case sizes with capacitance ranging from 10 pF through 0.33 μF and voltages of 50 and 100V. Two dielectric compositions are offered—BX for general purpose and NPO for high stability. "Solder Guard," an unusual copper termination, eliminates the silver scavenging and migration usually associated with ceramic chip capacitors.

Tantalum chips come in two styles—T411 and T421. Each style incorporates five case sizes, allowing the designer to minimize real estate for a given CV requirement. Capacitance ratings range from 0.10 to 100 μF and voltage ratings are 4 through 50V.

Bonding tantalum chips to the substrate is usually accomplished by solder reflow, although conductive epoxy can be used. The exclusive copper termination system permits high temperature assembly (up to 300°C for 3 min) as well as continuous circuit operation up to 175°C. For special applications requiring thermocompression bonding, tantalum chips with gold-plated Kovar bonding pads are available.

To reduce in-place cost, an integrated packaging-placement system for the T411 was developed. This system uses special shipping carrier strips that mate with an automatic placement machine which can be integrated into a substrate assembly line. This approach virtually eliminates human handling and reduces training, assembly cost and errors.

Vitramon Inc. offers a broad range of capacitance values—1 to 330 pF—for microwave applications. With silver-palladium termination, these ceramic chip capacitors are designed to mate with microstrip circuits. They exhibit a 0 ±30 PPM/°C temperature coefficient and a minimum quality factor of 5000 at 1 MHz.

To provide the designer with a convenient means for obtaining small quantities of chip capacitors for prototyping, Vitramon, Inc. recently introduced HyCirKit. Capacitors with either NPO or general-purpose dielectrics are available in these kits. Present development work is aimed at producing chip capacitors for operating in the gigahertz regions and developing higher "K" dielectrics to attain greater volumetric efficiencies without sacrifice in performance.

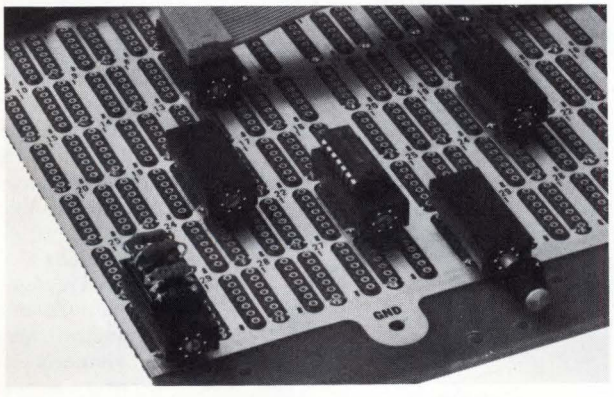
Voltronics has developed a subminiature variable capacitor (0.2 by 0.08 inch) for such circuits as 1- to 5-GHz oscillators, X-band transmitters, microstrips and similar applications. Sliding a shuttle into or out of a contact clasp adjusts the capacitance. There are positive stops. For fine tuning, special tools are available, but tweezer tuning has been satisfactory. Below 0.1 to

above 2.5 pF, a Teflon film capacitance is essentially constant through the gigahertz range. In addition to this device, designated CP2, Voltronics will be producing another variable capacitor (CP10) for the 1- to 10-pF range which will be 0.2 inch^2.

MISCELLANEOUS

ESC Electronic Corp.'s mainstay is delay lines. Because delay lines are essentially "custom" designed, they produce a wide variety of configurations. The EC, EP, EL and a low-profile series are specifically designed to be compatible with DIP devices. The EC, EP and EL Series feature delay ranges from 5 to 100 nsec, and are supplied with equally spaced taps. Maximum attenuation is 0.5 dB. In the low-profile family, there are three versions having delay to rise time ratios of 3.3:1, 6:1 and 10:1. All units are designed to meet the applicable requirements of MIL-D-23859.

Edison Electronics Div.'s newest member of their popular Dipswitch family (DIP rotary switches) is a 10-position switch. Based on the successful six-position design, the 10-position version still has six pairs of contacts (six single-pole switching functions) but it has 10 detent positions for 1-2-4-8 BCD decoding. Physical and electrical characteristics are the same as the six-position unit—IC compatibility with a 14-pin DIP, only 0.23 inch high, "Piggy Back" feature that converts the unit into a programmable 14-pin socket



Dipswitch finds many uses on a PC board (*EDISON ELECTRONIC DIV.*).

and a plastic housing impervious to conventional cleaning fluids. Rated electrical loads are 115V ac or 28V dc at 124 mA.

In addition to the rotary switches, Edison produces a series of lumped constant DIP delay lines, DL 5282. With true 14-pin DIP compatibility, the standard delay times are in 5-nsec increments within the 50- to 100-nsec range and 10-nsec increments for the 100- to 200-nsec range. Manufacturing processes make use of an epoxy transfer molding that ensures uniformity between units.

PICONICS Inc.'s principal product is broadband chokes for insertion into DIP or equivalent packages. One popular device is 0.025 inch in diam and from 0.05 to 0.10 inch in length, depending on the value. Inductances up to 2 μH come in the same package size. Both fixed and tunable inductor chips that have a ceramic pad capable of being bonded on the top or bottom depending upon the required geometry are also obtainable.

The PV and PVW Series are tunable chip components for precision circuit adjustments. Precision discriminators, balanced modulator transformers, impedance matching transformers and intercoupling intertransformers for IC applications are available. These devices generally have a 0.07-inch diam and a 0.16-inch length. PICONICS has found that over 90% of the conventional sized inductive devices used today can be miniaturized into this size. Also, special construction techniques permit them to obtain self-resonances as high as 18 GHz in some of these devices.

RCL Electronics Inc. offers besides a series of miniature rotary switches, fixed and variable delay lines that meet standard commercial DIP pin spacing. The fixed delay lines are available in two configurations—Standard DIP (DP-100) and Coffin DIP (DP-300). Delay time range is from 10 to 500 nsec with a maximum number of 10 taps. In the variable line, four versions are available with delay ranges of 0 to 5, 0 to 20, 0 to 30 and 0 to 40 nsec. □

Acknowledgments

EDN/EEE wishes to thank the following companies for making the story of minicomponents possible through their contributions of time and information.

AIRCO SPEER ELECTRONICS, Niagara Falls, N.Y.; **ALLEN-BRADLEY CO.,** Milwaukee, Wisc.; **AMERICAN LAVA CORP.,** subsidiary of 3M Co., Laurens, S.C.; **AMPHENOL CONTROLS DIV.,** Bunker Ramo Corp.; Janesville, Wisc.; **CENTRALAB ELECTRONICS DIV.,** Globe-Union Inc., Milwaukee, Wisc.; **CORNING GLASS WORKS,** Corning, N.Y.; **CTS CORP.,** Elkhart, Ind.; **DIONICS INC.,** Westbury, N.Y.; **EDISON ELECTRONICS DIV.,** McGraw-Edison Co., Manchester, N. H.; **THE ELECTRO MOTIVE MFG. CO., INC.,** Willimantic, Conn.; **ELTEC INSTRUMENTS INC.,** Lancaster, N.Y.; **ESC ELECTRONICS CORP.,** Palisades Park, N. J.; **HYCOMP, INC.,** Maynard, Mass.; **KDI PYROFILM CORP.,** Whippany, N. J.,; **MICRO NETWORKS CORP.,** Worcester, Mass.; **MINI-SYSTEMS, INC.,** North Attleboro, Mass.; **MONOLITHIC DI-ELECTRICS, INC.,** Burbank, Calif.; **MOTOROLA SEMICONDUCTOR PRODUCTS INC.,** Phoenix, Ariz.; **PAKTRON DIV.,** Illinois Tool Works Inc., Alexandria, Va.; **PICONICS INC.,** Tyngsboro, Mass.; **RCL ELECTRONICS, INC.,** Irvington, N. J.; **SOLID STATE ELECTRONICS CORP.,** Sepulveda, Calif.; **STETTNER-TRUSH INC.,** Cazenovia, N.Y.; **TEXAS INSTRUMENTS INCORPORATED,** Dallas, Tex.; **TRW INC.,** Capacitor Div., Ogallala, Nebr.; **UNION CARBIDE CORP.,** Greenville, S.C.; **USCC/CENTRALAB,** Burbank, Calif.; **VISHAY RESISTOR PRODUCTS,** Div. of Vishay Intertechnology, Inc., Malvern, Pa.; **VITRAMON, INC.,** Bridgeport, Conn.; **VOLTRONICS CORP.,** Hanover, N. J.

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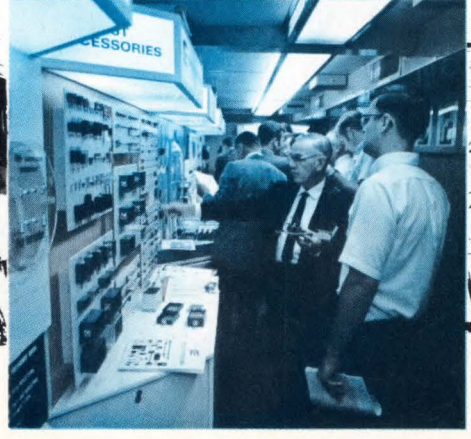

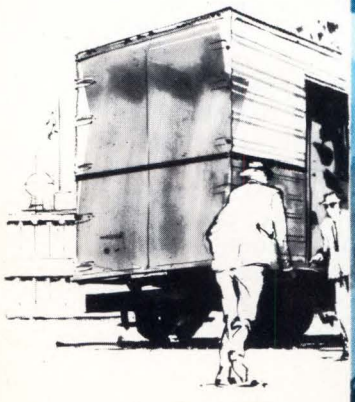

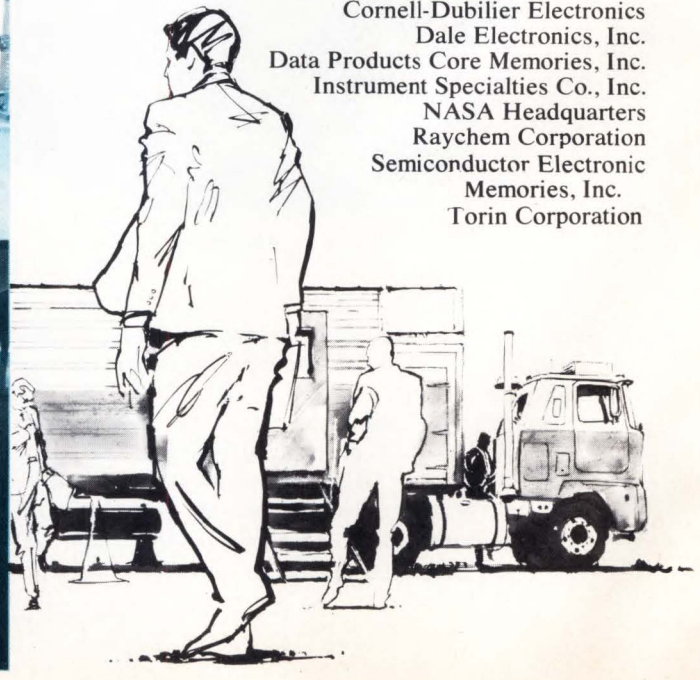

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EDN/EEE CARAVAN ROUTING

November 1 - December 3, 1971

DATE/DAY/TIME	AREA	SITE
Monday, Nov. 1		
9:00 - 11:30 a.m.	Nashua, N.H.	Sanders
1:30 - 4:30 p.m.	Tewksbury, Mass.	Wang Labs.
Tuesday, Nov. 2		
9:00 - 12:00 noon	Maynard, Mass.	Digital Equipment
1:30 - 4:30 p.m.	W. Concord, Mass.	General Radio
Wednesday, Nov. 3		
9:00 - 12:00 noon	Burlington, Mass.	RCA
1:30 - 4:30 p.m.	Needham, Mass.	Sylvania
Thursday, Nov. 4		
9:00 - 11:30 a.m.	Marlboro, Mass.	RCA
1:30 - 4:30 p.m.	Melrose, Mass.	Mohawk Data
Friday, Nov. 5		
9:00 - 12:00 noon	Norwood, Mass.	Raytheon
1:30 - 4:30 p.m.	Framingham, Mass.	Honeywell
Monday, Nov. 8		
9:00 - 11:30 a.m.	Plainview, L.I., N.Y.	Potter
1:30 - 4:30 p.m.	Syossett, L.I., N.Y.	Fairchild
Tuesday, Nov. 9		
9:00 - 12:00 noon	Piscataway, N.J.	Burroughs
1:30 - 4:30 p.m.	Plainfield, N.J.	Lockheed
Wednesday, Nov. 10		
9:00 - 12:00 noon	Camden, N.J.	RCA
1:30 - 4:30 p.m.	Willow Grove, Pa.	Philco-Ford
Thursday, Nov. 11		
9:00 - 12:00 noon	North Wales, Pa.	Leeds and Northrup
1:30 - 4:30 p.m.	Paoli, Pa.	Burroughs
Friday, Nov. 12		
9:00 - 11:30 a.m.	Waynesboro, Va.	General Electric
1:30 - 4:30 p.m.	Salem, Va.	General Electric
Monday, Nov. 15		
9:00 - 11:30 a.m.	W. Palm Beach, Fla.	RCA
1:30 - 4:30 p.m.	Ft. Lauderdale, Fla.	Systems Engrg. Labs.
Tuesday, November 16		
9:30 - 12:00 noon	St. Petersburg, Fla.	Honeywell
Friday, November 19		
9:00 - 12:00 noon	Dallas, Texas	University Computing Co.
1:30 - 4:30 p.m.	Irving, Texas	Recognition Equipment
Monday, November 22		
9:00 - 12:00 noon	Phoenix, Ariz.	Honeywell Information Systems Inc.
1:30 - 4:30 p.m.	Scottsdale, Ariz.	Motorola
Tuesday, November 23		
1:30 - 4:30 p.m.	San Diego, Calif.	Stromberg Datagraph
Wednesday, November 24		
9:00 - 12:00 noon	La Jolla, Calif.	Control Data Corp.
1:30 - 4:30 p.m.	La Jolla, Calif.	NCR
Monday, November 29		
9:00 - 12:00 noon	Concord, Calif.	Systron Donner
1:30 - 4:30 p.m.	San Leandro, Calif.	Friden
Tuesday, November 30		
9:00 - 12:00 noon	Mountain View, Calif.	Sylvania
2:00 - 4:30 p.m.	Walnut Creek, Calif.	Varian Associates
Wednesday, December 1		
9:00 - 12:30 p.m.	Santa Clara, Calif.	Memorex
1:30 - 4:30 p.m.	Santa Clara, Calif.	Hewlett-Packard
Thursday, December 2		
9:00 - 1:00 p.m.	Palo Alto, Calif.	Philco-Ford
2:00 - 4:30 p.m.	Palo Alto, Calif.	Hewlett-Packard
Friday, December 3		
9:00 - 12:00 noon	Sunnyvale, Calif.	Singer-Link
1:30 - 4:30 p.m.	San Jose, Calif.	IBM

Richard Hein Of Advanced Digital Research Corp. Speaks Out

On Field Maintenance of Computers And Other Digital Systems

Today's soaring costs of field service are presenting problems to both equipment users and manufacturers in the computer, peripheral equipment, digital control system and instrumentation fields. Obviously, the user expects the equipment he purchases to be reliable, but he recognizes that failures will occur even in the most expensive, highest quality equipment. And when a failure does occur, he understandably expects prompt and competent aid.

The manufacturer understands that dollars spent to produce reliable equipment will minimize his field service costs. He also knows that service he offers his customer—in the event of equipment failure—often serves as a valuable sales tool.

To complicate matters for both users and manufacturers, the cost of providing adequate field maintenance is rapidly increasing. Over the past few years, this problem has accelerated for four basic reasons:

1. Labor costs have gone up because of the higher level of talent required to analyze problems in equipment that is becoming increasingly more sophisticated each year.
2. More people are now required to maintain larger quantities of equipment in the field.
3. Equipment in the field offers higher performance than ever before, meaning an increase in capital investment for higher performance test instrumentation.
4. Because of inflation, labor costs continue to advance—often at a skyrocketing pace.

Because of these factors, equipment costs more to the user and returns less profit to the manufacturer. There are several methods for reducing these costs though—ways that will maximize the efficient use of a field service engineer's time. Before we discuss means of cost-cutting, let's make a close examination of the diagnostic procedure usually employed for trouble-shooting digital logic circuitry.

Field diagnosis is generally accomplished by a sequential procedure, each step requiring a different approach to its solution.

This procedure is the same whether used to locate faulty components or to isolate problems to a faulty printed circuit board.

These steps can be divided into five phases: the gross look, forms of self test, the coarse look at logic, the close look at logic and a fine grain logic examination. Let's take a close look at each phase.

Phase I—The Gross Look. This is a visual check to isolate the problem to a major section or functional area by observing the system's response to its controls. Questions answered include: Is it cockpit trouble? Is the system plugged in? Is the power on? Do the peripherals operate properly?

Phase II—Forms of Self Test. System (or program) fault finders and self-diagnostic programs are used in this phase for isolating problems. This technique is most useful on larger systems and answers the question: Is it a hardware or program problem? Computer diagnostic routines have been available for some time and are used effectively. However, it is not economically possible with today's techniques to use this approach exclusively. It must be supplemented with external methods and instrumentation.

The first two phases—gross look and self test—precede problems that require instrumentation for their solution. However, instrumentation is often used in these phases to verify a diagnosis specifying a trouble spot (such as the case when the problem is isolated to a single component, group of components or printed—circuit board).

Phase III – The Coarse Look at Logic. At this point suspected problem areas are checked (via instrumentation) to determine if signals exist where they should. This is a quick rundown through the logic chain to check for clock trains, reset pulses and logic level to determine whether events do or do not occur. It is similar to signal tracing in an audio system.

Phase IV – The Close Look at Logic. This step determines whether or not events occur in proper timing relationship to other events in the system. Pulse widths, clock train frequencies, and timing of critical pulses relative to other pulses (or pulse trains) are observed. In addition, circuits are checked for noise.

Phase V – A Fine Grain Logic Examination. This is a very detailed analysis of the logic and requires a visual display (analog) of one or more signals simultaneously. Pulses are examined for rise and fall time, overshoot (ringing), undershoot and other analog parameters. Problems involving this step are rarely encountered in equipment which has passed the design-debugging phase of production. These problems are usually encountered in-house during preproduction runs or at the time of installation of preproduction and engineering systems.

An estimate of time routinely devoted to each of these phases in shown in **Table I**.

TRAVEL, Overhead	30%
PHASE I, Gross look	5%
PHASE II, Self diagnostics	15%
PHASE III, Coarse logic examination	25%
PHASE IV, Timing problems	15%
PHASE V, Close examination	10%

Table I – **Estimated breakdown** of a field engineer's time.

Reducing field diagnosis time will increase productivity and save money.

Examination of the diagnostic procedure described reveals the potential for special purpose, inexpensive diagnostic measurement tools for digital troubleshooting to supplement more general-purpose instruments. Much of a field engineer's time is now devoted to the techniques of measuring circuit parameters rather than to the analysis and solution of problems. If a field engineer can make more efficient use of his talents by devoting more time to analyzing the problem, isolating trouble spots and repairing the equipment, he is more valuable to the equipment user and manufacturer.

In addition, by applying digital rather than analog techniques to the measurement of digital circuit parameters, the potential exists for use of less expensive instrumentation in analysis of digital problems.

The need in digital circuit analysis is for one or more tools which will allow an engineer or technician to solve the problems associated with each of the last three diagnostic phases (III, IV and V). The oscilloscope is the traditional instrument used for all three of these steps. However, it suffers from several obvious disadvantages in field trouble-shooting of digital equipment – notably, high initial expense, lack of complete portability, inconvenience of readout (which is not at test point) and problems of analyzing and evaluating digital events with an analog device.

Some large companies have made wide application of highly-specialized diagnostic instrumentation as part of a formalized trouble-shooting system to minimize the use of more generalized, expensive instrumentation (such as oscilloscopes). Few companies, however, have the volume requirements to justify the development of specialized tools needed to make optimum use of this approach; therefore, in the majority of

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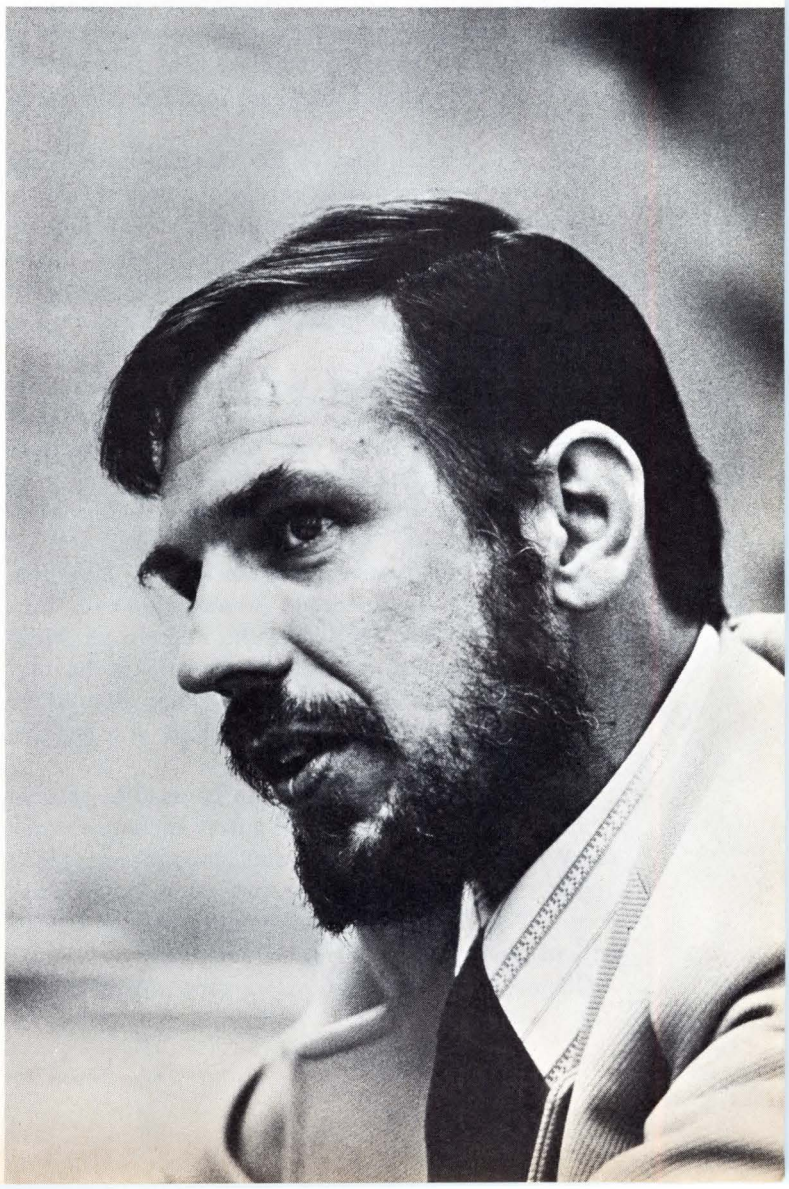


cases diagnosis of digital equipment problems still depends on the multimeter and the oscilloscope.

Use digital techniques to measure digital events; analog instrumentation for analog measurements.

For the sake of simplicity in servicing, let us attempt to make the required measurements using the same circuit elements as the system being tested. In other words, use digital techniques to measure digital events and analog instrumentation for analog measurements. An example will clarify the reasoning behind this statement.

In Phase III, the procedure is to observe logic levels and the occurrence of pulse trains and/or single pulses such as clocks, shifts, starts, transfers or reset pulses. Truth tables of the logic elements used are also verified during this phase to uncover faulty elements. There is a relatively high probability that any given problem is caused by failure of an integrated circuit chip or similar component. The result—the most probable failure mode of a system that has previously been operating properly—is that a signal does not actuate a gate, flip-flop or similar logic element. Estimates of the occurrence of this type of failure run to between 50 and 70% of the digital problems in electronic equipment.

The use of a multimeter for these measurements will yield information regarding static or slowly changing logic levels, but does not give sufficient information regarding dynamic events (clocks, single pulses, etc.) for an accurate diagnosis. The use of an oscilloscope for these measurements is time-consuming and overly complex.

Digital instrumentation, however, lends itself nicely to the analysis of this type of problem. For example, a simple hand-held probe that uses two independent pairs of indicators can be used to observe logic level (high or low) and to obtain qualitative timing information (i.e., to estimate the duty cycle of pulse trains). A logic low condition can be indicated by one lamp and a logic high by the other. Because this pair of indicators operates in real time, the relative brilliance of the two indicators can be used to estimate the duty cycle of a pulse train (i.e., the "0" lamp is brighter than the "1" lamp for a low duty cycle of a positive going pulse train).

A second pair of indicators can be used to observe dynamic events, such as single pulses and pulse trains occurring on a data line. The indicators (designated Q and $\bar{Q}$) will toggle once each time an event or pulse occurs. Therefore, the Q and $\bar{Q}$ indicators will repeatedly toggle to indicate a train of pulses.

Obviously, an event indicator is especially useful for observing single pulses of short duration. Should a relatively long pulse occur (say 9 μsec) with a short pulse (say 50 nsec) immediately following, as in a start or reset pulse with a ring on the trailing edge, the Q and $\bar{Q}$ indicators will toggle twice, displaying the occurrence of two pulses rather than the expected single pulse. Incorporation of a pulse stretcher circuit to display the single pulse would not allow an indication of the presence of the second pulse, misleading the user in his diagnosis of the problem.

An example of an instrument with this capability is the Logic Pen shown in **Fig. 1**. It is used as a digital signal tracer to determine logic levels, single pulses and pulse trains, and to verify the truth tables of logic elements as the circuit is probed. All indicators are adjacent to the test point being observed, and no adjustments are required for its operation. Convenience and simplicity result in dramatically reduced time devoted to the technique of measurement.

If the problem is not solved during Phase III, the procedure in Phase IV is to observe quantitative timing relationships of pulses and pulse trains in the logic circuitry. Pulse widths, periods of pulse trains, random noise and relative timing between pulses on two data lines—such as a synchronous data pulse relative to a clock pulse—are measured. Problems associated with this step are probably the result of component aging or a maladjustment in the circuit.

Here again digital instrumentation can be used to analyze the circuit for proper performance. It isn't necessary to observe pulses visually—only to obtain timing information. A digital device with the ability to do this job can be highly portable. Power can be taken from the same supply used by the circuit under test, and the circuitry required to give timing information can be compactly packaged.

A test instrument designed to be used in this phase and capable of measuring the parameters outlined is the Chronos DTM (**Fig. 2**). Pulse widths and pulse-train period can be determined easily by observing two indicator lamps, making a switch adjustment and reading a calibrated dial.

In addition to requiring fewer adjustments than an oscilloscope, this instrument simplifies evaluation (no calculations are required) and is completely portable.

Both of the instruments described are examples of the simplicity inherent in utilizing digital techniques for observing digital events. Working together they provide all the information necessary for evaluation in Phase III and IV of the maintenance procedure.

The final maintenance, Phase V, typically involves observing analog parameters such as rise time, fall time, overshoot, undershoot and other detailed pulse-shape analyses. These measurements do not appear to be readily amenable to analysis with inexpensive dig-

Fig. 1—**The Logic Pen determines logic level,** and provides an estimate of duty cycle and an indication of pulses or pulse trains.

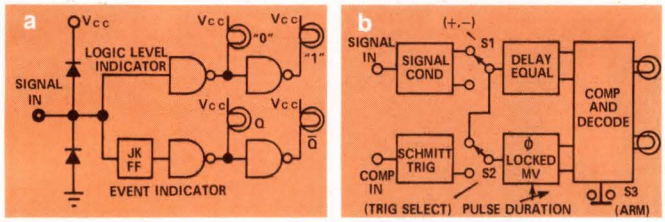
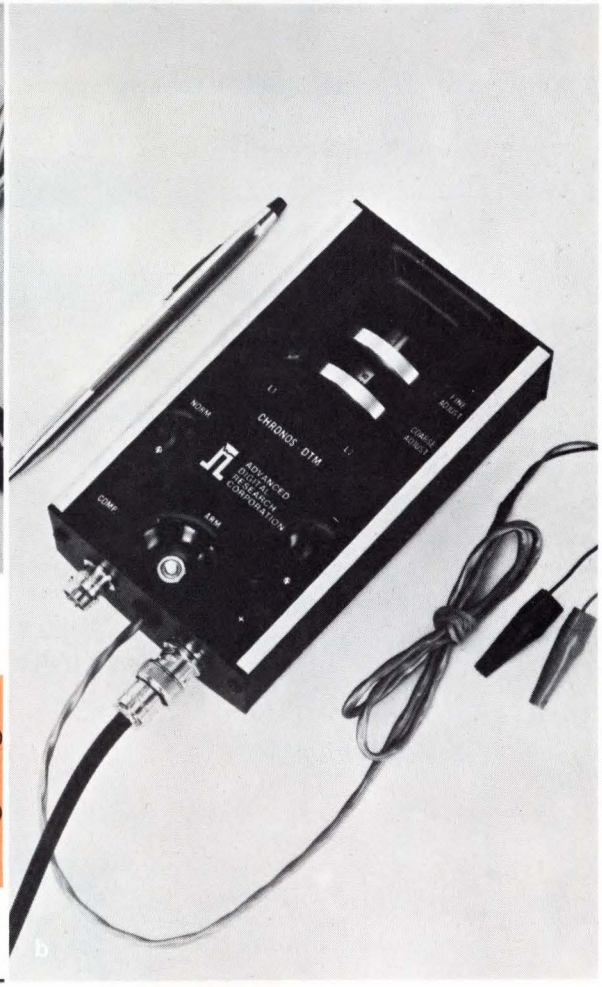


Fig. 2—**Chronos DTM measures pulse widths,** periods, random events and relative timing between pulses on two data lines.



ital techniques and instrumentation. However, these problems normally occur in engineering or preproduction prototype equipment which is not normally encountered in the routine field service environment. Frequently problems of this complexity are solved by returning the system or module to the factory, where the necessary test equipment is available, for repair.

Cost savings can be realized through increased efficiency and the use of low-cost test equipment.

It all boils down to the fact that most field service work on digital equipment can be done more efficiently and at a considerable saving in cost of instrumentation. Digital test instrumentation to replace an oscilloscope costs $300 (for the two examples shown). By reducing the demand for the scope in field service, it can be utilized in areas where it is cost-justified and more effective. Of more importance is the fact that digital test instrumentation provides increased efficiency for a service engineer. An increase in an individual's productivity is a continuing savings day after day. It's estimated that savings gained by applying digital solutions to digital problems can easily equal $2000/year/person.

This obviously means that field maintenance of computers and other digital systems no longer has to cost an arm and a leg. That's progress! ▭

About Richard Hein

Richard Hein is president of Advanced Digital Research Corporation which was formed two years ago with the goal of providing low-cost digital test equipment. Prior to that he was involved in the formation of Finnigan Corp., and was production manager of that firm. A chemist by background, Hein's interest and knowledge in electronics and digital equipment are the result of 10 years experience with electronic firms and analytical instrumentation. He has been granted two patents and is a member of A.C.S. and the American Institute of Physics.

FOR A FREE REPRINT OF THIS ARTICLE, **CIRCLE NO. L62**

HOW SWITCHING TO CELANESE NYLON IMPROVED THIS DREMEL MOTO-TOOL.

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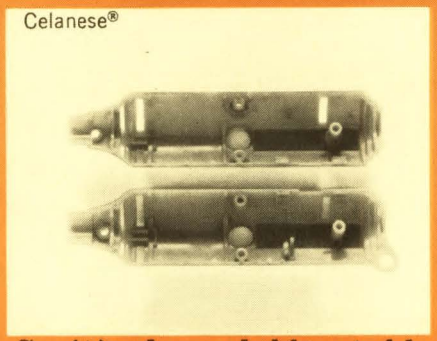

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SCIENTIFIC SABOTAGE OF SWITCHING SYSTEMS

Engineering schools seldom offer courses in relay circuit design, and almost no one understands relay applications well enough to criticize them. Here is a tongue-in-cheek look at relay failures and how to cause or avoid them, at your option.

EDWARD U. THOMAS, Grumman Aerospace Corp.

Relay selection is covered so lightly in college that most engineering students think it's a breeze. After graduation, they continue with that attitude—that is, until they begin to experience relay failures. At this point they either blame the relay manufacturer, or they decide to learn more about relay circuit design. Once an engineer has educated himself in relay selection, some of the failures encountered by his colleagues begin to look like deliberate sabotage. The relay-wise engineer knows that most relay failures can be predicted—and prevented.

The Contact Rating Trap

The most sophisticated switching system can be compromised by the selection of electrical switching "booby traps." In some circles, this operation would be termed "misapplication." It is done regularly and the results are devastating. Reliable relays from qualified sources can be employed in simple switching circuits, where they appear to be used within the listed contact ratings as given on the specification sheet or implied by the manufacturer's catalog—yet they give you spectacular breakdowns. The beauty of a misapplication involving interpretation of the contact ratings is that your boss won't be able to figure out what has gone wrong. Further, the relay failures may be designed with a built-in time delay. In some cases there will be no failures, because the amount of switched energy is too low to ionize the gas around the contact. Thus in two similar circuits, the relay in one will not fail, while the other will experience random failures. The nonfailures will lull all concerned into a false feeling of security. When failures do occur, the manufacturer automatically becomes the prime suspect. These failure modes are like Russian roulette—sooner or later, catastrophe will strike, as shown in the accompanying photographs. Once you understand the triggers that caused these failures, you will be in a position to place side bets.

Load Transfer Mortalities

Load transfer between +28V and negative (or ground) with miniature relays having small contact gaps automatically insures catastrophic failure. The military rating and qualification test requirements are for ON-OFF switching, not load transfer. To make life more difficult for the saboteur, beginning with MIL-R-5757E load transfer ratings are a part of the specification. These ratings apply to both ac and dc.

Why is this load transfer switching tactic successful in producing failures in some cases and not in others? The amount of electrical energy switched is the deciding factor. If the load is of high impedance and pure resistance, low currents and reactances are involved. There will be little danger of ionizing the gas when the contact opens, and arc-over probably will not occur. But in another circuit or with another relay (e.g., TO-5), the results will be dramatic.

Sequential two-relay circuit applications, as in **Fig. 1**, permit the use of miniature and subminiature relays at their full rated load values without potential catastrophic failure. Because of the sequential operation in each direction (pick up and drop out), simultaneity of contact operation is impossible. Contacts do not transfer between plus and minus while carrying current, hence they cannot develop a catastrophic arc. This design is to be avoided like the plague if your goal is to preprogram failures into your circuit.

The relay saboteur's approach is shown in **Fig. 2**. If it is well done, he may even be granted a cost reduction award—that is, if company bureaucracy moves quickly enough to preceed **Fig. 3**'s occurrence. How bet-

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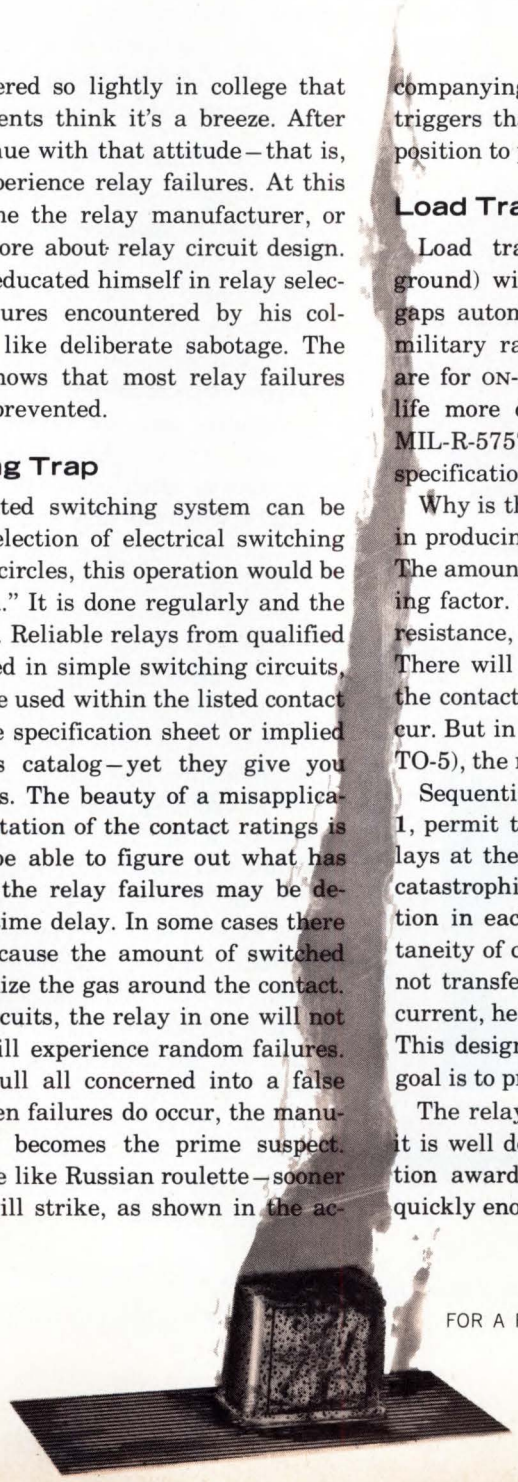

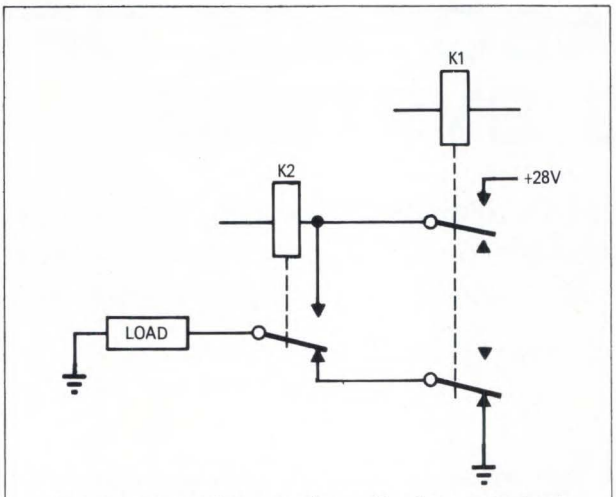

Fig. 1—**Sequential operation** will allow safe load transfers in miniature relays.

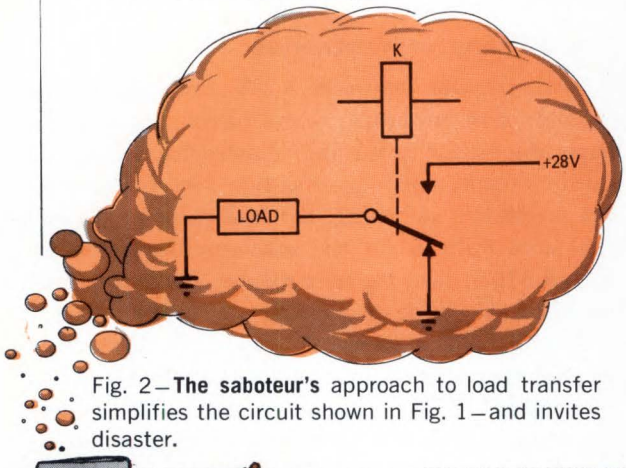

Fig. 2—**The saboteur's** approach to load transfer simplifies the circuit shown in Fig. 1—and invites disaster.

Fig. 3—**Welding of contacts** is a predictable occurrence when relays are misapplied.

ter could you simplify a system than to replace two relays with one? You can even show a theoretical improvement in the reliability factor.

A 4pdt relay of the MIL-R-5757/7 type that was originally designed for 2A, 28V dc resistive circuits, but that was later rated for 1 or 2A at 115V ac by the manufacturers is shown in **Fig. 4**. This 115V rating is for single phase with ungrounded relay case—a feature not mentioned in the catalogs. Where the case is grounded and 1A at 115V is switched, there is sufficient energy to ionize the gas around the contact. With the grounded case at the positive crest of the ac wave, arc-over can occur (emulating a cold-cathode gaseous discharge tube). In **Fig. 4** arc-over occurred not only between poles, but to case, coil and everything else that was in the vicinity.

Three-Phase Phenomena

Arc-over also can occur pole-to-pole when 3-phase circuits are switched (because of the higher phase-to-phase voltages). Of course, a 4pdt MS27400 relay can be mounted in the same space (1-inch cube) and will reliably switch 3Φ at 10A, as well as minimum current. But this relay is rated for 115/200V 3Φ service. It leaves no room for indulging your gambling instincts.

Another popular form of scientific sabotage is switching two 3-phase circuits on a 6pdt 5A 115V relay such as MS25269 (or the plug-in version MS25329). Again, when the phase voltages and the energy levels are in the right proportions, the built-in booby trap is triggered—and the relay manufacturer gets cursed unfairly because the designer failed to recognize the limitations of the military specification detail sheet and the attendant military specification.

There have been a couple of abortive attempts to deprive us of this usage. For example, one relay manufacturer had a detail drawing MS21987 (6pdt 5A 3Φ 115/200V) prepared around his relay, but found he could not meet the military drawing with his own values as listed. Another manufacturer could meet the drawing but did not see a market—too many designers were specifying the wrong relay and would not retrofit. Another attempt dealt with a 6pdt 10A version, but again its innovator could not meet the published values once he had the MS drawing issued to his own proposed values. (MS27420 has long since been cancelled because there never was a qualified source.) My suggestion, if you should become trapped and must solve the problem, is that two MS27400 4pdt 10A relays will work very nicely within their 3-phase ratings.

More Load-Transfer Perils

Next on the all-time hit parade for switching system

sabotage is the transfer of ac loads between unsynchronized ac sources, the results of which are shown in **Fig. 5**. True, the manufacturer's 115/200V rating on contacts covers 3Φ but only for ON-OFF switching, not load transfer. Not only will MS25271 4pdt 10A relays blow up, but so will their smaller counterparts rated at 5A (115V dc), namely MS25267 (MS25325 for plug-in). These relays are designed for single-phase, single-source ON-OFF switching. A 3Φ version of the MS25267 is the MS27218 (4pdt 5A). Commercial physically-interchangeable versions of these relays exist. In the commercial counter parts, the contacts are specifically rated for load transfer at 0.8 power factor at 3Φ between unsynchronized ac sources. These also are rated at one-fourth the normal current and one-fourth the

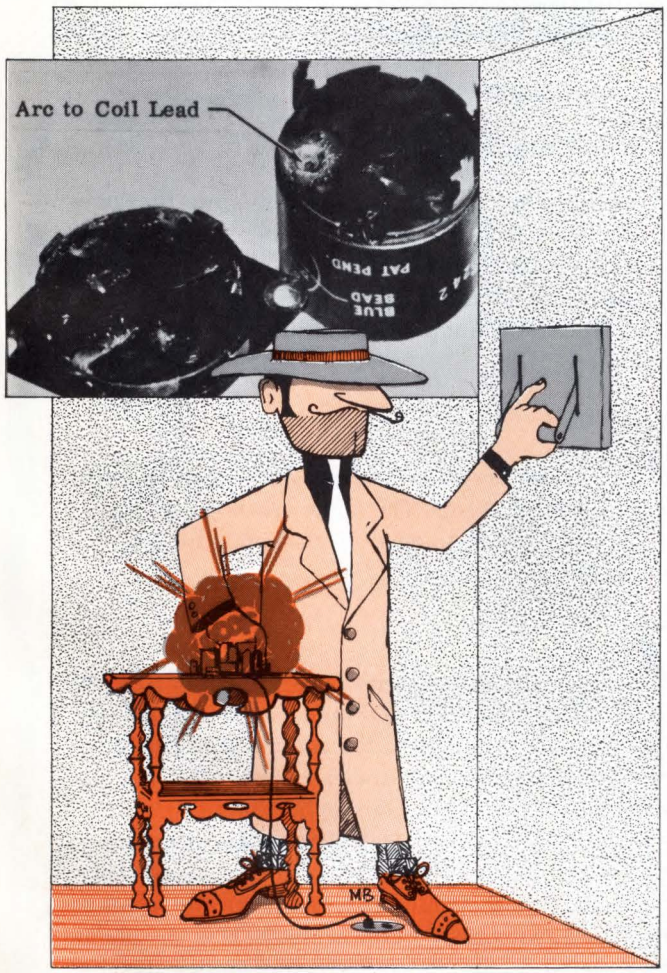

Fig. 4—**Explosive failure** of a miniature relay may be exciting to the saboteur, but it gives everyone else nightmares.

total number of operations. In such designs, the transfer air gap must be adequate to permit arc extinction even when the ac voltages are 180° out of phase.

The Proof Is in the Testing

Testing of load-transfer relays to prove that the circuit works is very important in the development of successful sabotage and can be employed to deceive everyone including yourself. For this, use a laboratory power supply and connect phase A to both sides of the same pole, and phases B and C in a similar manner. When this is done, the phase sequence will be the same for either position of the transfer relay. As a side benefit, the relay will successfully pass all life tests when connected in this manner, for there will be no voltage differential across the transfer gaps. It is even highly unlikely that anyone will challenge your test procedure.

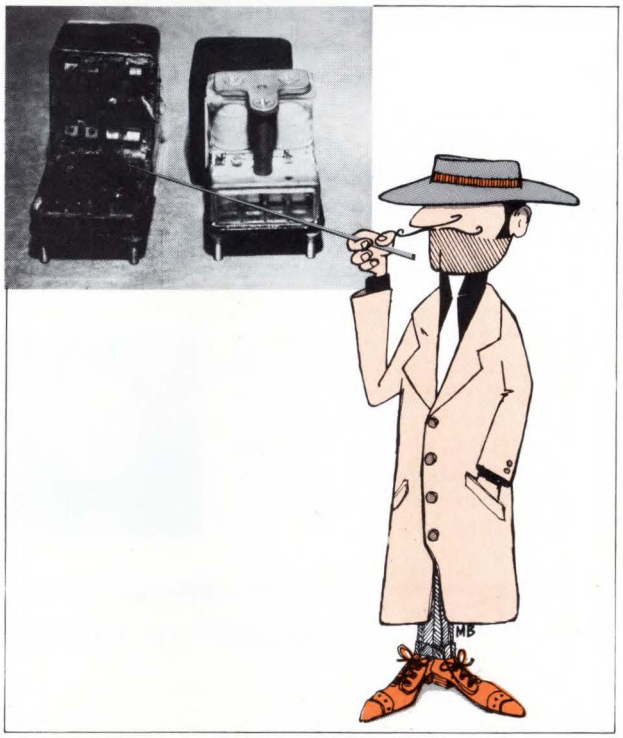

Fig. 5—**Switching of loads** between 3Φ unsynchronized sources can have devastating results. (Photographs courtesy of GRUMMAN AEROSPACE CORP.)

Inductive Logic

Another area to display your knowledge of ratings, and at the same time to produce occasional contact welds, is to make a relay switch a transformer rectifier load at the rated inductive currents for the contacts as in **Fig. 6**. (Never mind that the detail sheet shows the inductive ratings of one-fifth the usual number of operations for resistive loads, which might indicate you are working near the limit for the contacts!) The nice thing about a transformer is that the magnetic core will have residual magnetism. Occasionally, the residual magnetism from the last operation is at a phase angle opposite that of the supply voltage and will create a magnetizing current surge.

(Continued)

This surge will weld the contacts because of the high peak instantaneous currents, even though the duration is short. Having a capacitor input in the filter circuit will help make the transient current even greater when the supply voltage is at its peak value. When welding does occur, a professional saboteur will then complain to the relay manufacturer about his products.

Edward U. Thomas is an engineer in the Vehicle Electronic Design Group at Grumman Aerospace, where he has been employed for 12 years. He received a B.S.E.E. from Yale Engineering School, is chairman of the SAE A-2R Relay Committee and is a senior member of IEEE and ISA.

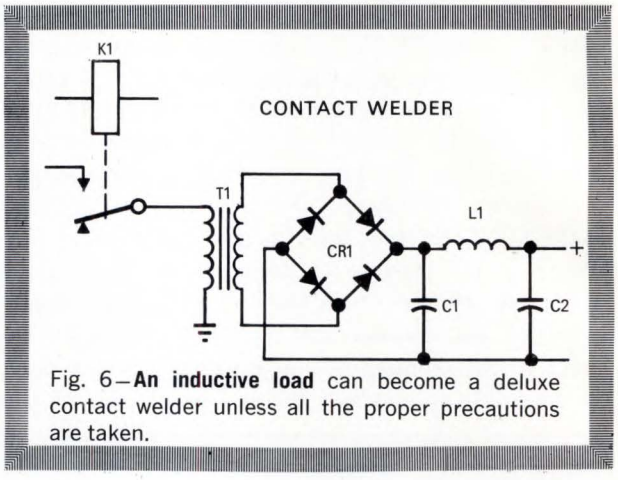

Fig. 6—**An inductive load** can become a deluxe contact welder unless all the proper precautions are taken.

SUMMARY OF HINTS FOR SYSTEM SABOTAGE

1 Use resistive load ratings for inductive, motor and lamp loads. (Contact life will be considerably shortened.)

2 Use a relay at considerably less than rated contact voltage and current without specifying a "minimum current" capability. (It will take about 5000 to 10,000 operations in the field before sufficient offgassing will occur to contaminate the contacts, and by then you should be well into your second or third new project.)

3 Have a relay feed a transformer load that has a capacitor-input filter on the secondary rectification circuit. Sooner or later the transformer core magnetization will be just right to draw an extremely high current. If you are lucky, a contact will weld.

4 Choose a plug-in relay with tinned terminals and an inexpensive socket for use in a salt atmosphere.

5 Pick several crystal-can magnetic latch relays that have two coils—each with a different set of polarity connections, but each of which will fit into the same socket. Then mount the sockets close to each other. Murphy's Law ("If two parts can be interchanged, someone will") comes into play here on a truly random basis. You never know when it'll happen, only that it will.

6 Add diodes across the relay coils without consulting the manufacturer. The make-break times may be slowed considerably, and if so, the relay contacts will degrade rapidly.

7 Never, under any circumstances, refer to MIL-STD-1346 *"Relays, Selection and Application"*. Broad dissemination of the information contained in this Military Standard has been known to severely limit the possibility of sabotage by misapplication.

From the foregoing, it can be seen that it is easy to employ military qualified relays, give cursory attention to the data sheet ratings yet scientifically sabotage the whole switching system while shifting the blame from yourself onto the relay manufacturer. Having once committed yourself to a design, stick to your guns. Never give in. Meanwhile keep watch on the field reports for the success of your planned gambling with the physics of contact switching phenomena. As you can see, it's really quite easy to become a proficient relay-wrecker. □

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ELECTRONIC COUNTERS

CIRCLE NO. 19

Low Cost Sample-and-Hold Circuit

By carefully analyzing the tradeoffs available to him, a designer can make significant cost reductions—in this instance, by replacing a FET op amp with a JFET and a programmable IC op amp.

MARVIN K. VANDER KOOI, Fairchild Semiconductor

Operational amplifiers in sample-and-hold circuits ideally should have high slew rates for fast acquisition times and extremely low input bias currents for long hold periods. These characteristics can usually be obtained using a FET-input op amp, but at the expense of increased voltage drift with temperature. A closer look at the problem reveals that the high slew-rate requirement exists only during the sample period, while the low input-bias requirement is of consequence only during the hold period of the cycle. The programmable μA776 operational amplifier permits switching from a high slew rate op amp requiring a 50-nA input bias current to a holding amplifier mode requiring only a 750-pA input bias current (which is the order of magnitude stated for FET-input op amps). The sample-and-hold circuit shown in **Fig. 1** demonstrates this approach.

In typical applications, the input device to such a sample-and-hold circuit will be an op amp or a signal processor of some type. Because these devices can normally live with a relatively low Z_{IN} during the hold cycle, an R_1 value of as low as 100 kΩ can be tolerated. If the Z_{IN} value must be higher, R_1 can be increased up to about 1 MΩ, at the cost of a slower FET turnoff time. During the sample period, CR_1 is reverse biased, and Z_{IN} rises to the approximately 2-MΩ input impedance of the op amp at full set current.

Output level is held within 1% for approximately 2 sec, making it ideal for digital readout applications.

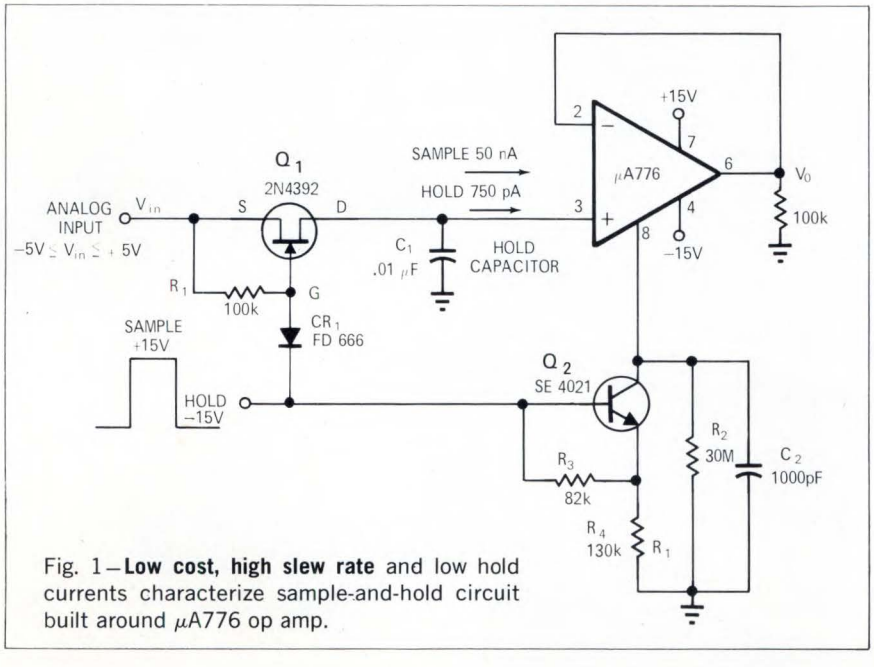

Fig. 1—**Low cost, high slew rate** and low hold currents characterize sample-and-hold circuit built around μA776 op amp.

Circuit operation is as follows: During the sample period, FET Q_1 is on, and the hold capacitor C_1 charges to a voltage equal to the analog input voltage. The same 15V sample voltage that turned on Q_1 also turns on the emitter-follower composed of transistor Q_2 and resistor R_1. This causes approximately 100 μA of I_{SET} current to flow into pin 8 of the op amp, raising the slew rate to about 5V/μsec. When the logic input swings to the −15V hold level, Q_1 and Q_2 switch off. This causes the voltage on the hold capacitor to be isolated from changes in the analog input voltage—reducing the I_{SET} current to the programmable op amp to a standby level of 0.5 μA determined by resistor R_2. Since the input bias current is almost directly proportional to the set current, the input bias current drops from 50 nA down to 750 pA. Although the slew rate also decreases proportionately, this has no effect on circuit operation during the hold period of the cycle. □

Marvin Vander Kooi, employed at Fairchild Semiconductor when he prepared this article, has since moved to National Semiconductor, Mountain View, Calif., where he is an applications engineer responsible for LIC applications. He holds B.S. and M.S.E.E. degrees from Ohio State University, and is a member of IEEE and Sigma Xi.

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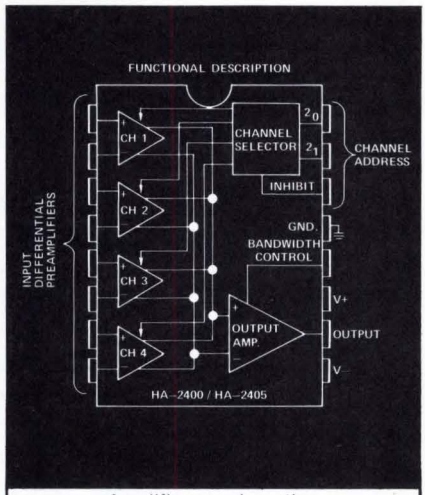
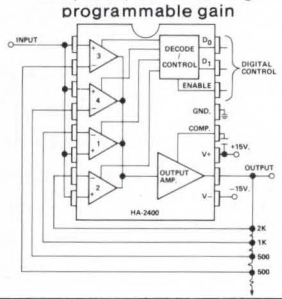
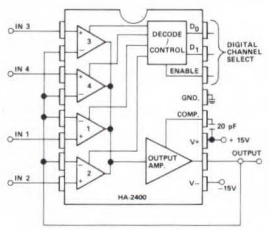


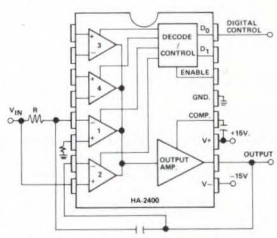
Amplifier, non-inverting programmable gain



Analog multiplexer with buffered input and output



Integrator/ramp generator with initial condition reset



More challenges:
The foregoing diagrams show just three of many applications we've designed using the PRAM. The following lists other possibilities we haven't had time yet to prove out. Why don't you try your hand at designing them or any other ideas you come up with, and send them to:
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CIRCLE NO. 20

Design Ideas

Digital Transmission Lines Combine High Speed, Low Cost

Need a small, fast transmission line for interconnecting high speed logic circuits? Twisted pairs may provide a solution to your problem.

CHARLES T. SMALL & EDWARD S. DONN, Hewlett-Packard Co.

When interconnecting high-speed logic circuits, there may be a requirement for a small, fast transmission line to take the place of a bulky coaxial line. Twisted-pair lines allow compact wiring between PC boards and provide common-mode noise rejection.

Response speed and impedance of twisted pair lines depend on the type of wire used and the "turns ratio," or number of twists per inch. By selecting the proper wire, turns ratio and length, you can tailor a line to fit your particular application.

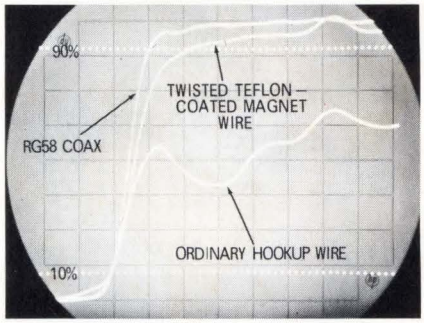
For relatively low frequency circuits—less than 2- to 4-nsec rise times—use twisted 32-gauge enamel-covered magnet wire. A characteristic impedance of 50Ω will be obtained with a turns ratio of approximately 5 turns/inch. This turns ratio is not very critical. A 12-inch line has a rise time of approximately 1.4 nsec.

For faster rise times, use "Teflon"-coated 30-gauge magnet wire for the signal conductor and 30-gauge stranded bare wire for the ground conductor. Again, the turns ratio is approximately 5/inch for a characteristic impedance of 50Ω. With the low-loss "Teflon," the pulse-response speed is increased. A 12-inch line will provide a rise time of approximately 0.9 nsec.

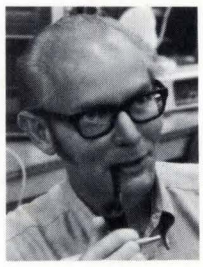
Higher characteristic impedances of 100Ω can be obtained by using ordinary PVC hookup wire for the twisted pair. For this application use 24-gauge hookup wire with 3 turns/inch. In this case, the turns ratio is critical and should be as close to 3 turns/inch as possible.

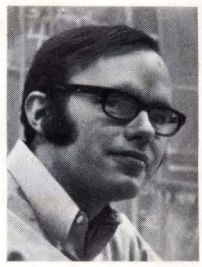
A comparison of the step response of a 12-inch twisted "Teflon"-coated magnet-wire line to a 12-inch RG58 coaxial cable and ordinary PVC hookup wire shows rise time of the twisted-pair line is not as fast as the RG58 but is superior to regular hookup wire. However, with the more flexible twisted-pair cable, shorter lengths can be used to reduce pulse rise-time degradation.

Material costs are approximately $0.002/ft for the enameled wire line and $0.03/ft for "Teflon" line. □



Comparison of step response with scale factors of 0.5 nsec/div and 0.2V/div.





Edward Donn has been with Hewlett-Packard, Colorado Springs Div., for 4 years and is currently a project leader in digital instrument design. Donn is a graduate of the Univ. of Florida with a B.S.E.E.

Charles Small is a senior test engineer with Hewlett-Packard, working in circuit design. He has an Associate Engineering Degree in Applied Science, and has been with Hewlett-Packard for 5 years.

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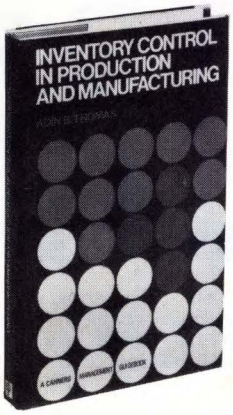

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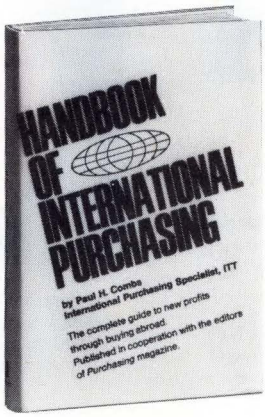

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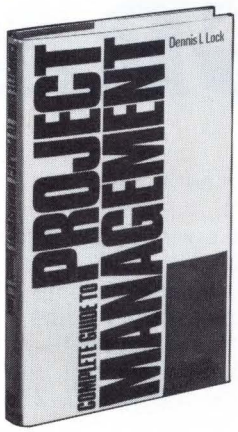

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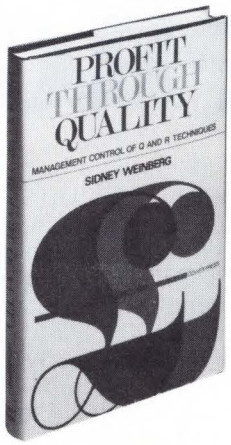

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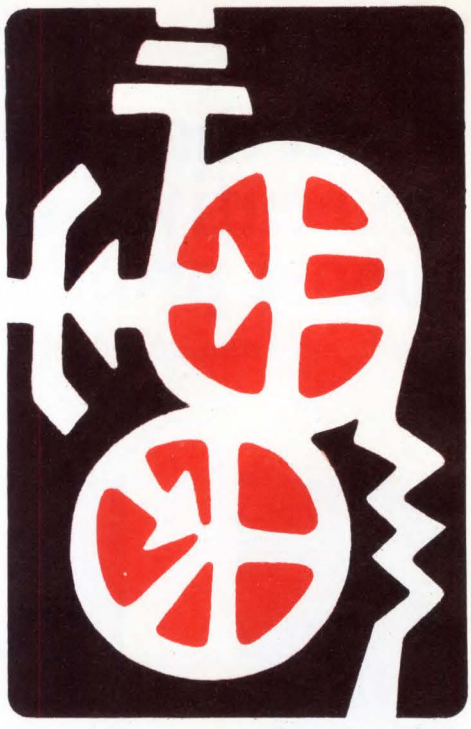

Readers have voted Gil Bank winner of the July 15 Savings Bond Award. His winning circuit was called "A wideband, linear VCO". Mr. Bank is with Westinghouse Ocean Research, San Diego, Calif.

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Linear bidirectional ramp generator

To Vote For This Circuit Circle 151

by Richard W. Currell
Newell Research
Saratoga, Calif.

A simple bidirectional linear ramp generator can be constructed using a dual op amp (such as the μA747) and a few external components. The circuits described here were originally designed to vary the reference voltage for a dc motor servo, and thus control acceleration and deceleration rates.

In the basic circuit (**Fig. 1**), ramp rate is determined by R_2 and C_1. Potentiometer R_1 determines the ramp amplitude by controlling the magnitude of V_{in}.

If R_1 is adjusted so that V_{in} is ±10V (for SW_1 in positions 1 and 3), then the circuit will behave as follows:

With SW_1 in position 2, V_{in} is zero and V_{out} will ramp to zero from its previous level. With SW_1 in position 1, V_{in} is now 10V, and V_{out} will ramp

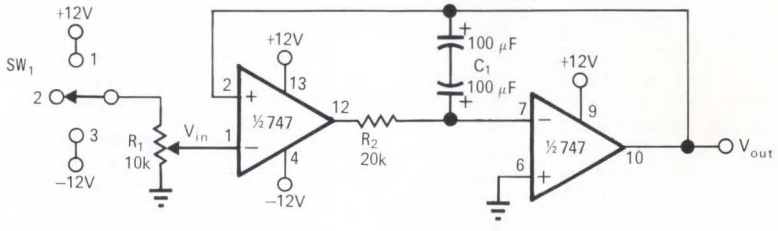


Fig. 1—**Ramp generator** integrates the stepped input voltage V_{in}.

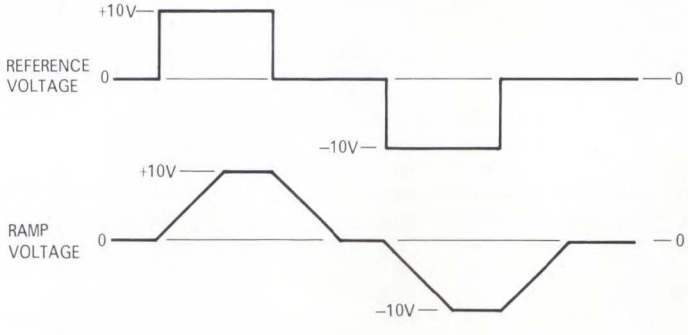


Fig. 2—**Typical input** and output waveforms for the circuit of Fig. 1.

to this level. Similarly, with SW_1 in position 3, V_{in} is −10V, and V_{out} ramps to −10V.

Typical input and output waveforms are shown in **Fig. 2**. If the values of R_2 and C_1 are as indicated in **Fig. 1**, then V_{out} will take one second to ramp from zero to 10V.

The circuit can be easily modified as shown in **Fig. 3**, so that the ramp rate can be externally controlled. A FET switch, Q_2, introduces a shunt resistor which diverts current to ground, and thus slows the ramp. With the component values shown, the fast ramp (FET off) has a duration of 100 msec and the slow ramp (FET on), 1 sec. Transistor Q_1 allows the FET to be conveniently controlled by a 5V logic signal. □

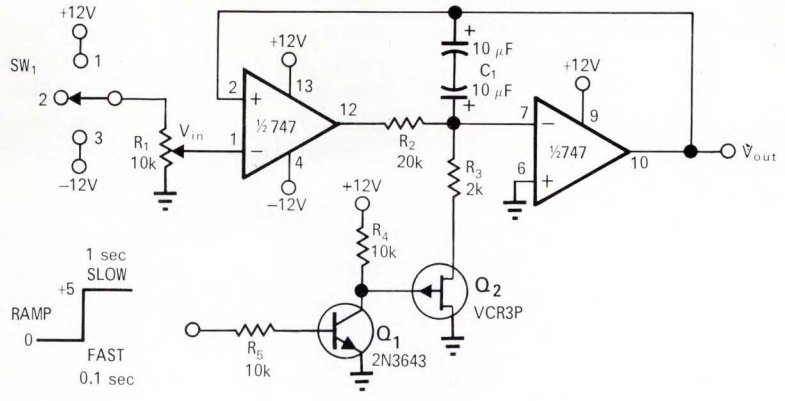


Fig. 3—**Modified circuit** includes a FET switch which allows the ramp rate to be controlled by a logic signal.

Low-speed logic probe

To Vote For This Circuit Circle 152

by John W. Hamill
Brookhaven National Lab
Upton, N.Y.

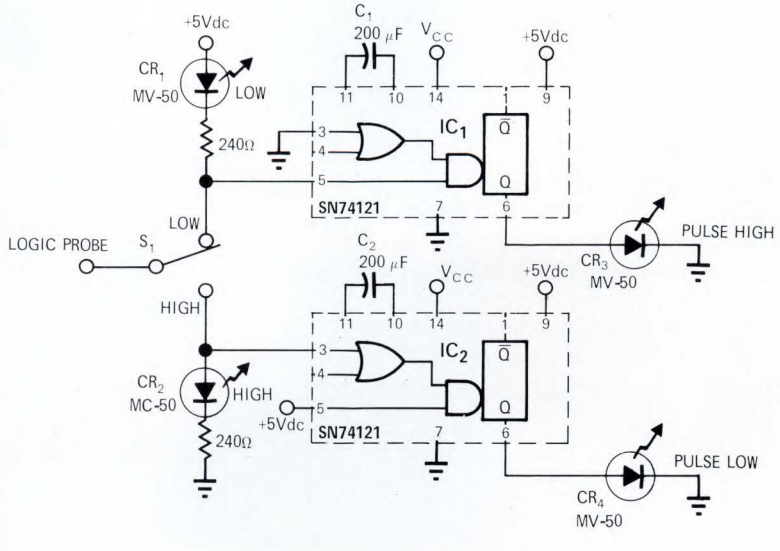
Using two IC monostable multivibrators and four light-emitting diodes, one can build a handy and inexpensive logic probe. The circuit is useful for low-repetition-rate applications where single narrow pulses are encountered. Such situations occur in computer-interface and logic-control systems. The one-shot multivibrator stretches pulses as narrow as 50 nsec so that they provide a clear LED indication.

Switch S_1 allow the user to determine the steady state of the circuit under test. If the steady state is low, lamp CR_1 will light when the switch is in the LOW position. Conversely, if the steady state is high, CR_2 will light with the switch in the HIGH position.

The other two lamps indicate the presence of a pulse superimposed on the selected steady-state signal. For example, if the steady-state is low and the switch is in the appropriate position, then the leading edge of a positive-going pulse will trigger monostable IC_1 thus lighting CR_3. Alternatively, a negative-going pulse will light CR_4.

External connections to pins 9, 10 and 11 of the monostable ICs determine the durations of the output pulses and hence the length of time that the pulse-indicating LEDs will remain illuminated. With the connections shown (using the 2-kΩ internal timing resistor and a 200-μF external capacitor), the ON time is 200 msec. If the pulse repetition frequency is high, the pulse light will remain on continuously.

This circuit can be compactly packaged either in a pen-shaped container or in a small box. The lamps should be labelled as indicated on the schematic. A battery can be included to provide the necessary 5V power source, or the voltage can be derived from the logic under test. □



Simple logic-probe circuit can be easily packaged as a compact hand-held unit.

Gated 60 Hz clock avoids glitches

To Vote For This Circuit Circle 153

by Robert I. White
University of Wisconsin
Madison, Wis.

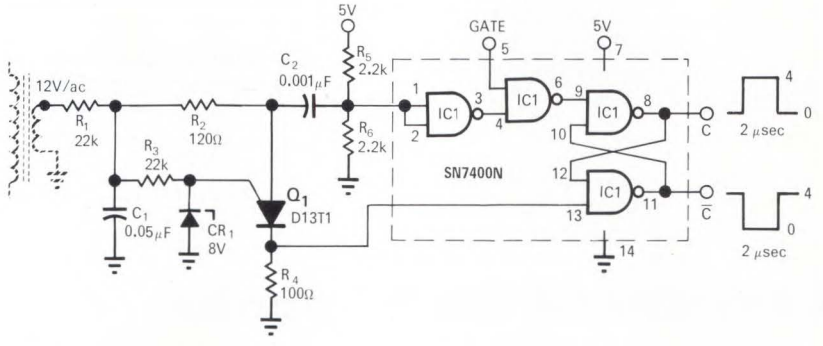
A poorly-designed gated asynchronous clock can create marginal pulses if the gate happens to be enabled or disabled during a clock pulse. The circuit described here, however, provides an inexpensive solution to the "glitch" problem. Using a single 7400-series IC plus a few discrete components, the circuit generates complementary gated clock pulses that are never less than 2 μsec in duration.

As can be seen in the schematic, 60-Hz timing signals derived from a 12V transformer are filtered by an RC network (to remove high frequency noise) before being discriminated by a programmable UJT. This part of the circuit is fairly conventional, and the approach has been described elsewhere (see *EEE*, May 1970, p. 105).

When the voltage on C_1 reaches about 8.5V, Q_1 fires and generates complementary pulses for the logic circuit. The negative-going pulse, at pins 1 and 2 of the IC, is considerably shorter than the pulse entering pin 13.

If the gate input (pin 5) is enabled during the short pulse, the flip-flop turns on, thus generating a logic-1 output at pin 8. After 2 μsec, the long pulse (entering pin 13) returns to zero, thus changing the flip-flop back to its original state (logic-0 at pin 8). Since the flip-flop can be triggered into the logic-1 state only when both the gate level and the short pulse are present, no output pulse of less than 2-μsec duration can occur.

Clock accuracy depends, of course, on line stability. Measurements have shown clock accuracies close to 0.01% for 1-sec time periods in Madison, Wis. □



Clock generator provides output pulses that are always longer than 2 μsec, regardless of the relative timing of the gating signal and the ac line.

One-Chip "UAR/Ts" For Telecommunications

PROGRESS IN LSI SUBSYSTEMS

A subsystem-on-a-chip that could well become one of the 709s of LSI is the UAR/T or universal asynchronous receiver-transmitter. Two companies – General Instrument Corp. and American Micro-systems, Inc. – now offer these at attractive prices, and others can be expected to follow.

The P-channel MOS circuit performs the widely-needed function of converting between the basic narrowband, serial telephone or Teletype lines and parallel data terminals or other electronic equipment. It probably can also be used for such similar applications as between a serial tape memory and a minicomputer. The UAR/Ts offered by GI and AMI are called universal because they can be commanded to handle 5-, 6-, 7- or 8-bit codes, several different formats and optional parity checking. Both operate at well over 10 kHz baud (bits per second), which is more than adequate for telephone and Teletype lines.

They sell for $30 to $50 each and for as low as $20 in large quantities. Even using MSI, an equivalent TTL UAR/T would take up two to four PC boards containing up to 100 DIPs, according to Bill Siefert, GI product manager. Siefert estimated the TTL cost at $25 to $30 if produced in large quantities. The real saving is at low volumes, Siefert said. A system builder can "design in" this LSI quickly at a parts cost of $30, while he would have to make a design project out of a TTL system and pay at least $100 for parts. These MOS UAR/Ts would seem ideal for the many small companies now starting in the very promising data communications field.

AMI's UAR/T was announced at WESCON and an AMI spokesman said they have received hundreds of inquiries just from the data sheets handed out at the show. The spokesman said that AMI has applied for a trademark on the term "UAR/T," but the people at GI claim that they have been using the term for some time.

GI's UAR/T was acquired from an MOS house that went under, Solid State Data Sciences. GI says these circuits were originally presented to industry two years ago. The present GI device, however, is a complete redesign with additional features.

PRICE SCHEDULE

Quantity	Price ($)	
	GI AY-5-1012	AMI S-1757
1-24	30.00	47.00
25-99	30.00	38.50
100-999	22.50	28.10

(Note: GI also sells the UAR/T in separate receiver and transmitter versions with 24-pin DIPs rather than a single 40-pin DIP. The price for these is one-half that of the complete UAR/T.)

A Complete Subsystem

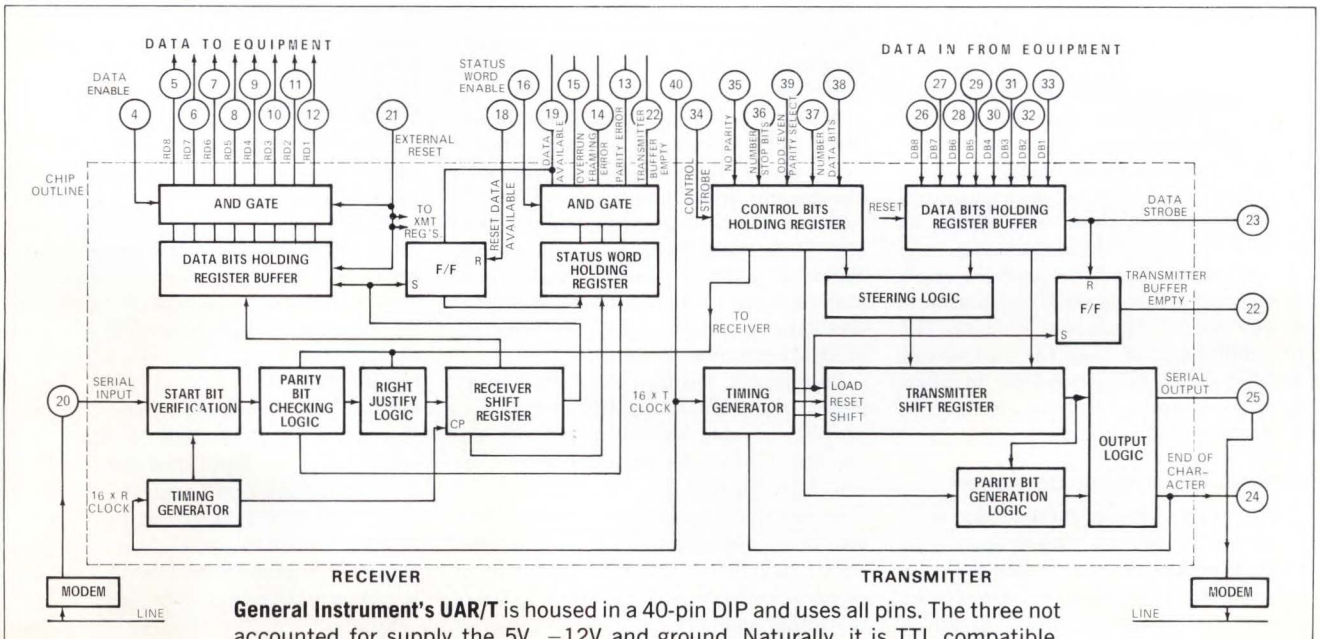
Some idea of the capabilities built into these LSIs can be had by examining the block diagram of the GI device. Both the receiver and transmitter sides of the chip are double buffered: the data flows through two registers. This means that the chips can transmit and receive at different speeds, and is the reason that the systems are called asynchronous.

The pin functions give further clues to the GI device's versatility. Three different parity arrangements can be selected: no parity (pin 35), odd/even parity (39) or parity error (13). The transmitter can select either one or two stop bits (pin 36). The character length can be changed from 5 to 8 bits (pins 37 and 38). Pins 34 through 38 permit the user to rapidly set up and change the data format if so desired.

The receiver monitoring (pins 13, 14, 15, 16, 18, 19 and 22) tells the user when the data has come in, whether or not it has come in correctly and when the receiver is ready for more data. The timing clock (pin 40) operates in a divided-by-16 mode for noise rejection.

General Instrument Corp., Integrated Circuits Div., 600 W. John St., Hicksville, NY 11802. **159**

American Micro-systems, Inc., 3800 Homestead Rd., Santa Clara, CA 95051. **160**



General Instrument's UAR/T is housed in a 40-pin DIP and uses all pins. The three not accounted for supply the 5V, −12V and ground. Naturally, it is TTL compatible.

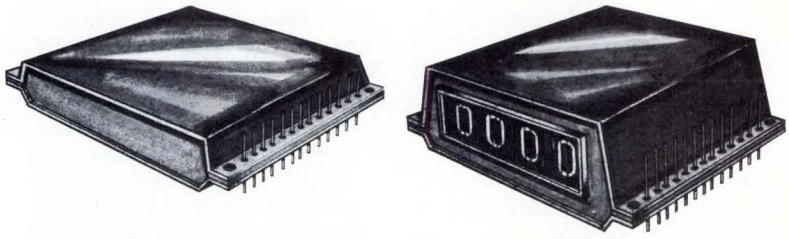
Unusual Modules Provide Packaging Versatility

PROGRESS IN PACKAGING

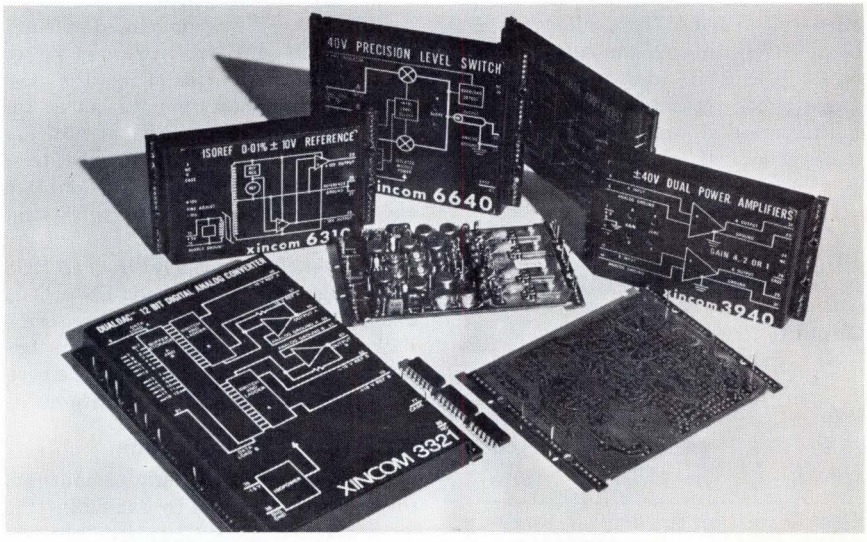
A strange looking module assembly developed by Xincom Corp. eventually may have as great an impact on circuit and instrument packaging as the dual in-line case had on IC packaging.

Like the DIP, the new "Pinto" (pin test oriented) package has the advantage that terminals are accessible from above and below the PC board or chassis. Thus the Pinto package overcomes a serious drawback of conventional plastic encapsulated modules—pins projecting from the underside only.

But while DIPs cost less than most other IC packages, Pinto may well turn out to be more expensive than plastic module cases. The basic Pinto module package is a three-part assembly consisting of a PC board and two metal covers. Thus parts and labor costs would almost certainly exceed those of a potted plastic package. Currently Xincom is charging from $12 to $26 (depending on size) for Pinto cases in sample quantities, but of course increased demand would probably allow substantial price reductions. Xincom does not claim that Pinto is a low-cost package, but rather that it is an extremely versatile and useful package.



Sketches of new "Pinto" package used for a circuit module (left) and for a small instrument (right). Assembly consists of a PC board sandwiched between two metal covers. Termination pins along the edges accept wire-wrapped connections.



First members of growing family of maxi modules for computer instrumentation. Module without its metal cover plates is shown in the center.

Maxi or Mini

The company fully expects that low-complexity circuit modules, such as op amps, will continue to be packaged in plastic because price competition will not permit anything more expensive. But in due course, almost all low-cost circuit modules will be replaced by ICs anyway, so Xincom is bypassing the low-cost end of the market.

According to Brian Sear, president, the prime market for Pinto packages will be in what he calls the "maxi module and mini instrument" area. By this he means that the circuits will cost more than most of those currently offered as modules but less than most of those now offered as bench or rack-mounted instruments.

Pinto packages can be used for small instruments (such as DVMs or counters) as well as for "black-box" circuits. The only difference is that the instrument packages have greater height to allow readouts, controls, connectors, etc., to be mounted on the front end.

Various Packaging Schemes

In the normal configuration, Pinto modules are supplied with wire-wrapped pins staked along the two edges of the package.

Complete systems can be assembled by making wire-wrapped connections to the appropriate pins. Schematic diagrams are screened onto the top surface of its standard circuit modules. This makes it easy to determine the required interconnections and to debug finished equipment.

Alternatively, Pinto modules can be soldered to PC boards just like conventional modules. Or they can be screwed to a chassis and interconnected using flexible cables terminated in wire-wrapped sockets. Thus Pinto modules allow a wide choice of different packaging schemes, making them suitable for breadboarding, prototype assembly or quantity production of instrumentation systems.

Because the modules have metal cover plates, they can be readily designed to provide suitable shielding and thermal sinking. Unlike potted assemblies, they are easily repairable.

In addition to the basic modules, Xincom offers a selection of compatible hardware, including card files, rack-mount chassis, motherboards and sockets. Users can either assemble their own Pinto modules, using hardware supplied by Xincom, or they can select suitable standard circuit modules from the expanding line that the company manufactures.

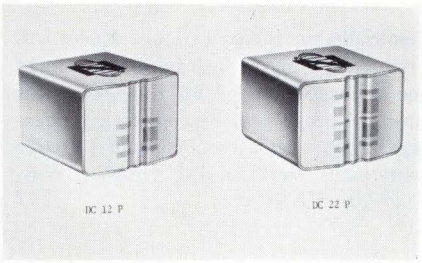
Complete Circuits Available

Standard circuit modules already announced include a 40V precision level switch (Type 6640), a precision power-amplifier pair (Type 3940), a ±10V isolated reference source (Type 6310) and a dual 12-bit DAC (Type 3321). Other circuits to be introduced soon include a voltage-controlled timing generator, a 10-nsec digital phase synthesizer and a 100-MHz crystal oscillator.

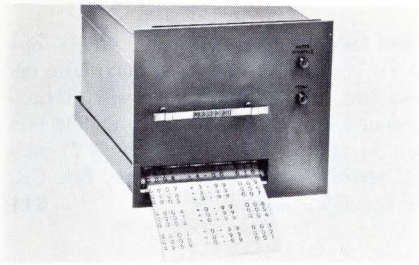
Prices for complete circuit modules range from $100 to $800. Unassembled metal cases for Pinto modules cost from $12 for the smallest version (4 by 1.6 by 0.55 inch) to $26 for the largest version (4 by 5.6 by 1.25 inches). Card files are available at prices from $194 to $348, and a rack-mount chassis costs $200.

Xincom Corp., Box 648, 20931 Nordhoff St., Chatsworth, CA 91311. **161**

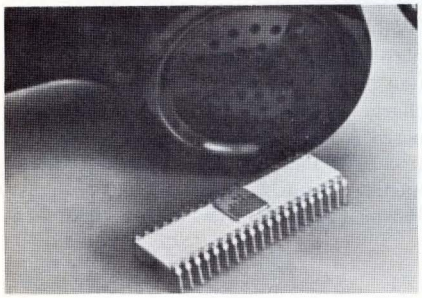
Precision voltage calibrator Model PM 2330 is a battery-operated device with a LED readout indicating when a voltage is within 0.05% of preset value. Standard units have two, three or four calibrated voltages and the preset voltage can be up to 500V dc. An additional feature is a slide switch for determining if a voltage is within a specified error band. Pioneer Magnetics Inc., 1745 Berkeley St., Santa Monica, CA 90404. **302**



Digital cassette heads DC12P and DC22P meet all ECMA, ANSI and ISO proposed standards. Available in "read-after-write" format, the cross feed between the write and read gaps is reduced 2 to 4% at 10 ips. Units operate at a resolution of 95 to 100% at a ratio of 800 to 1600 flux reversals/inch recording densities, and are available in multichannel configurations. Nortronics Co., Inc., 8101 10th Ave. N., Minneapolis, MN 55427. **305**

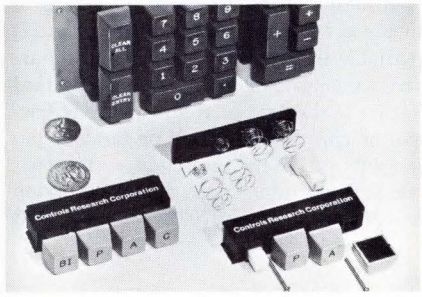


Printer BCD Moduprint is designed for applications where time, date and count are combined with data from BCD sources. Printer capacity is 14 columns on 4-inch tape, 12 positions/column. Front panel dimensions are 7 by 6 inches. The printer plugs into the enclosure containing the interface and time base as well as all interconnects. Price starts at $350 each. Practical Automation, Inc., Trap Falls Rd., Shelton, CT 06484. **308**

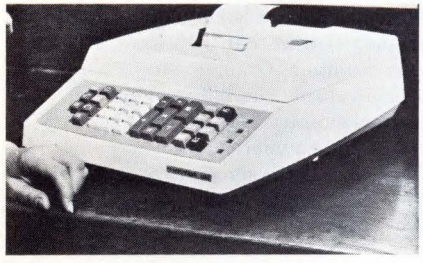


Universal asynchronous receiver/transmitter UART is an MOS/LSI device featuring full duplex asynchronous operation, TTL compatibility and a dc-to-10,000-baud rate. Package is a 40-pin DIP ceramic case, and a low-threshold-voltage process is used in the fabrication. Unit prices range from $47 (1-24) to $28.10 (100-999). American Micro-Systems, Inc., 3800 Homestead Rd., Santa Clara, CA 95051. **303**

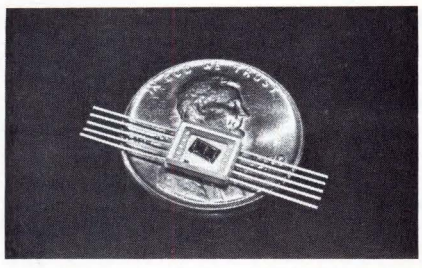
Cassette reel-motion indicator permits continuous monitoring of tape recorder operation. An instant visual warning of end of tape, broken tape, jammed tape and battery failure is given. There is no distracting buzzer or beep. Two models come in each package for either open or closed recorder operation. Package price is $1.29 each. Graf-Pacific, 12222 Bristol Dr., La Mirada, CA 90638. **306**



Keyboard switches, "BI-PAC," employ a simple 6-piece design using dual spring/contacts, and cost as low as $0.30/switch position, including the two-shot molded keytop. Switches have a patent-pending design consisting of two goldplated conical, wire spring contacts that offer redundant contact points and wiper action. Controls Research Corp., 2100 S. Fairview, Santa Ana, CA 92704. **309**



MOS/LSI calculator, Series 1800, is offered in five models. Visual features include memory and overflow lights. Each register and memory has 14-digit capacity. Negative and positive values can be changed by one key. The keys are color coded and grouped for operator recognition and function control. Prices range from $595 to $895. Victor Comptometer Corp., 3900 N. Rockwell St., Chicago, IL 60618. **304**



Seven-segment LED display TIL310 features a 0.1-inch-high character mounted on a 0.205-inch wide by 0.28-inch long metal ceramic flat pack. When forward biased at 20 mA, the typical brightness is 150 fL, peak emission is at 6500 Å and the spectral bandwidth between half-power points is 200 Å. Price, in 1000 piece quantities, is $3.95 each. Texas Instruments Incorporated, Box 5012, M/S 308, Dallas, TX 75222. **307**

A series of calculators has 16 working registers, 10 of which are accessible from the keyboard for storage and manipulation of data. There are more than 30 models—both programmable and nonprogrammable, with display and printer versions. Many models permit keyboard register splitting to effectively double storage capacity. Compucorp Calculators, A Div. of Computer Design Corp., 1734 21st St., Santa Monica, CA 90404. **310**

Read-only memory, ROMTEC 450-B, has full-cycle time of 450 nsec, maximum access time of 180 nsec and power dissipation of 150 μW/bit. The up to 98,304 bits are packed on a 13- by 11- by 1.77-inch PC board. Aztec Data Systems, Box CR, Irvine, CA 92664. **311**

Plug-in modems of the 100 Series use a one-circuit-board design for any combination of acoustic or direct connected modems in answer only, originate only and originate/answer configurations. Frequencies and interface are compatible with Bell 103 type equipment. Novation, Inc., 18664 Topham St., Tarzana, CA 91356. **312**

Teleprinter Series 30 operates asynchronously at speeds of 10, 15 and 30 cps and is available in RO, KSR and ASR modularized versions. An unusual but standard feature is the provision for the use of friction or sprocket-feed, roll or fan-fold paper without parts interchange. International Teleprinter Corp., 493 Washington Ave., Carlstadt, N J 07072. **313**

Spiradel delay lines, called "Midi", offer fixed timing delays ranging from 30 to 600 nsec. The round packages have dimensions of 0.81-inch dia. by 0.31-inch high. Standard lines are available in 100, 175, 500 and 1000Ω impedances. Allen Avionics, Inc., 224 E. 2nd St., Mineola, NY 11501. **314**

Card-reading terminal, CT Series, reads punched cards as if the data were being typed from the keyboard. Model CTA reads 10, 15 and 30 cps from standard 80 column cards and Models CTB and CTC operate at 15 or 30 cps in standard EBCD code for 2741 type Selectric unit. Western Telematic Inc., 5507 Peck Rd., Arcadia, CA 91006. **315**

Disc storage system, 5600 Series, doubles the storage capacity of present IBM 2314-type systems. Doubling the number of cylinders yields 50 million bytes/drive capacity while maintaining track and format compatibility. Telex Computer Products, Inc., 6433 E. 41st, Tulsa, OK 74135. **316**

Electrophotographic printer Model 10 produces 8.5- by 11-inch hard copies in 14 sec or less. Intended for the OEM, this unit produces a positive copy from a negative input with a resolution of 100 line pairs/inch. Varian, 611 Hansen Way, Palo Alto, CA 94303. **317**

General purpose computer, Micro 1600/21, has an instruction set with 107 different operations. The basic system contains 8-addressing modes with variable length instructions and binary arithmetic. Unit is in a desk-top enclosure with control panel. Microdata Corp., 644 E. Young St., Santa Ana, CA 92705. **318**

Dual programmable asynchronous line adapter Model CT-9101 provides half or full duplex transmission between terminals and CPU through RS-232 C Type data sets. Adapter may be controlled by CPU for start-stop operation, with any 5, 6, 7 or 8 level code and either 1 or 2 stop bits. Comtec Data Systems, 12701 S. Van Ness Ave., Hawthorne, CA 90250. **319**

Binary ladder networks of R/2R type have up to 12-bits resolution and 1/2 LSB accuracies. Package configurations vary from DIP types to plug-in. In quantities of 100, a 10-bit ladder is priced at $20.38. Ward Leonard-Hagerstown Div. of Angstrohm Precision Inc., Box 1827, Hagerstown, MD 21740. **320**

Multiple modem system, Series 12, consists of card-rack chassis, power supplies, modems and Data Access Arrangement (DAA) files. Any combination of modem types, including data set equivalents to the Bell System 103A/E, 103F and 202C/D, may be accommodated. Price is $308/channel. Anderson Jacobson, Inc., 1065 Morse Ave., Sunnyvale, CA 94086. **321**

Tape drive and controller combination Model 3410 operates at 37.5 ips and can be modified for higher speeds. There is a 7-track NRZ version with 200 or 550 bpi and a 9-track phase-encoding version with 800 bpi. Digital Scientific Corp., 11455 Sorrento Valley Rd., San Diego, CA 92121. **322**

Code converter, Model 705-1 Micro Face, simplifies the interfacing of the 700/720 Series calculators at a cost of only $300. Smaller than a telephone, it can multiplex as many as ten units. Wang Laboratories, Inc., 836 North St., Tewksbury, MA 01876. **323**

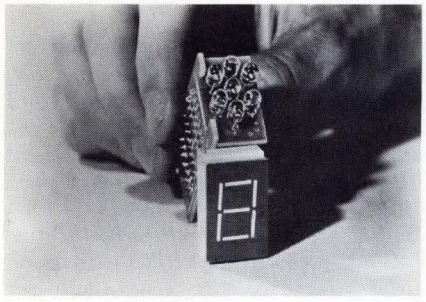
Memory drums, DR6E Series, are head-per-track units with capacities from 520 to 2160k bits. Five versions are available with a wide variety of coatings, head types and motors, and are field expandable. California Electro Mechanisms, 22519 S. Normandie Ave., Torrance, CA 90501. **324**

Cassette vacuum transport Model 440 CVT uses a vacuum column to achieve high performance and speed with consistent low skew and excellent start/stop characteristics. The 440 CVT uses proposed ANSI/ECMA-standard cassette but it can be modified for any bidirectional media. Dicom Industries, Inc., 715 N. Pastoria Ave., Sunnyvale, CA 94086. **325**

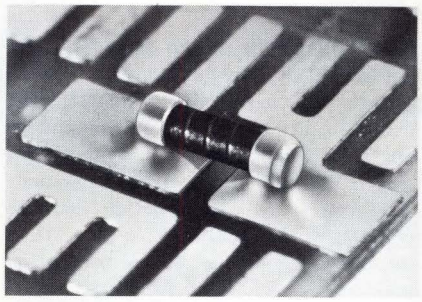
Nine-track dual-gap magnetic tape head Model ERWA-171909 offers write-to-read crossfeed of <3% without an external shield. An advanced contour design was developed for use with low-speed tape transports in the range of 45 to 112.5 ips. Applied Magnetics Corp., 75 Robin Hill Rd., Goleta, CA 93017. **326**

Graphic display system 6500 is a disc-refreshed system that uses low-cost television monitors. Graphic entry rate is one single-valued curve/frame period, and character entry rate is 2550 cps. Up to 4335 alphanumeric characters may be displayed on the screen at one time. Data Disc, Inc., 686 W. Maude Ave., Sunnyvale, CA 94086. **327**

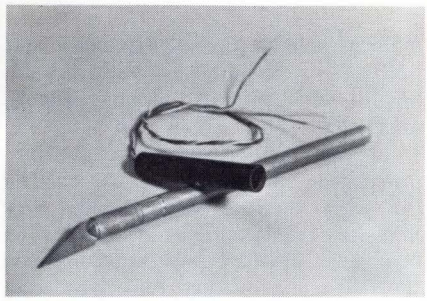
Cassette tape cartridges, 1000 Series are compatible with more than 600 Cartri-File mini-tape units. Available continuous-loop tape lengths are 10, 25, 50 and 150 ft, depending on user's requirement. Tape is 1/4-inch wide, 1.5 mils thick and is of computer grade. Tri-Data, 800 Maude Ave., Mountain View, CA 94040. **328**



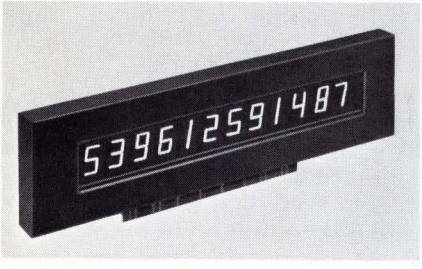
LED readout, Dialight Series 730, features 0.625 inch character height. It looks like a 7-segment bar display but in reality is a 7-diode array of point sources whose light is diffused by special plastic lenses. Readouts with decoder-driver circuits operate from 5V, draw 160 ma and sell for $9.90 in 1000 quantities. Dialight Corp., 60 Stewart Ave., Brooklyn, NY 11237. **171**



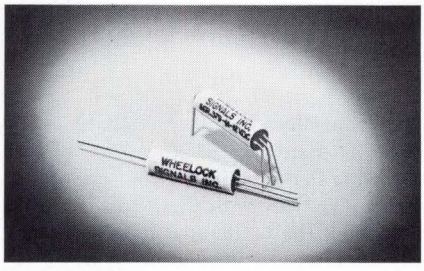
Micro-resistors in new rod configuration are available in resistances from 10Ω to 20 MΩ. Designed for micro-miniature applications, they allow contact to be made directly by soldering the nickel alloy caps to the board. The unencapsulated resistors are available in thin- or thick-film versions with 1% tolerances. Mepco, Inc., Columbia Rd., Morristown, N J 07960. **174**



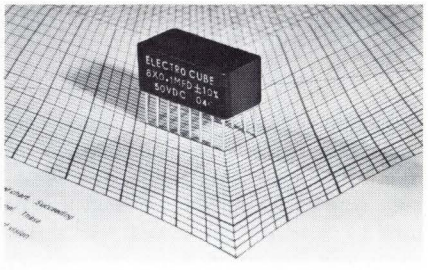
Infrared emitter/sensor detects and indicates proximity and size of objects. Model IR-15 emits an infrared beam while simultaneously monitoring reflected IR. An analog output from +5 to +15V is in linear proportion to size of, and/or distance to, the sensed object. Entire package is one inch long and 5/16 inch in diam. Price is $75 in unit quantity. Kolt Engineering, Box 1172, Los Gatos, CA 95030. **177**



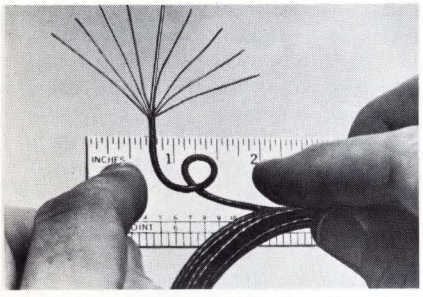
Multi-character numerical display panels are available with 8 to 16 digits. NDP 1250 panels have 9-segment, 0.40-inch high characters and operate on 160 to 180V dc. Designed to operate in a time-share mode with an on time of 80 to 800 μsec, the display panels have a maximum cathode current of 25 mA/digit. National Electronics, Inc., Geneva, IL 60134. **172**



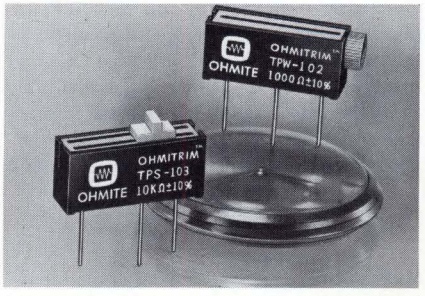
Ultra-miniature needle relays occupy a volume of only 0.02 inch^3, measure 0.19 inch in diam and weigh 1.1g. Seven versions are available with contact ratings of 7W within the limits of 150V dc and 250 mA dc. Contact resistance is 100 mΩ, and release time is 0.06 msec at rated voltage. Wheelock Signals, Inc., 273 Branchport Ave., Long Branch, N J 07740. **175**



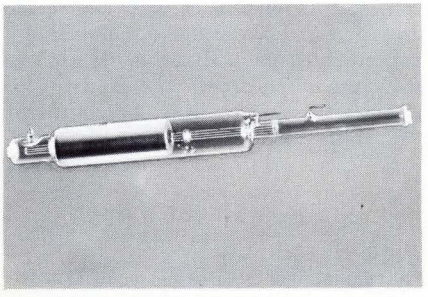
Multiple capacitors in a single DIP are available from Electrocube Corp. As many as eight capacitors can be packaged in a case 0.385 by 0.340 by 0.820 inch with 16 leads spaced on 0.10-inch centers. Combinations of dissimilar dielectrics, capacitance values and voltages are possible. Electrocube, Inc., 1710 S. Del Mar Ave., San Gabriel, CA 91776. **178**



Subminiature underwater cable features break strength in excess of 100 lb and flexibility that allows 1/4-inch radius bends. The new cable consists of nine conductors, all individually insulated and color-coded. Eight of these conductors are 30 AWG cabled around the ninth conductor of 25 AWG. Clad in polyurethane, the cable has an OD of 0.080 inch. Berk-Tek, Inc., Box 60, Reading, PA 19607. **173**



Wirewound trimmers, the Ohmitrim TPW and TPS Series, have nominal 1W rating and are offered in resistance values from 10Ω to 20 kΩ. Leads are gold plated and spaced for 0.10-inch hole patterns. Two actuators are available, a lead-screw of approximately 35 turns and a slide. Price is $0.88 each in 5000 quantities. Ohmite Manufacturing Co., 3601 W. Howard St., Skokie, IL 60076. **176**



Aluminum cathode helium-neon laser tubes, designated MT 710 and 711, have power outputs of 1.5 and 2.4 mW and are priced at $80 and $90 each in lots of 100. Resistance of the aluminum oxide cathode coating to sputtering allows the manufacturer to guarantee the tubes for 9000 hrs or 1 year of operation. Metrologic Instruments, Inc., 143 Harding Ave., Bellmawr, N J 08030. **179**

DIP heat sinks for use with standard dual in-line packages limit temperature rise to less than 40°C at 0.3W and 50°C at 0.8W under natural convection conditions. The aluminum units have a hardcoat finish to provide nominal electrical insulation. The two basic versions permit standard or high density mounting on PC boards. The heat sinks are held in position between the DIP and its socket. Astrodyne, Inc., 353 Middlesex Ave., Wilmington, MA 01887. **180**

Cermet trimmer resistors, 3/4 inch long, are rated at 0.75W at 25°C and 0.5W at 85°C. Type 75 is a 20-turn, immersion-sealed unit with operating temperature range of −65 to +125°C. Resistance values from 100Ω to 1 MΩ are offered. Price is $1.59 each in 100 piece quantities. Allen-Bradley Co., 1201 S. Second St., Milwaukee, WI 53204. **181**

Automatic gold spot plater for etched-lead frame sheets selectively gold plates sheets used in the packaging of ICs. The equipment is 8 ft wide by 10 ft long and may be used to plate any size etched lead frame sheet with 100 millionths of pure gold in approximately 2 min/sheet. Gold savings over frames fully gold plated is said to be up to 90%. Auric Corp., 470 Frelinghuysen Ave., Newark, N J 07114. **182**

New elastomer features high resilience, excellent flex life and low-temperature flexibility. "PAREL-58" is a sulfur-vulcanizable copolymer of propylene oxide and allyl glycidyl ether. It compares favorably with natural rubber, and offers moderate oil resistance and excellent resistance to ozone and heat. Hercules Inc., 910 Market St., Wilmington, DE 19899. **183**

Palladium/silver conductor paste (S4026) retains its high adhesion strength through multiple refirings. This material can be fired from 775 to 975°C with 4 to 8 min at peak temperature. Fired films display excellent leach resistance to solder, wire bond readily and are compatible with all major resistor systems. The paste is available in production quantities for $15/troy oz. Bala Electronics Corp., 14 Fayette St., Conshohocken, PA 19428. **184**

3MM terminations in the new SMA line feature VSWR as low as 1.25 in KU band. Components meet MIL-C-45662A and MIL-C-39012 and feature a maximum length of 0.5 inch and a maximum weight of 3g. The terminations utilize a passivated stainless steel construction and are available with either jack or plug. They are priced at under $5 in production quantities of 100 or more pieces. EMC Technology, Inc., 1300 Arch St., Philadelphia, PA 19107. **185**

Silicon-on-sapphire in 1-1/2-inch wafers is available to semiconductor manufacturers and R & D laboratories. The wafers are offered in SOS N and P Type in 1 μm thickness with typical resistivity ranging from 0.4 to 40Ω/cm. Crystal orientation of (100) allows standard preferential etches. Inselek, 743 Alexander Rd., Princeton, N J 08540. **186**

Chip capacitors are now available with preform material (80-20 AuSn) pre-attached to the termination. This allows the user to do away with the production step of placing the individual preforms under the capacitor and then effecting the eutectic attachment. Preform CAP allows direct attachment to the circuit with cost saving in production time. Monolithic Dielectrics, Inc., Box 647, Burbank, CA 91503. **187**

Contact-and-brush assemblies for severe-environment applications feature porcelain holders and "Paliney-7" contacts. Operating temperatures up to 400°F are possible, and higher temperatures can be tolerated by selection of other contact materials. The assemblies are available in standard or custom-designed dimensions. J. M. Ney Co., Maplewood Ave., Bloomfield, CT 06002. **188**

Magnetically stable core iron, Electromagnet Iron, is designed as a replacement for magnetic ingot iron. It was developed to reduce the problem of magnetic and mechanical aging. Aluminum and titanium additions stabilize it to tie up the small amounts of carbon and nitrogen that would otherwise cause both mechanical and magnetic aging. The iron is available in sizes and shapes similar to magnetic ingot iron. Armco Steel Corp., Middletown, OH 45042. **189**

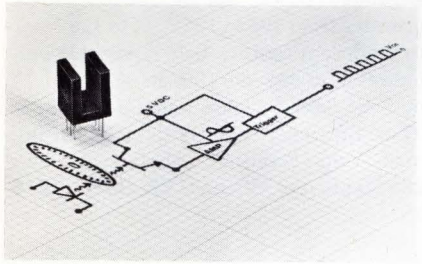
Cyanide-free immersion tin plating process protects against oxidation and corrosion of printed circuit boards. Called Enplate TIN-421, it is supplied as two components—TIN-421A, a liquid and TIN-421B, a powder—which are combined with water to make the operating solution. The new process has a fast plating rate and produces bright, dense tin deposits on tin-lead solder or copper and copper alloys. Enthone, Inc., Box 1900, New Haven, CT 06508. **190**

Subminiature relays of the Series HM have a 3A rating in an SPDT configuration. Various voltage ranges are available from 3 to 60V dc. Operating power is 250 mW minimum at 20°C. Relay life is rated at over 20 million operations. Babcock Electronics Corp., Subs. of Esterline Corp., 3501 No. Harbor Blvd., Costa Mesa, CA 92626. **191**

High Q voltage variable capacitor family for UHF tuning applications includes Types 1N5461, A, J, C through 1N5476, A, B, C. Units come in a standard DO-7 glass package, with a range of 6.8 to 100 pF and a Q up to 600. These abrupt junction voltage variable capacitors are designed specifically for critical frequency control applications. CODI Semiconductor, Div. of Computer Diode Corp., Pollitt Dr. S., Fair Lawn, N J 07410. **192**

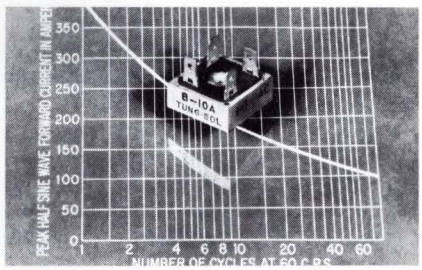
Multi-layered bussing system called bus·con provides high capacity, low-impedance power distribution on 6-layer circuits. The system consists of a machined frame, PC connectors, one or two 3-layer bus bars, bus strips and all necessary mounting hardware. System prices vary according to numbers of connectors, busses, etc. SAE Advanced Packaging, Inc., 2165 S. Grand Ave., Santa Ana, CA 92705. **193**

Substrates available for additive circuitry production, called Taylorclad laminates, have a surface coating of 0.002-inch thickness. This assures adhesion of metal conductors equal to MIL-P-13949 requirements. The substrates are furnished in two grades, GEC-520 (NEMA grade G-10) and Fireban 620 (NEMA grade FR-4), and are available in 36- by 42- or 36- by 48-inch sheets of 0.014- to 0.500-inch thickness. Synthane-Taylor Corp., Valley Forge, PA 19481. **194**

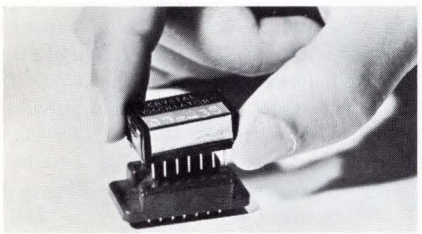


Optical switch Model OS-391S-060 or -200 generates a square wave with a 50 nsec rise time and a 200 nsec. fall time. A mechanical device passing through the 0.06 or 0.2 inch air gap breaks a light beam and opens the circuit. This NC contactless switch is housed in a 6-pin DIP that is only 0.5 by 0.4 by 0.4 inch. Price, in 100 lot quantity, is $12.90 each. HEI, Inc., Jonathan Industrial Center, Chaska, MN 55318. **195**

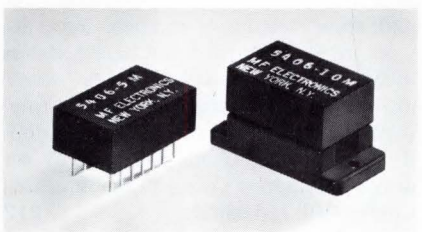
Audio power amplifiers MFC9020 and MFC6070 are rated at two and one watts of output power respectively. The MFC9020 comes in an 8-pin stagger-lead plastic package with two heat dissipating "tabs". The MFC6070 is supplied in a smaller 6-pin stagger-lead case. Unit prices in lots of 100 and up are $1.56 (MFC9020) and $0.95 (MFC6070). Motorola Inc., Semiconductor Products Div., Box 20924, Phoenix, AZ 85036. **198**



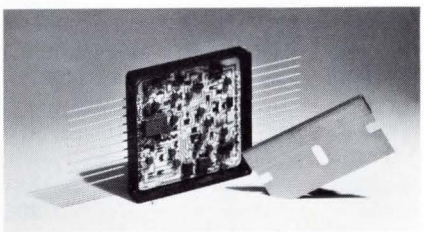
Full-wave bridge rectifiers B-10 Series meet an average dc current rating of 30A (at 55°C) in the standard 1-1/8-inch square package. One-cycle forward surge rating is 400A at rated load and I_{Rmax} is 10 μA at rated PRV. These units are priced as replacements for similar bridges rated from 8 to 25A and from 50 to 1000 PRV/leg. Tung-Sol Div., Wagner Electric Corp., 630 W. Mt. Pleasant Ave., Livingston, N J 07039. **201**



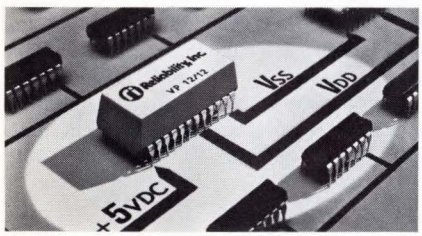
Clock oscillator CO-238, DIP compatible, drives 10 TTL loads at any frequency within the 3 to 30 MHz range. Requiring only 5V dc for operation, they offer stability better than ±0.0025% over the 0 to 70°C temperature range. The 0.5- by 0.8- by 0.35-inch module plugs directly into a 14-pin DIP socket. Price (1 to 4 pieces) starts at $85 with quantity discounts as great as 70%. Vectron Laboratories, Inc., 121 Water St., Norwalk, CT 06854. **196**



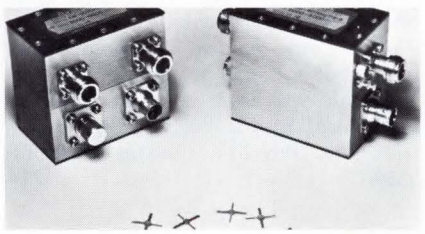
Oscillator 5406 plugs directly into DIP sockets and seats to only 0.3 inches in height. Frequency range is 4 to 35 MHz with stabilities of ±50 or 25 ppm from 0 to 65°C. Units are available for the full operating temperature range. Required input voltage is 5V dc, and the TTL output sinks 16 mA up to 10 MHz, 20 mA above 10 MHz. In quantities of 1 to 4, the price is $35 each. MF Electronics Corp., 118 E. 25th St., New York, N Y 10010. **199**



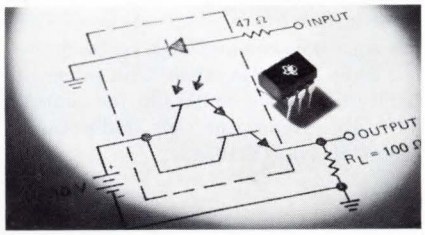
Audio amplifiers GMA9042 (FET input) and GMA9043 (bipolar input) feature an externally programmable AGC attack and decay response over a 2 to 200 dB/sec range. Other characteristics include a figure of merit 1 dB output change over the AGC dynamic range of 50 dB, 1 mA maximum power drain and dimensions of 1.5 inches square by 0.25 inch thick. Prices range from $95 (1-9) to $70 (100-499). Gulton Indsutries, Inc., Metuchen, N J 08840. **202**



Voltage converter, V-PAC, makes use of the bipolar voltage source (5V), to generate any voltage or combination of two voltages from −30 to 30V for the MOS ICs. With standard 24-pin spacing, the dimensions are 1.3 by 0.6 by 0.38 inches. Unit prices are from $36 (single-voltage unit) to $44.50 (dual voltage). Reliability, Inc., 5510 Greenbriar, Houston, TX 77005. **197**



Microstrip amplifier AM-4070N covers the 2 to 4 GHz frequency range with a noise figure of 6 dB maximum. Available amplifiers have either in-line or front-mounted TWT replacement connector configurations. Size is approximately 3 by 1.75 by 1.25 inches. Versions are offered with minimum gains of 26 and 33 dB. Avantek Inc., 2981 Copper Rd., Santa Clara, CA 95051. **200**



Optically-coupled isolator TIXL113 consists of a gallium-arsenide LED and an npn darlington-connected phototransistor in a 6-pin DIP. The darlington output stage ensures an input-to-output current transfer ratio of 15,000. With a ±1500V isolation rating, the unit price is $2.75 in 100-piece quantities. Texas Instruments Incorporated, 13500 N. Central Expressway, Dallas, TX 75222. **203**

Plug-in power supply units for inductive loads convert 115V ac to 90V dc. Each unit contains an encapsulated full-wave silicon rectifier bridge. Models MCS-800 and -801 handle loads up to 0.8A, and MCS-802 provides solid-state switching with 0.5A capacity. Prices range from $16.50 (MCS-800) to $60 (MCS-802). Warner Electric Brake & Clutch Co., 449 Gardner St., Beloit, WI 53511. **204**

Power buffer has unity gain, dc-to-40 MHz bandwidth and a power handling capability of 1.25W at 125°C. The slewing rate of the device is >1000V/μsec. Unit comes in a 16-lead TO-8 package. Price is $21.95 each (100 piece quantities). Circuit Technology, Inc., Farmingdale, NY 11735. **205**

Amplifier Model MWDH-20G-12 operates from 500 kHz to 100 MHz and provides a frequency response that is flat within 0.5 dB. Typical noise figures for the 0.09 cubic inch unit are 4.5 dB at 30 MHz and 5 dB at 60 MHz. Price is $225 each. ANZAC Electronics, Div. of Adams-Russell, Co., Inc., 39 Green St., Waltham, MA 02154. **206**

Switch driver SD 1001 provides up to 400 mA peak current with <10 nsec total delay plus risetime. Drivers are TTL compatible and offer fail-safe operation. Price is $65 each in quantities of 1 to 9. LRC, Inc., 11 Hazelwood Rd., Hudson, N H 03051. **207**

Miniature coaxial transfer switches weigh only 6 oz, and have volume of only 3.5 cubic inches. Features include low VSWR, low insertion loss and high isolation over the dc to 12.4 GHz range. Unit prices are $180 (dc control) and $195 (ac control). RCL Electronics Inc., 83 Radio Circle, Mount Kisco, NY 10549. **208**

Regulated power supplies, EPS Series, are available from 5 to 24V with current output up to 3A. Features include ±0.25% regulation, 5 mV ripple and trim adjustments for voltage and current limits. Unit price is $25 in quantities of 10. Deltron Inc., Wissahickon Ave., North Wales, PA 19454. **209**

Passive bandpass filters, Series BPF, have standard bandwidths of 2% and operate from 1 to 100 kHz. Bandwidths of 1 to 10% are also available. They provide center-frequency stability of ±0.5% over the −40 to 70°C temperature range. Units are encapsulated and suitable for PC mounting. Price is $65 each in 1 to 4 quantity. Beukers Laboratories, Inc., 1324 Motor Parkway, Hauppauge, NY 11787. **210**

Solid-state time delay relay Series IDS operates resistive or inductive loads with ±2% repeat accuracy. Three versions offer fifteen time ranges from 0.1 sec to 10 min. Pricing for 500-999 quantities ranges from $15.33 (±20% tolerance) to $25.66 (±5% tolerance). Omnetics, Inc., Box 113, Syracuse, NY 13211. **211**

MOS drivers are designed specifically for high-speed testing of complex logic devices at real time rates. Characteristics include programmable voltage levels (±30V), 2V/nsec at 50 pF slewing rate, >10 MHz data rate and TTL compatibility. Prices range from $80 to $275 per device. Computest Corp., 3 Computer Dr., Cherry Hill, N J 08034. **212**

"L" band amplifier, Model A-2000, measures 3.5 by 5.625 by 5 inches and weighs 5.75 lb. Typical gain factor of 9 dB yields a 10-kW power output. Bandwidth is on the order of ±30 MHz. Acrodyne Industries, Inc., Montgomeryville, PA 18936. **213**

Analog peak analyzer, Model 3004, detects and holds the magnitudes of up to three consecutive analog peaks. The 5- by 9- by 0.75-inch unit requires a minimum peak input of 50 mV, and has accuracy of ±1% or 20 mV, whichever is greater. Electromechanical Systems Div., ABA Industries, Inc., Box 517, Pinellas Park, FL 33565. **214**

Crystal oscillators of the 20A01046 Series operate within the 15 to 25 MHz frequency range. Stability is ±25 ppm over the temperature range of 0 to 70°C. The 14-pin DIP mounts in the standard 0.1 by 0.3 PC grid pattern. Voltage requirement is 5V dc ±5%. Erie Frequency Control, Carlisle, PA 17013. **215**

Regulated power supply Model 510-28 operates from 105 to 127V, 47 to 420 Hz ac to produce a continuously-adjustable output of 22 to 30V dc. Dimensions are 1.75 by 3 by 6.5625 inches and the weight is 27 oz. Efficiency is better than 75% at full load. Vega Precision Laboratories, Inc., 239 Maple Ave., Vienna, VA 22180. **216**

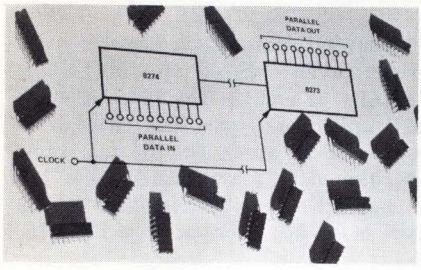
Broadband frequency doubler Model 5040 multiplies S to C band, has over 25% bandwidth. Spurious signals are 40 dB down and conversion loss is 6 to 9 dB Standard package size is 8 by 3 by 1 inches including input and output ferrite isolators. Zeta Laboratories, 616 National Ave., Mountain View, CA 94040. **217**

RF amplifier, Model A5812, uses PIN diode attenuators in AGC loop to achieve constant output over a wide range of input levels. Power requirement is 24V at 3 mA. Seven stages of amplification provide 50 dB of gain from 2.10 to 2.33 GHz. Overall size, less connectors, is 7.15 by 0.9 by 2.0 inches. Aertech, 825 Stewart Dr., Sunnyvale, CA 94086. **218**

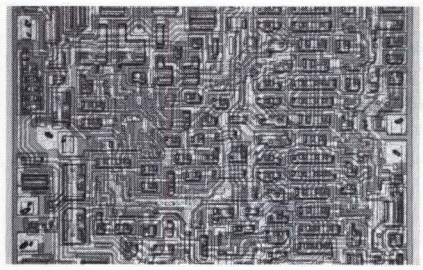
A/D converters ADC 900 Series come in 8-, 10- or 12-bit resolutions. Conversion speeds are 2 μsec (12-bits), 1 μsec (10-bits) and 800 nsec (8 bits) with accuracies of ±0.025%, ±0.1% and ±0.4% respectively. Phoenix Data Inc., 3384 W. Osborn Rd., Phoenix, AZ 85017. **219**

Temperature-compensated crystal oscillator JKTCXO-8 is available at frequencies between 25 kHz and 20 MHz. Package size is 2 by 2 by 0.625 inch, and power consumption is <125 mW. There is a choice of four stability ranges. DC input is 12V ±5% at 10 mA. CTS Knights, Inc., Sandwich, IL 60548. **300**

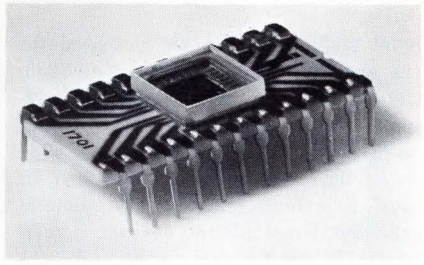
Voltage reference, The Certavolt PVS 10B, delivers 10V dc ±10 ppm with an input voltage of 28V ±10%. Voltage output of the 1- by 1- by 0.45-inch unit varies <2 ppm with load variations of 0 to 10 mA. Operating temperature range is −30 to 125°C. Computer Diode Corp., Pollitt Drive S., Fair Lawn, N J 07410. **301**



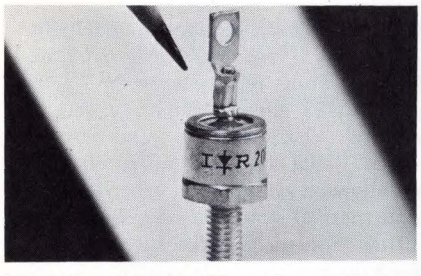
Ten-bit shift register ICs of medium-scale complexity are now available. The "8274" is a 10-bit parallel-in, serial-out shift register and the "8273" is a serial-in, parallel-out version. Both operate from 5.5V sources and are available in 16 lead plastic or ceramic packages. Prices begin at $3.34 each in 100 quantities. Signetics, 811 E. Arques Ave., Sunnyvale, CA 94086. **220**



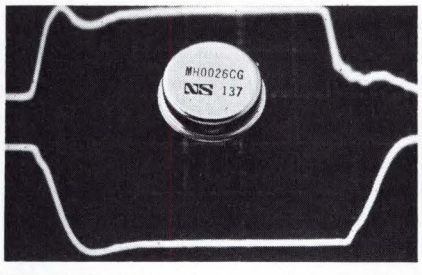
A single monolithic chip contains decade counter, 4-bit latch, BCD-to-decimal decoder and Nixie driver. This single 16-lead DIP, Type SN74142, will replace an SN7490, SN7475 and SN74141 or their equivalent, representing a significant reduction in PC board area. Prices begin at $3.65 for the plastic version in 100 quantities. Texas Instruments Incorporated, Box 5012, Dallas, TX 75222. **223**



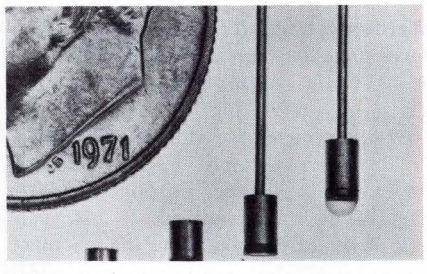
A 2048-bit MOS ROM can be erased and reprogrammed in the field. Denoted as E-ROM (for erasable ROM) this new memory permits quick error correction and program updating. It is erased by shining light from an ultraviolet lamp through a transparent quartz lid on the package. It then can be reprogrammed electrically by manual or tape programmer. Intel Corp., 3065 Bowers Ave., Santa Clara, CA 95051. **226**



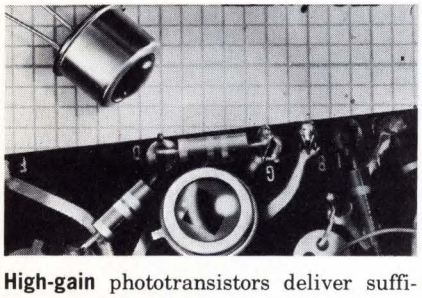
General-purpose rectifiers, the 20F Series, have repetitive reverse voltage ratings from 50 through 600V and surge current ratings up to 400A. Maximum average forward current for single phase operation is 20A, and maximum peak forward voltage drop at rated average forward current is 1.35V. Price in 100-999 quantities for the 50V 20F5 is $0.50 each, for the 600V 20F60, $2.27. International Rectifier Corp., Semiconductor Div., 233 Kansas St. El Segundo, CA 90245. **221**



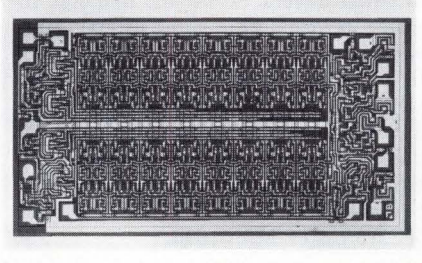
Monolithic clock drivers will drive large dynamic MOS memories faster than hybrid IC drivers. MH0026/MH0026C two-phase drivers can pulse at 5 MHz with rise and fall times less than 20 nsec when pushing a 1200 pF load. Six of these new dual drivers can run all the precharge and input address lines of a 100K bit silicon RAM array. Prices range from $7.75 to $27.00 in single quantities. National Semiconductor Corp., 2900 Semiconductor Dr., Santa Clara, CA 95051. **224**



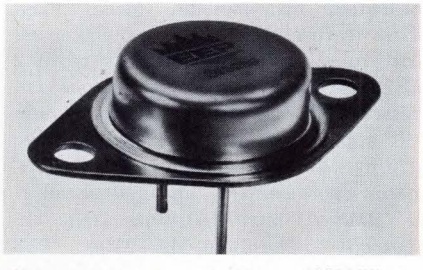
Silicon phototransistors, CLT 3000, 3100, 4000 and 4100, represent four new series available for either direct mounting on PC boards or with 0.5-inch coaxial collector leads. The phototransistors are available in either lensed or flat window packages and cover a range of light current sensitivities from 0.4 to 3.0 mA at 20 mW/cm². Prices, in 500 quantities, range from $1.79 to $1.99. Clairex Electronics Corp., 560 S. Third Ave., Mount Vernon, NY 10550. **227**



High-gain phototransistors deliver sufficient output to directly drive TTL, DTL or RTL logic at very low light levels. The STPT-260 "Quantistor" is extremely sensitive to radiant energy, providing 70 mA typical output at 5mW/cm² and 11 mA at 1mW/cm². Its switching speed is 6 μsec, and its peak spectral response is at 800 nm. Sensor Technology, Inc., 7118 Gerald Ave., Van Nuys, CA 91406. **222**



Low-power bipolar 64-bit memory, model Am31L01, has access time of 70 nsec at current draw of 35 mA vs 30 nsec and 105 mA in the standard version. This Schottky-diode memory, organized 16 words by 4 bits, is available for commerical temperature ranges at $12.80 and for military range at $25.60 (both in 100 piece lots). Advanced Micro Devices, Inc., 901 Thompson Pl., Sunnyvale, CA 94086. **225**



Fifteen-amp power transistors 2N3055 are now available from another source—European Electronic Products. Featuring low saturation voltages—$V_{ce(sat)}$ of less than 1.1V @ I_c = 4A—the 2N3055 is a highly popular amplifier and switching device. Price is $0.68 in quantities of 2000 pieces. European Electronic Products Corp., 10150 W. Jefferson Blvd., Culver City, CA 90230. **228**

Digital multiplexer ICs are designed for general purpose data selection. The 8233, 8234 and 8235 are three versions of a 2-input, 4-bit MSI IC. The 8233 provides non-inverting data paths, while the 8234 inverts. The 8235 version is designed for input to adders, registers and general paralleled data handling devices. Signetics, 811 E. Arques Ave., Sunnyvale, CA 94086. **229**

Gallium-arsenide avalanche diodes are available in 58 models, ranging from a 4-GHz device that delivers 4W at 100 to 140V to a 40-GHz unit with a 100 mW output at 25V. Raytheon Co., Micro State Products, 130 2nd Ave., Waltham, MA 02154. **230**

Microwave transistor, Type TA7995, features overlay multiple-emitter-site construction and emitter-ballasting resistors. The device offers high gain (7 dB) and 10W of output power at 2 GHz from a 22 or 28 volt power supply. It is available in a low-thermal-resistance stripline package at $185 each in quantities of less than 100 units. RCA Solid State Div., Somerville, N J 08876. **231**

Monolithic op amps, Type LM118, 218 and 318 operate at slew rates in excess of 50V/μsec. Feedforward compensation techniques in inverting circuits can boost slew rates to over 150V/μsec. The LM118 can slew a 10V step change and settle to within 0.1% of the output value in 500 nsec. National Semiconductor Corp., 2900 Semiconductor Dr., Santa Clara, CA 95051. **232**

Monolithic discriminator, Model 6283 MDB, features linearity of <5% over ±2 kHz from its center frequency of 10.2 MHz. The unit eliminates extraneous zero crossings that can produce false lock-on in AFC applications. It is packaged in a case 1.75 by 1.25 by 0.50 inches. The discriminator operates with an input level of 2 VRMS. Damon/Electronics Div., 115 Fourth Ave., Needham, MA 02194. **233**

Fast-recovery silicon rectifiers, TA7984, TA7985, TA7986 and TA7987, have voltage ratings of 100, 200, 400 and 600V, respectively, and an average forward-current rating of 40A. Price range for 1000-unit quantities is $3 to $6.70. RCA Commercial Engineering, Harrison, N J 07029. **234**

Bipolar static random-access memories, Types IM5523 and IM5533 are new additions to the IM5503 line of high-speed, fully decoded, static 256-bit RAMs in 256 × 1 organization. Compatible with DTL/TTL, their on-chip address decoding and high-speed chip select functions facilitate the incorporation of these memory elements into larger arrays. Intersil, 10900 N. Tantau Ave., Cupertino, CA 95014. **235**

Hybrid transistor J01001 provides 70W broadband VHF coverage with infinite VSWR capability. For higher power levels, two or more devices can be paralleled. Price in quantities of 100 is $67.50 each. TRW Semiconductor Div., 14520 Aviation Blvd., Lawndale, CA 90260. **236**

PA "Photochip" arrays, cadmium sulfide and cadmium sulfo-selenide photodetectors, are available with as few as two detectors or as complex configurations with up to 20 cells. Three basic materials are offered with peak spectral responses of 515, 575 and 625 nm. Price in 500 quantities is $3.50 each. Electronics Div., Allen-Bradley Co., 1201 S. 2nd St., Milwaukee, WI 53204. **237**

Surge arrestor CG75 fires at 75V, dissipates current pulses in the magnitude of 5000A and has a guaranteed life for 50 discharges under maximum load conditions—typical life, 200 discharges. The arrestor comes in button form for spring clip mounting or with #20 AWG wire leads. Signalite, Div. of General Instrument Corp., 1933 Heck Ave., Neptune, N J 07753. **238**

IC power drivers, Series 400 and 500, incorporate monolithic gates driving high-current switching transistors. Available in 14-lead DIP and flat packs, these devices are compatible with DTL and TTL and have a current capability of 250 mA/driver. Series 400 has a voltage capability of 40V, and series 500 100V. Sprague Electric Co., 115 Northeast Cutoff, Worcester, MA 01606. **239**

Silicon rectifiers, 44001 to 44007, are diffused-junction devices in axial-lead plastic packages. They are electrically identical to JEDEC Types IN4001-IN4007. Voltage ratings are 50, 100, 200, 400, 600, 800 and 1000V, and average forward current rating is 1A. RCA Commercial Engineering, Harrison, N J 07029. **240**

Schottky TTL MSI circuits recently added to the Series 54S/74S are the SN54S/74S181, 153 and 74. The 181 arithmetic logic unit offers typical add times of 20 nsec for 16-bit words. The 153 dual 4-line to 1-line data selector/multiplexer has gate delays of only 2.8 nsec. The 74 dual Type D flip-flop clocks at up to 110 MHz. Texas Instruments Incorporated, Box 5012, Dallas, TX 75222. **241**

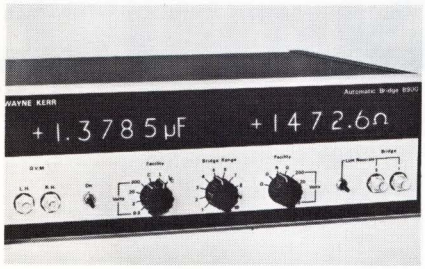
Class AB power amplifier, Model 540, is capable of providing output drive current of 120 mA typical. Unit prices in quantities of 100 to 999 are $3.40 (military) and $2 (commercial). Signetics Corp., 811 E. Arques Ave., Sunnyvale, CA 94086. **242**

Dual monolithic, N-channel, field-effect transistors, Types SMF3954, 3956 and 3958, are direct replacements for 2N3954 and 2N5452 offering improved thermal tracking characteristics and current ranges. Rapid chip-to-chip thermal transfer allows each FET to experience the same thermal state in a very short period of time. Solitron Devices, Inc., 8808 Balboa Ave., San Diego, CA 92123. **243**

Silicon gate devices include four character generators (5 × 7 matrix), two 2k-bit ROMs and five shift registers. All units are TTL/DTL compatible. Unit prices for 100 to 999 quantities range from $10 to $16.70 (character generators), $20 to $22 (ROMs) and $4.90 (shift registers). Fairchild Semiconductor, 484 Ellis St., Mountain View, CA 94040. **244**

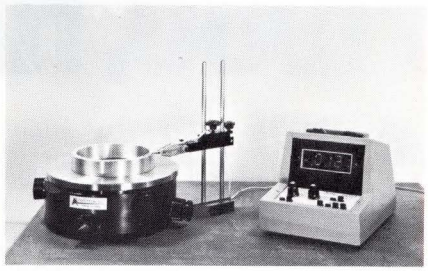
High-power impatt diodes are now available for use at C-band. VAO-30 Series consists of 10 devices, ranging from 10 mW to 1W r-f CW power output. These low-noise, avalanche silicon diodes are designed for use in fundamental oscillators operating at frequencies between 6.0 and 8.0 GHz. Operating voltages are 100 to 125V. Varian, Solid State Div., Salem Rd., Beverly, MA 09195. **245**

Quad gate series offers units with four channels of analog gating that are designed to eliminate the need for an external driver. Four models are available—IH5009, IH5010, IH5011 and IH5012. Packaged in silicone DIPs, the units are priced at $4 (100 pieces). Intersil, 10900 N. Tantau Ave., Cupertino, CA 95014. **246**



Automatic digital bridge, Model B900, provides direct readout of capacitance, inductance or the reciprocal of capacitance on one display and resistance, conductance, loss factor and Q on the other. The instrument can measure 2-, 3- and 4-terminal passive and active components and networks. TTL output is provided for use with ancillary equipment. The Wayne Kerr Co. Ltd., Tolworth Close, Tolworth, Surbiton, Surrey, England. **247**

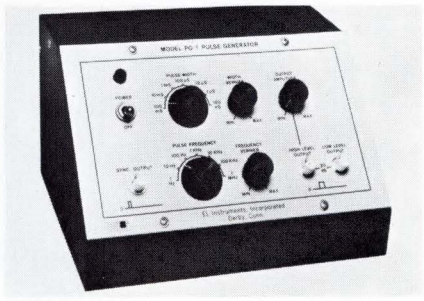
In-circuit IC fault locator evaluates RTL, DTL, TTL and MOS ICs as well as other semiconductors, PC boards and cable harness. The CL-2 scans a 30 gate wired-OR output in 30 sec. The injection signal is provided by a self-contained VLF transmitter and reception is by a phase-locked receiver with field-strength meter. Price is less than $850. Amex Electronic Systems Inc., 5319 W. 146th St., Lawndale, CA 90260. **250**



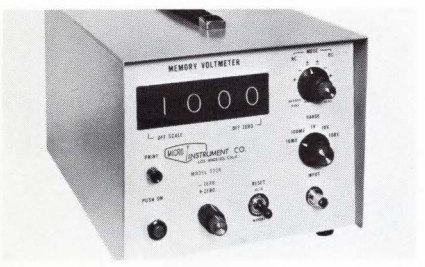
Digital differential gauge is useful for absolute, comparative or differential measurement. Consisting of a solid-state differential amplifier with two gauge heads that offer repeatability of 0.5 millionths of an inch, the Model ADG-201 has a maximum range of ±0.01 inch. The automatic bi-polar output is equipped with an over-range indicator light. Aerotech, Inc., 4055 William Flynn Hwy., Allison Park, PA 15101. **253**

Power supplies deliver 0 to 100V at 0 to 1 mA. Model 6211A, priced at $105, is a constant voltage/current limited unit while Model 6212A, priced at $130, is constant voltage/constant current. Features include 0.01% load and line regulation and an output isolated for up to 300V above ground. Hewlett-Packard Co., 1601 California Ave., Palo Alto, CA 94304. **248**

Digital multimeter with 23 ranges of measurement that include dc volts and current, ac volts and current and ohms has basic accuracy of 0.02% of reading. Other features include guarded input, isolated BCD and system functions, 40% overrange and high overload protection. Price is $695 each. United Systems Corp., 918 Woodley Rd., Dayton, OH 45403. **251**

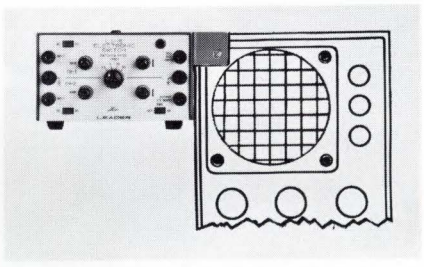


Pulse generator that sells for $150, Model PG-1, provides a frequency range of 1 Hz to 1 MHz and pulse-width range of 100 nsec to 100 msec. High-speed linear and digital ICs are extensively used. Rise and fall times of <20 nsec insure compatibility with RTL, DTL and TTL IC modules. El Instruments Inc., 61 First St., Derby, CT 06418. **254**



Transient millivoltmeter with 4-digit display measures the amplitude of spikes, surges, transients and single pulses in the 1 to 1000 mV range. Model 5206 provides response from dc to 10 μsec. It holds, until reset, the peak amplitude of applied voltages regardless of waveform, polarity or time of occurrence. BCD output is optional. Price is $1950. Micro Instrument Co., 12901 Crenshaw Blvd., Hawthorne, CA 90250. **249**

VCF waveform generator, Model 7230, covers from 0.0001 Hz to 20 MHz with 30V pk-pk output. Sine, square, triangle, ramp, pulse and sync waveforms are featured, along with adjustable dc offset, adjustable waveform symmetry and ac modulation or sweeping capability over a 1000:1 frequency ratio. Price, complete, is $795. Exact Electronics, Inc., Box 160, Hillsboro, OR 97123. **252**



Electronic switch for providing dual trace on any single-trace oscilloscope has frequency response of dc to 300 kHz (2 Hz to 300 kHz on ac). Model LS-5 has switching frequencies of 1.5, 5, 30 and 50 kHz. Vertical sensitivity is 0.05V/cm with input impedance of 1 MΩ and 40 pF. Price is $69.95. Leader Instruments Corp., 37-27 Twenty-Seventh St., Long Island City, NY 11101. **255**

HE CRASHED AT 50 mph. IN 1980, HE MIGHT SURVIVE.

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And in just a few years, your new car will have air pollution controls. Computers inside to control speed and braking. Bumpers that really take bumps. Air bags that will inflate at the moment of collision.

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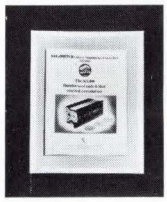
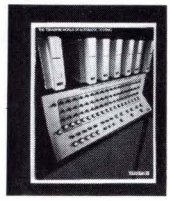
The American Business Press (ABP) is an association of over 500 publications serving business, industrial and professional audiences.

Aluminum heat-sink extrusions are shown with line drawings and dimensions in a six-page catalog that opens into a quick-reference guide in wall-chart form. The brochure includes 107 popular extrusion models. Precision Dipbraze Tor, Inc., 14715 Arminta St., Van Nuys, CA 91402. **256**

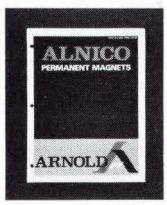


Thumbwheel switch brochure completely illustrates the features of the 1776 Series miniature switch. Information on special applications, prices, truth tables and distributor locations is included. Electronic Engineering Company of California, Electronic Products Div., 1441 E. Chestnut Ave., Santa Ana, CA 92701. **260**



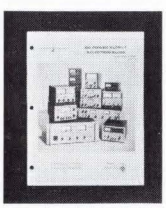
"The Teradyne World of Automatic Testing" is a 42-page illustrated catalog that describes the firm's lines of test equipment for semiconductors, passive components, relays, wiring harnesses, backplanes and other electronic devices. Teradyne, Inc., 183 Essex St., Boston, MA 02111. **264**

Relays, reed switches and optoelectronic components are covered in a 20-page distributor stock catalog. New additions include dual in-line packaged and pico-type reed relays, time-delay and latching relays as well as reed-triggered triacs. Product information includes illustrations, dimensions and prices. Sigma Instruments Inc., 170 Pearl St., Braintree, MA 02185. **257**

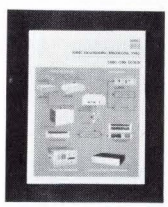


Alnico permanent magnets are described in a 16-page catalog that includes magnetic and physical properties for 10 grades of cast Alnico alloys, including the new ArKomax 800, and five grades of sintered Alnico. Typical demagnetization curves and other engineering information are given to aid in material selection. The Arnold Engineering Co., Box G, Marengo, IL 60152. **261**

Real-time peripheral devices of the RTP7400 Series are covered in this 16-page bulletin. Complete pricing and configuration information on each of the six major components of the series and on accessory items is provided in addition to dimensional information and a guide on how to configure the RTP System. Computer Products, 1400 N.W. 70th St., Box 23849, Ft. Lauderdale, FL 33307. **350**



"DC Power Supply Selection Guide" is a 40-page booklet that lists general-purpose and special-purpose power supplies by voltage and current in tabular form. The comprehensive tables include both performance data and operating features. Outline drawings with dimensions are also included. Hewlett-Packard Co., 1601 California Ave., Palo Alto, CA 94304. **258**

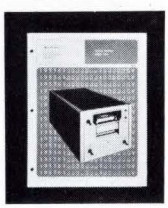


Transducers, digital test equipment, power supplies and timing and data products are summarized in this 16-page short-form catalog. It is packed with general and specific descriptions of the various products and contains application information and prices. SRC Div./Moxon Inc., 2222 Michelson Dr., Newport Beach, CA 92664. **262**

Instrument rental catalog includes rental information for general purpose test equipment such as analyzers, bridges, power supplies, generators, amplifiers, scopes, counters and meters. Seven nationwide inventory centers supply instruments within 24 hours. Rental Electronics, Inc., 16600 Oakmont Ave., Gaithersburg, MD 20760. **351**

Shaft-angle encoder systems that utilize resolvers as transducers are described in an eight-page catalog. A line of encoders with accuracies to 0.01° and in rack-mount or carrying-case configurations are discussed. Astrosystems, Inc., 6 Nevada Dr., Lake Success, NY 11040. **259**

Custom fiber-optic arrays are discussed in this four-page brochure that illustrates a card/tape reader application and points out the design advantages of fiber optic arrays over other approaches. Sensor Technology, Inc., 7118 Gerald Ave., Van Nuys, CA 91406. **263**



Digital printer, Model 1454, with speeds up to 3 lines/sec is described in Bulletin 5004. Photographs, complete specifications and information on the addition of seven-column plug-in modules are included. Beckman Instruments, Inc., 3900 River Rd., Schiller Park, IL 60176. **352**

Modular thumbwheel-switch product lines are detailed in a six-page brochure with descriptions, specifications and dimensioned photographs. In addition to standard lines, the literature includes "special standards," the Digivider voltage divider and the newest Series 29000 thumbwheel switch. The Digitran Co., 855 S. Arroyo Pkwy., Pasadena, CA 91105. **265**

Microminiature RF connector line, "Combomate," is described in a four-page brochure. A termination method is detailed for superior RF performance and elimination of new layout tooling changes. Connector Div., Microdot Inc., 220 Pasadena Ave., South Pasadena, CA 91030. **266**

Modular line of optical rotary encoders, "MOD-CODER/R," is described in a two-page bulletin that provides detailed specifications, a photo and outline drawing and a suggested list of applications. Sequential Information Systems, Inc., 249 Saw Mill River Rd., Elmsford, NY 10523. **267**

Miniature hardware guide is a 10- by 4-inch slide rule that gives complete specifications for micro-eyelets in sizes for ICs to PC boards, microrivets and microscrews, washers and nuts in sizes from 000 to 4. Circon Corp., Santa Barbara Airport, Goleta, CA 93017. **268**

Laminated buss bars, solderless clip-on busses and special buss interconnect devices are featured in a comprehensive 32-page catalog. Bussco Engineering Inc., 122 Penn St., El Segundo, CA 90245. **269**

Low-cost printers and plotters of the LP 3000 and LP 3300 Series are described in data sheet PD3-101. This bulletin includes specifications, suggested applications and a sample printout. Potter Instrument Co., Inc., 532 Broad Hollow Rd., Melville, NY 11746. **270**

Displays and controls are described in catalog C71-0571, a 20-page brochure that features electroluminescent and LED displays, controls and display/control combinations that have been built for aerospace applications by the Kearfott Div. of the Singer Company, 1150 McBride Ave., Little Falls, N J 07424. **271**

Thick-film pastes for hybrid ICs, ceramic packaging, digital display and microcircuit applications are covered in a four-page brochure that lists metal content, firing temperatures, properties and applications for conductive, resistive and glass-dielectric pastes. Electro-Science Laboratories, Inc., 1133 Arch St., Philadelphia, PA 19107. **272**

Solid tantalum capacitors (epoxy dipped) are described in a brochure that provides performance characteristics, outline drawings, typical performance curves and a listing of standard units. Union Carbide Corp., Components Dept., Box 5928, Greenville, SC 29606. **273**

Cermet resistor networks covered in Brochure 5850 include dual and single in-line packages compatible with automatic insertion machines. Features, specifications, dimensions and other data are given. Allen-Bradley Co., Electronics Div., 1201 S. Second St., Milwaukee, WI 53204. **274**

Automatic/semi-automatic op amp tester guide describes methods for testing up to 16 op amp or comparator parameters in less than 3.2 sec using precise synchronous-demodulation techniques. Teledyne Philbrick, Allied Dr. at Rte. 128, Dedham, MA 02026. **275**

Urethane resins are described in an application and properties chart that lists encapsulating resins, surface coatings, casting resins, adhesives and sealants. Furane Plastics, Inc., 5121 San Fernando Rd. W., Los Angeles, CA 90039. **276**

"Black-screen" display screen lighting technique is described for illuminated pushbutton switches. Colors or legends do not show when internal lamps are not lit. New product bulletin 232 is available from Switchcraft, Inc., 5555 N. Elston Ave., Chicago, IL 60630. **277**

Cold weld process for sealing semiconductor packages and other devices adversely affected by the heat of conventional sealing is described in Bulletin 501. Details and engineering drawings are also provided for standard headers and covers. National Beryllia Corp., Haskell, N J 07420. **278**

"Interconnection Techniques for Flat Flexible Cabling" is an eight-page brochure dealing with techniques to terminate flexible printed circuitry. A number of lightweight connectors are covered, including box mounting receptacles, miniature and subminiature, hermetic and PC board connectors. The Deutsch Co., Municipal Airport, Banning, CA 92220. **279**

"Extruded Sponge of DuPont VITON Fluoroelastomer" is a pamphlet that gives facts about grades, compression set values, fluid and heat resistance and cost comparisons. DuPont Co., Elastomer Chemicals Dept., Room 7523, Wilmington, DE 19898. **280**

Microelectronic hybrid thick-film capabilities and facilities are outlined in an eight-page brochure. It describes circuit design and production facilities, quality control and reliability procedures and packaging techniques. CTS Microelectronics, Inc., West Lafayette, IN 47906. **281**

DIP, transistor and tube sockets are described and illustrated in a 14-page guide featuring over 360 models including 14- and 16-pin DIP sockets; 3-, 4- and 7-pin in-line transistor sockets; 8-, 12- and 14-pin relay sockets and others. Elco Corp., Willow Grove, PA 19090. **282**

Enclosed relays are covered in an eight-page manual/catalog that describes the complete 1300 line of miniature multipole enclosed relays. Guardian Electric Mfg. Co., 1550 W. Carroll Ave., Chicago, IL 60607. **283**

Bushing catalog describes and illustrates 157 sizes and types of nylon strain reliefs and adapters, snap bushings, open/closed bushings, snub bushings, nylets, hole plugs and terminal bushings. Heyman Manufacturing Co., 100 Michigan Ave., Kenilworth, N J 07033. **284**

Electromechanical counters in 3-, 4-, 5-, 6- and 8-digit models are described in Bulletin 601. Specifications, wiring instructions are detailed dimensional information are shown for three different mounting styles of the Type RG long-life counters. SODECO, 4 Westchester Plaza, Elmsford, NY 10523. **285**

"..and another nice feature of this equipment –anytime you wish you can unplug it and make decisions yourself."

"Nothing" Is Noted

With apologies to the companies whose literature appeared in the "Also Worth Nothing" section of Design Dataline (Feb. 15 EDN), we at least provided a lift for one of our observant readers. He wrote:

"Gentlemen: I know that Also Worth Noting is the correct way, but this spelling in your February 15 edition is certainly more entertaining. Thank you for the cheer."

Sincerely,
Richard Stearns
Monarch Machine Tool Co.
Sidney, Ohio

Relay Book Questioned

An announcement of the "D.A.T.A. Book of Miniature and Subminiature Relays" that appeared in the August 15 EDN/EEE prompted Mr. E. U. Thomas, Chairman, SAE A-2R Relay Committee, to write the editor commenting on the book's limitations.

His recent review of this book was enclosed. It states in part:

"The D.A.T.A. book confines itself to MIL-R-5757, does not indicate which relays are 'not for new design' and gives no data for loads other than dc resistive. Data at 25°C only are not adequate for proper selection. A better document is MIL-STD-1346, Relays, Application & Selection, which gives complete listing of contact capabilities for relays preferred for new design and for which there is at least one QPL'd source. It is available from C.O.-U.S. Naval Supply Depot, 5801 Tabor Ave., Philadelphia, PA 19120, for much less than $27.50."

Generator Concept Not New

Gentlemen:

In the June 15 issue of EDN/EEE, page 58, I am puzzled as to what is novel about "Stepped saw-tooth tone generator" #162, which achieves eight octaves of tone with six ICs following a master oscillator and Schmitt trigger.

Mr. Haigler mentions three references to stair stepped generators then continues:

ITT#SAJ110 is a single-IC seven-stage frequency divider, that apparently could replace the six ICs in Krabbe's circuit.

In a circuit with the master oscillator running at double the highest output frequency, the highest output need not be a square wave. It also could have been stairstepped for better tone quality.

Very truly yours,
Edmund D. Haigler, P.E.

Mr. Krabbe responded to Mr. Haigler's letter with the comments:

"I think Mr. Haigler's puzzlement would be justified if he assumed that I was claiming novelty for a new circuit concept. My purpose in developing the published circuit was to introduce the possibility of using monolithic ICs in commercial organ manufacture.

Volume production of organs could take advantage of the IC's smaller volume, reduced component count, improved reliability and ruggedness, automatic insertion capabilities into PC cards and potential low cost. Small size and low power consumption would also make the final instrument smaller, lighter and therefore a more attractive buy.

Mr. Haigler suggested that the single ITT#SAJ110 could replace the four SN7474 flip flops in my suggested circuit. I was unaware of the availability of this IC device when I developed this circuit concept in 1970. But if it does indeed replace the SN7474s, then it provides a further important step in the right direction.

Present availability of the ITT device in my view enhances the usefulness of the circuit concept. By replacing the four flip flops with one monolithic device, the IC approach is extended. Equally important, the advantages of the AD555 quad switches are retained. The AD555 provides 12 bits of accuracy in an eight-bit application insuring guaranteed monotonicity in the output wave, thus, providing a more even distribution of harmonics."

Very truly yours,
H. Krabbe
Analog Devices, Inc.

Editor's Note: Mr. Krabbe's circuit was voted winner of the June 15 Circuit Design Award Program.

DC Power Supplies

Power Supply Selection Guide; Acopian Corp., Easton, PA 18042; 42 pages; free.

This publication, although a manufacturer's catalog, has been organized to work as an engineering design aid. Using it, an engineer can determine which supply is best for his application by selecting from more than 200,000 different power module possibilities. Despite the huge number of possibilities, the manufacturer says he can ship any model ordered within 3 days. Users determine part numbers by adding appropriate prefixes or suffixes to a basic number (a 28UA100L breaks down as 28-28V, UA-unregulated series, 100-1A, L-solder terminals). By using the catalog information, an engineer can also design a rack-mounted multiple-output power system, order it over the phone and receive the system, fully wired and tested, 9 days later.

Electronic Switching Theory and Circuits

H. J. Beuscher, A. H. Budlong, M. B. Haverty and G. Waldbaum; Van Nostrand Reinhold Company, 450 W. 33rd St., New York, NY 10001; 1971; 361 pages; $17.95.

A thorough background is provided in switching theory and circuits used in the design of digital systems. In addition to fundamentals, the authors also deal with some of the practical problems frequently encountered in logic design.

Subjects covered include: propositional logic; analysis and synthesis of electronic combinatorial circuits from a logic designer's and a circuit designer's point of view; a similar approach for electronic sequential circuits including both asynchronous and synchronous circuits; methods of state reduction and minimization; survey of semiconductor gates including DCTL, TDL, TRL, DTL, ECL and TTL; monolithic ICs; and relay design techniques including symmetric and sequential circuits.

A set of problems at the end of each chapter is designed to test the reader's comprehension of the material presented and to introduce new concepts in related areas.

Transistor D.A.T.A. Book

D.A.T.A., Dept. 71H, 32 Lincoln Ave., Orange, N J 07050; Fall 1971; $36.50 for two semiannual editions.

Complete commercial transistor lines of 106 foreign and domestic manufacturers are included in this edition, which incorporates a 35% update from the Spring issue.

Over 19,000 devices are listed by major electrical characteristics and are cross-referenced to more than 425 outline drawings. U.S. military transistors are listed separately by type number, with qualified manufacturers. Possible substitutes for a given type are also listed in order of basic parameters.

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Advertiser's Index

Application Notes

Low-power channel amplifier for use in FDM and PCM telephone equipment—one that has good noise performance, low quiescent power consumption, high output current capability and absolute short circuit protection—is described in an eight-page applications bulletin. European Electronic Products Corp., 10150 W. Jefferson Blvd., Culver City, CA 90230. **375**

"Experiments with Function Generators and Multipliers" is an eight-page application note that describes some basic experiments in frequency and amplitude modulation. Function generators and multipliers are used to examine various communication techniques. Clarke-Hess Communication Research Corp., 43 W. 16th St., New York, NY 10011. **377**

Ferroresonant technique of voltage stabilization is described in a six-page brochure that contains performance graphs, mechanical installation data and descriptions of 58 types of "PRM" voltage stabilizers. Models covered span the range from 4.5 to 240V dc, with ratings from 60 to 300W. Kepco, Inc., 131-38 Sanford Ave., Flushing, NY 11352. **379**

"Ultra-Linear 100W, 12.5 volt HF/SSB Power Amplifier" is the subject of the 15-page application note CT-113-71. It discusses the use of high frequency single-sideband transistors in an amplifier that is capable of withstanding an all phase infinite VSWR at maximum power output. Detailed performance characteristics, schematic diagrams and parts lists are included. TRW Semiconductors, 14520 Aviation Blvd., Lawndale, CA 90291. **376**

"Withstand Current Ratings for Automatic Transfer Switches" is a primer on short circuit characteristics. It discusses RMS and peak current, symmetrical and asymmetrical current and the amount of fault current that will flow through a short circuit. The effects of short circuits on automatic transfer switches are described, and parameters to consider in selecting transfer switches are discussed. Automatic Switch Co., Florham Park, N J 07932. **378**

"Power Supply Killers" is an eight-page bulletin designed to assist specifiers, users and purchasers in selecting power supplies. A method is described for choosing a power supply on an economic basis, from a number of sources offering essentially equivalent items. Selection is based on initial cost plus expected repair costs during the anticipated life of the equipment. Deltron Inc., Wissahickon Ave., North Wales, PA 19454. **380**

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