Electronic Design®

VOL. 25 NO. 9

FOR ENGINEERS AND ENGINEERING MANAGERS

APRIL 26, 1977

The flat, flexible cable spectrum ranges from conventional wires woven into a ribbon to flexible circuit boards. Choose the right cable and you can save time, money, weight and space. But you must choose correctly from hundreds of different kinds and interpret some "flexible" specs. Make the connection on p. 60.

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Style	Charac-teristics	Qualified Terminals	Description
MIL-R-27208			
RT10	C2	L,P	1″ long
RT12	C2	L,P,Y	1¼″ long
RT22	C2	L,P,W,X	½″ square
RT24	C2	L,P,W,X	⅜″ square
RT26	C2	W,X	¼″ square
MIL-R-39015			
RTR12	D	L,P,Y	1¼″ long
RTR22	D	L,P,W,X	½″ square
RTR24	D	P,W,X	⅜″ square

CERMET

Style	Charac-teristics	Qualified Terminals	Description
MIL-R-22097			
RJ12	C,F	L,P,Y	1¼″ long
RJ22	C,F	L,P,W,X	½″ square
RJ24	C,F	L,P,W,X	⅜″ square
RJ26	C,F	P,W,X	¼″ square
RJ50	C,F	P	¼″ round
MIL-R-39035			
RJR12	C,F	L,Y	1¼″ long
RJR24	C,F	P,W,X	⅜″ square
RJR26	F	P,W,X	¼″ square
RJR28	C,F	P	½″ long
RJR32	C,F	D	¾″ long DIP

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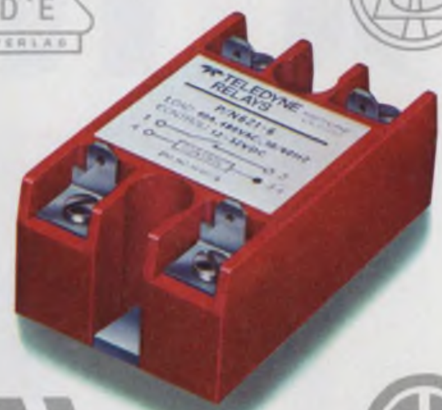
CIRCLE NUMBER 245

CIRCLE NUMBER 2

SSR UPDATE

Our International Connection



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CIRCLE NUMBER 3

Electronic Design®

FOR ENGINEERS AND ENGINEERING MANAGERS

VOL. 25 NO. 9

APRIL 26, 1977

NEWS

TECHNOLOGY

PRODUCTS

DEPARTMENTS

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ELECTRONIC DESIGN is published biweekly except 3 issues in July by Hayden Publishing Company, Inc., 50 Essex St., Rochelle Park, NJ 07662. James S. Mulholland Jr., President. Printed at Brown Printing Co., Waseca, MN. Controlled circulation postage paid at Waseca, MN and New York, NY, postage pending Rochelle Park, NJ, Atlanta, GA. POSTMASTER: Please send form 3579 to ELECTRONIC DESIGN, P.O. Box 13803, Philadelphia, PA 19101.

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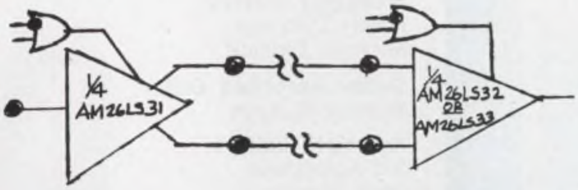

Am26LS31
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Am26LS32
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Across the desk

Monolithic? 12 bits? A DAC?

I was delighted to see, in the February 15 issue (p. 36) that I have been "immortalized by deposition" in having my initials appear, under a slightly eroded heart, on Precision Monolithics' 12-bit current-switching DAC. It was also pleasing to learn that they remember my oft-repeated statement that "there are no (current-switching) monolithic 12-bit DACs on the market . . .and there never will be." Despite PMI's development, I remain convinced of the validity of my statement.

Before explaining further, let me point out that the engineering staff at Analogic has the highest regard for the technical competence of the people at Precision Monolithics. Indeed, Analogic is a substantial customer for its products. And its latest development, though not yet in production, confirms our high opinion of the company—but in no way controverts my original statements.

First, the new DAC is *not*, strictly speaking, a monolithic device. It has thin-film resistors, and they are *deposited* (like my initials and the bitten heart) on the substrate in a separate operation. It is my understanding, and both Webster and technical dictionaries seem to agree, that the term "monolithic" means to be composed of a single material. Thus, a silicon substrate with diffused impurities may be considered monolithic, but a silicon substrate with added thin-film resistors cannot.

I was further pleased to read that the PMI people agree with statements I have made on many occasions and have themselves concluded that laser-trimmed, thin-film resistors may not be stable enough for precision converters. As a matter of fact, the new PMI device isn't even a complete DAC. It is a circuit from which a DAC may be made; that is, it does not contain a reference or an output amplifier or bypass capacitors, etc. Therefore, its specifications, whatever they ultimately may be on the basis of production experience, are not "self-contained." We might call this device, at best, a "DAC circuit."

Now then—what about the "unattainability" of a 12-bit monolithic DAC? For a device to qualify as a 12-bit DAC, it is not sufficient that the device be capable of accurate 12-bit conversions merely at the moment of manufacture, or on shipment, or at incoming inspection, or even at the moment of installation in the host equipment. A *real* 12-bit device must *maintain* its accuracy over an extended period of time, over a reasonable operating temperature range, and after many on/off cycles. If we examine the parametric constraints involved in creating such a 12-bit device, we discover certain fundamental technical problems.

Let's assume that the happy day will come when a manufacturer of DACs or DAC circuits will supply a histogram of the probability of shift as a function of time, temperature, further manufacturing procedures, even environment. Such a histogram would take into account the fact that the initial trimming procedure cannot be perfect because of the finite number of trim operations, which were described in the PMI article.

So initially there will be a nonlinearity error of an eighth, a quarter or a half a bit, depending on the fortuitous combination of initial condition and trim capabilities. Furthermore, initial errors will stem from the fact that the trimming equipment, like any other instrument, has a certain amount of random and systematic noise and is not based at the NBS.

(continued on page 11)

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

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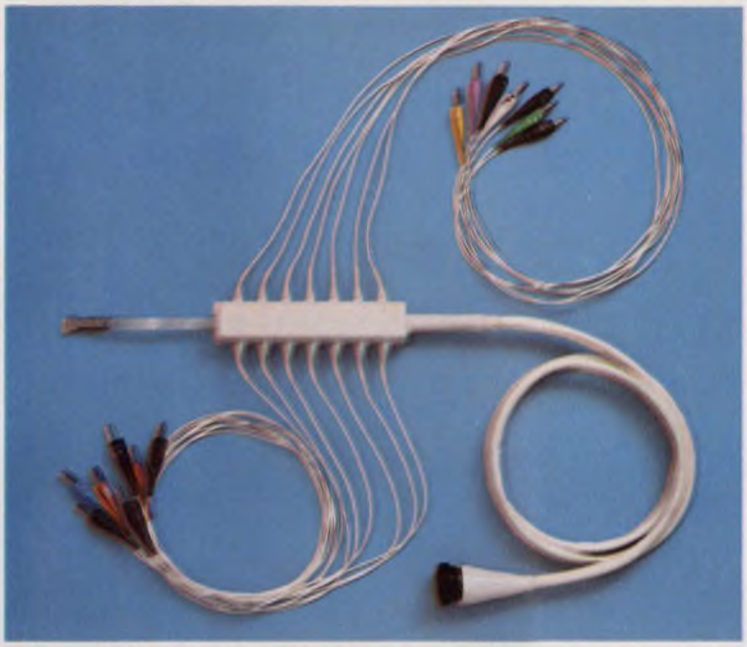

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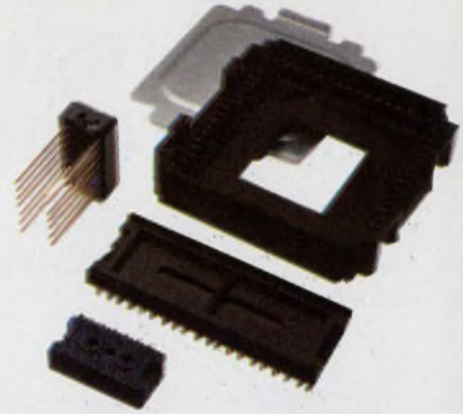

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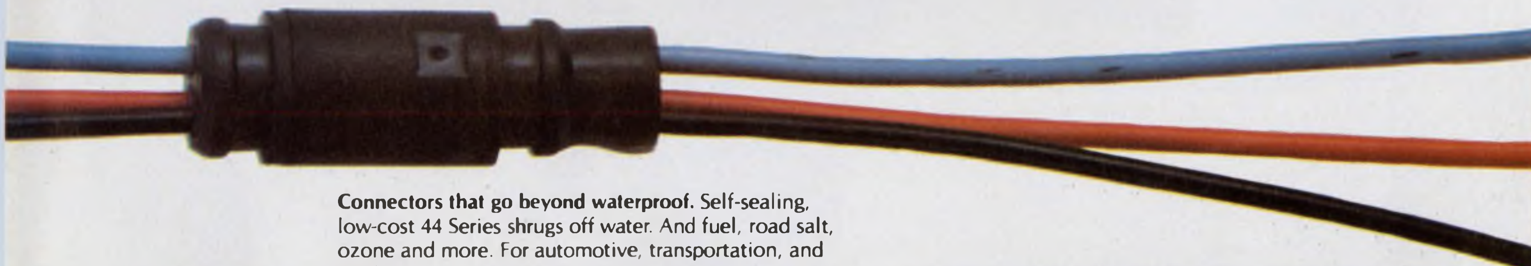

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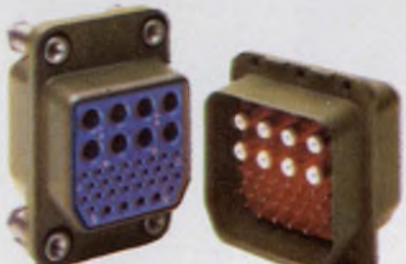

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CIRCLE NUMBER 8

Across the desk

(continued from page 7)

Therefore, we must accept the fact that there will be initial errors. We must also accept the fact that the resistors will drift with time. It is not a question of whether they will drift or not—it is only a question of *how much.* And once the zeners are zapped and the resistors drift, the zeners cannot be zapped again a year later. Indeed, for a device of this type, it may be impossible, once a unit has drifted out of specification, to bring it back again. We will then have to face failure —not a failure to function, but a failure to meet specifications. Presumably, if a 12-bit DAC is needed to begin with, it will be needed a year later. Now we see why so much money is spent on engineering rework, debugging and warranty service for analog-to-digital and digital-to-analog converters.

More problems will crop up. Other parameters will drift. The V_{BE} offsets of the current-switching transistor will change some finite amount. The reference will change. The offset in the servo amplifier will change as well as the offset in the output amplifier. All of these changes—some small, some large —must be constrained to within a fraction of a bit, including the effects of differential variations in resistor values over temperature. For a unit to be called a 12-bit DAC legitimately, there must be some means of recalibrating the device after some reasonable time of operation.

Now suppose we intend to purchase a substantial number of DACs—say, a thousand—and put them into equipment that we manufacture. Let us also assume that the requirements *demand* 12-bit-DAC performance; otherwise, the whole discussion is meaningless. After a reasonable time (say, a year) in the hands of our customer, and after exposure to even a modest operating temperature range (let's say ±20 C), and after several hundred on/off power cycles, what percentage of the units we have installed will still be 12-bit DACs?

An experienced and conscientious manufacturer might allow himself a failure rate of perhaps 3% per year from *all* sources, and the DAC would be only *one* source. But let us be even more generous, and stipulate that, after one year, 970 DACs remain accurate to 12 bits. When someone can meet that criterion with a *truly monolithic device,* one may indeed be forced to "eat one's heart out."

What are the realities? We have already discussed the fact that all resistors drift with time. It would indeed be an excellent set of resistors, by any standard, that could be counted on, in quantity, to track to within 30 to 60 ppm per year. Indeed, to accomplish this today would require either premium-grade, wirewound resistors or the highest-quality bulk-film resistors. Resistors alone would account for a quarter of a bit of drift.

Let's assume that V_{BE} changes account for another tenth or two-tenths of a bit, and allow some reasonable change for leakage variations, and for changes in the reference. Then, to maintain a linearity of ±½ bit, the over-all temperature coefficient of the unit would have to be constrained to some fraction of a ppm/°C. Maybe some of our assumed 1000 monolithic (or quasimonolithic) 12-bit DACs will do all this, but I think PMI, and more experienced readers, would agree that *too many of them won't.* And that's why I remain unconvinced.

Additional insight into this problem can be obtained by reviewing the excellent article on amplifiers, starting on page 72 of the same issue. It's a most needed article, for it points out the limitations and deficiencies of available operational amplifiers, both from a functional point of view and with respect to the manufacturers' specifications. Analog-to-digital and digital-to-analog converters are much more complex than operational amplifiers *per se.*

Thus, it is not necessary to fall back on semantic definitions to protect the technical honor of the 12-bit DAC. We must realize that 12-bit devices, let alone those with 13, 14, 15 or 16 bits, require more attention to detail than may be available in semiconductor processing.

Nevertheless, we wish to acknowledge Precision Monolithics dedication to the advancing semiconductor-converter art and to thank them—dare I say "wholeheartedly"?—for associating me so intimately with its efforts.

Bernard M. Gordon
Chairman

Analogic Corp.
Wakefield, MA 01890

Sure it is

Let me confirm the mutual respect that Precision Monolithics' engineering staff has for Mr. Gordon and Analogic. We do not consider modules

(continued on page 16)

technology which, as you might suspect, is a patented Fairchild process.

The new process not only allows us to turn out faster parts for less cost, but also enables us to reduce die sizes from 20% to 50%.

And, if the initial results with the WEI process are any indication, you haven't seen anything yet.

SO WHAT ELSE IS NEW?

How about a 35ns 4096 X1 static TTL RAM? Or a 256 X 1 ECL RAM with a T_{AA} of 6ns typical? Both of these products and more are way beyond drawing board status at Fairchild. In fact, we should be announcing quantity production and distributor availability any day now.

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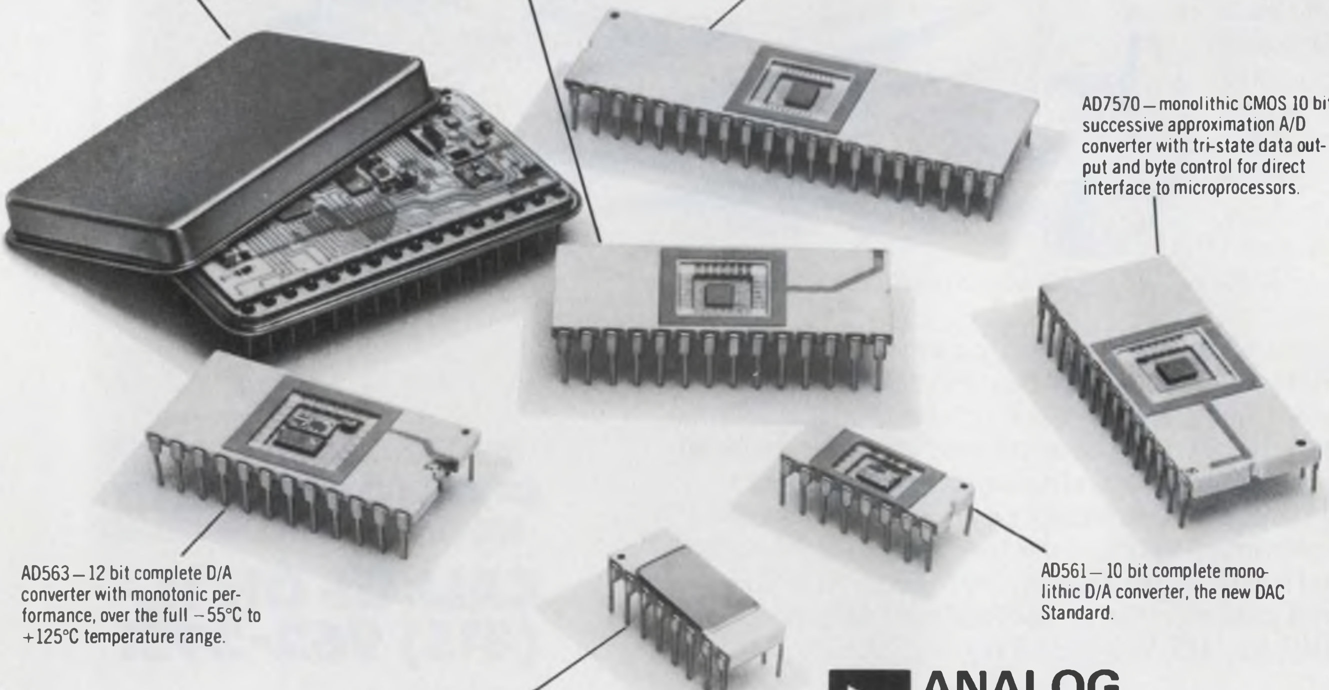
And look what our bipolar expertise plus innovations in thin film processing and laser trimming technology ultimately led to. The first monolithic laser wafer trimmed bipolar converters with unmatched accuracy and stability.



AD572—complete 12 bit successive approximation A/D converter can guarantee no missing codes over the full −55°C to +125°C temperature range.

AD7522—first monolithic CMOS 10 bit multiplying D/A converter with input buffer and holding register, allowing direct interface to microprocessors.

AD7550—13 bit monolithic CMOS integrating A/D converter using our revolutionary "Quad Slope" conversion technique for extremely high precision and stability. Tri-state data output and byte control for direct interface to microprocessors.

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AD563—12 bit complete D/A converter with monotonic performance, over the full −55°C to +125°C temperature range.

AD561—10 bit complete monolithic D/A converter, the new DAC Standard.

AD7520—first monolithic CMOS 10 bit multiplying D/A converter.

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Across the desk

and monolithics competitive, and we value Analogic as a good customer for many of our products.

Mr. Gordon's treatise on our DAC-12 seems to focus on two points: definition of "monolithic," and definition of "DAC."

1. Mr. Gordon is misinformed about the definition of "monolithic." *The IEEE Standard Dictionary of Electrical and Electronics Terms* says that a monolithic integrated circuit is "an integrated circuit whose elements are formed in situ *upon or within* a semiconductor substrate with at least one of the elements formed within the substrate." By Mr. Gordon's definition, there is no such thing as *any* monolithic circuit, since every one of them has thin-film metal interconnects.

2. "Complete" should be defined by the buyer. High-speed multiplying DACs *do not need* a reference, and an output op amp just slows them down.

The success of PMI's 8-bit DAC-08, which is also a current-output, multiplying DAC (recently second-sourced by four major semiconductor companies), calibrates what the *market* is buying, if not what Mr. Gordon is selling. We probably have more DAC-08s in final test or distributor stock than all the 8-bit modules ever produced.

The rest of Mr. Gordon's letter expounds on manufacturing techniques and the theoretical aspects of long-term stability.

I don't think we have to apologize for using the standard IC-production method of "yielding," "culling" or sorting by performance grade. Further, the zener-zap trimming technique is quite analogous to "tweaking up" a module.

Regarding long-term stability, PMI's 6, 8, and 10-bit DACs have been qualified to "Level A" reliability on virtually every military/aerospace program since 1970. Such qualifications include the most stringent AQLs and PDAs on all performance parameters during accelerated life tests at 125 C and higher. We will qualify the DAC-12 as soon as production units are available.

Rather than debate semantics and theory, let's wait for the results. If the DAC-12 does not meet Mr. Gordon's criteria for stability, we will, at that time, remove the chewed-up heart from the metal mask.

Earl Rogers
President
Precision Monolithics, Inc.
Santa Clara, CA 95050

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CIRCLE NUMBER 14

TAKE A CLOSE LOOK AT THESE BURROUGHS PLASMA DISPLAY BREAKTHROUGHS.

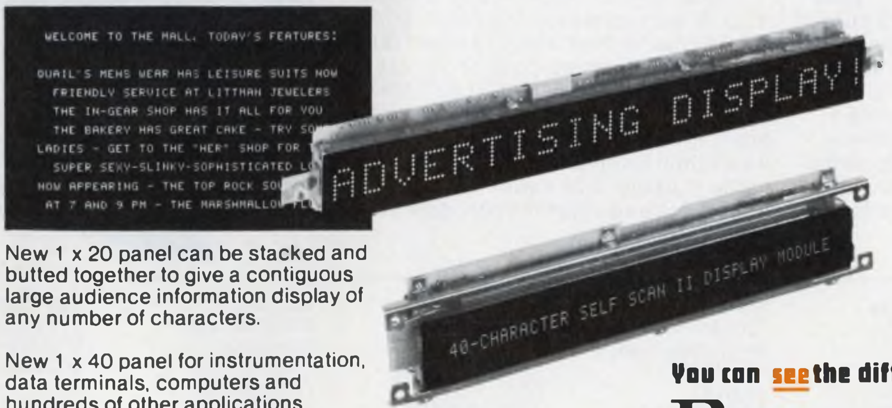
Easier to read
Greater brightness
Improved contrast
Larger matrix dot
Broader horizontal viewing angle
Lower power requirements
Cost effective design

The new Burroughs SELF-SCAN® II single register gas plasma panels are breakthroughs in visibility and readability, making them ideal for all types of applications — from audience information displays to instrumentation applications. They are digitally addressed to interface easily with microprocessors and computers.

Only 15 connections are required. These new units complement Burroughs' standard line of single register 16 and 32 character plasma displays.

The Burroughs SELF-SCAN II 1 x 20 and 1 x 40 displays. Certainly worth looking into.

Burroughs Corporation, Electronic Components Division, P.O. Box 1226, Plainfield, New Jersey 07061. Telephone (201) 757-5000. SELF-SCAN displays are available nationwide through our distributors, Hamilton/Avnet and Cramer Electronics.



New 1 x 20 panel can be stacked and butted together to give a contiguous large audience information display of any number of characters.

New 1 x 40 panel for instrumentation, data terminals, computers and hundreds of other applications.

You can see the difference

Burroughs

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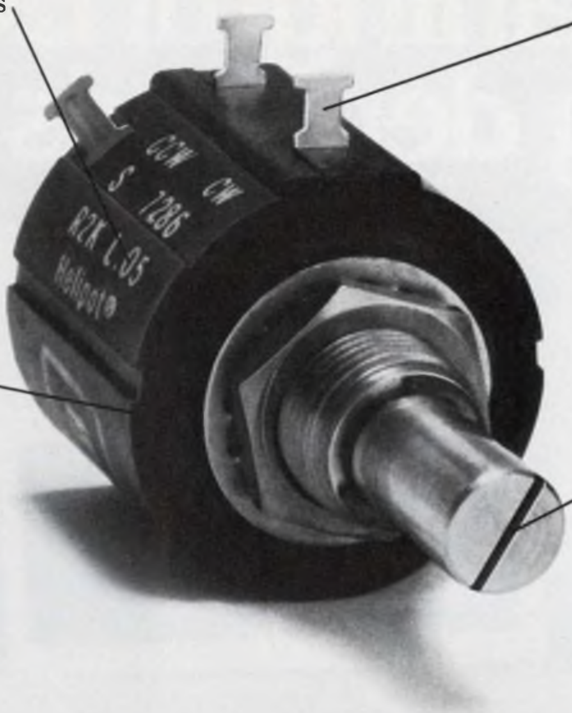
CIRCLE NUMBER 15



The Beckman 7/8" 10-Turn Model 7286

Pay less for a better-quality precision potentiometer.

Look at more of the specific features of the 100%-inspected Model 7286:

- Operating temperature of 125°C (max).
- Independent linearity well within 0.25%.
- Separate contact position guide to decrease coil wear.
- Power rating: 2 watts at 70°C.
- Resistance range: 11 standard wirewound versions from 100 ohms to 100K ohms.
- Excellent setting stability.

One of the fine Beckman Helipot® family of standard pots, in sizes from 7/8" to 3-5/16." All available in wirewound; many available with conductive plastic, cermet, or hybrid resistance elements.

Available for delivery now. To order, or for more information, call your nearest Beckman Helipot distributor, or call (714) 871-4848, Extension 1776.

And the price: just $4.68*

BECKMAN®

*In the 100-piece quantity.

CIRCLE NUMBER 17

What this country needs is a good $39 DPM.

And we've got it.

The AD2026 from Analog Devices. Priced at $39 in hundreds*, it's the first real alternative to the measurement grade analog panel meter. And the first to give you all the advantages of a DPM at a practical price. Advantages like visual appeal, accuracy, resolution, small size and reliability.

The AD2026 is a three digit, logic powered DPM that measures and displays voltages from −99mV to +999mV on 0.5″ LEDs. It consumes only ¾ Watts of 5V power. And because the AD2026 can be scaled with a simple resistive divider on its input pins, you can get direct readout in any engineering unit with equal or better resolution than APMs.

With an accuracy of 0.1% of reading ±1 digit, the AD2026 is again far superior to conventional APMs, where their inherent inaccuracy usually limits the total performance of the instrument.

The AD2026 conserves on space, too. Its small front panel size of 3.4″ x 2.0″ and only 0.64″ needed behind the panel makes it smaller than 3½″ scale APMs. But its performance outclasses 4½″ APMs.

When it comes to reliability, the AD2026 is unsurpassed. Its I^2L technology combines most of the active analog and digital circuitry on *one* chip. The AD2026 has only 14 components and a MTBF of 250,000 hours at 25°C. In a 24-hour-a-day application, you shouldn't expect a failure for 28 years.

A new commercial tester automatically tests all AD2026's for defects such as bad components and solder shorts. It also fully tests both the LSI chip and the complete DPM. Following 168 hours of failure free burn-in, the units are again 100% tested.

The AD2026. Its low price ($39/100s), small size, superior performance, and remarkable reliability make it the only sensible alternative to APMs. Which is just what this country needed.

Check it out. Return the coupon with your check or money order today to order an evaluation sample at the low 1-9 quantity price of $62. And when you receive your evaluation samples you will also receive a Credit Certificate for $23 redeemable when you place your order for the first hundred or more AD2026's.

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The real DPM company.

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West Coast: (213) 595-1783,
Texas: (214) 231-5094.

- ☐ Please send me ______ AD2026 for testing and evaluation at the low (1-9) price of $62. (Enclose check or money order.)
- ☐ Enclosed is my purchase order for 100 AD2026 DPMs at the unbelievably low price of $39 in 100s.
- ☐ I'm not ready to order my AD2026 DPM for testing and evaluation, but I would like to receive all available technical information.

ED 4/26

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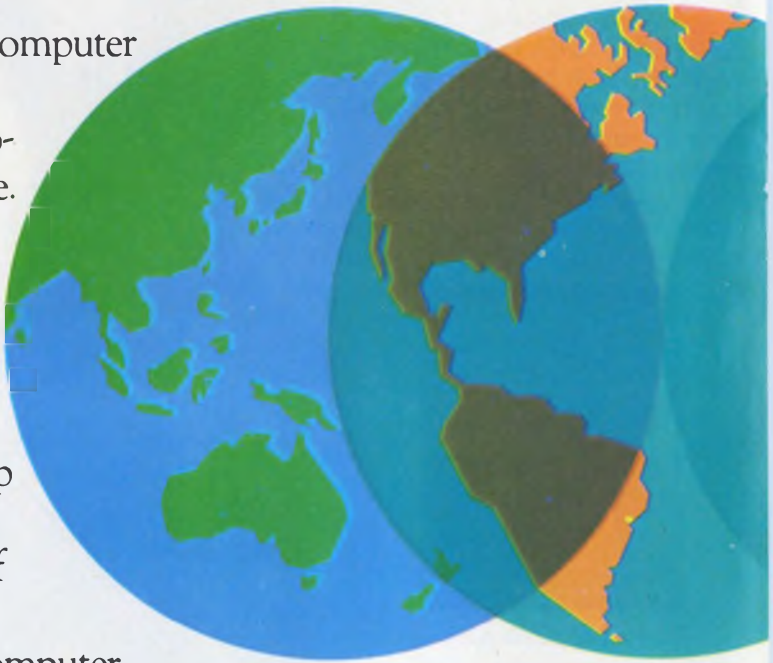
*Substantial quantity discounts available.

CIRCLE NUMBER 19

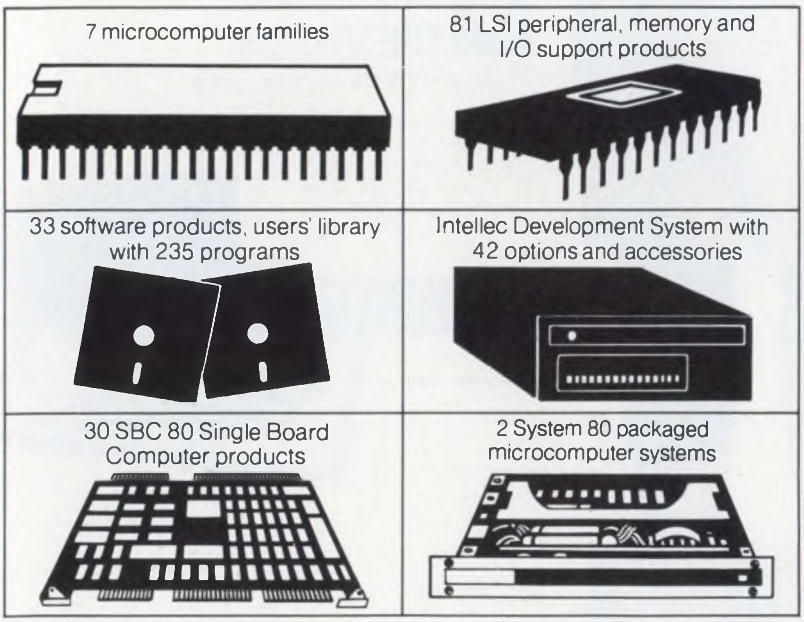
Intel delivers micro ahead of the fast



In 1971, Intel invented the microcomputer and quickly became the world's largest supplier of microcomputers and microcomputer support products. We still are.

Over the past six years we've invested millions of dollars to make the microcomputer even more useful and more economical. Today there are over 195 Intel® microcomputer hardware and software products available to help people like you keep ahead of costs, ahead of the competition and ahead of the fast changing world.

We're now offering seven microcomputer families. Including the newest high performance 8085 and the single chip 8748 with resident PROM. And 81 LSI peripheral, memory and I/O support circuits to help you cut design time, do more and get to market first. To reduce design time even further, choose one of our SBC80 Single Board Computers or System 80 packaged microcomputer systems.



But a wide selection of microcomputer components and systems is only half the story. We also provide programming support, including the PL/M high level microcomputer language to help you cut months off those big software development jobs. And Intellec® microcomputer development systems with ICE™ in-circuit emulation

All our memories are worth remembering.

Everybody knows NEC Microcomputers makes the fastest and most reliable 4K MOS RAMs on the market.

But that's just the start of our state-of-the-art memories.

We've got both static and dynamic types. In NMOS, CMOS and bipolar technologies. All made with the same care and quality control we give to our more famous products.

And we can deliver them in the quantity you need, when you need them.

At prices that are very competitive.

So if you are in the market for memory components, remember everything we have.

And remember us.

NEC Microcomputers, Inc., Five Militia Drive, Lexington, MA 02173. 617-862-6410.

Product	Description	Organization	Access Times (Max) (ns)
2101AL	NMOS Static RAM	256 x 4	250-450
2102AL	NMOS Static RAM	1K x 1	250-450
2111AL	NMOS Static RAM	256 x 4	250-450
5101	CMOS Static RAM	256 x 4	450
2205	Bipolar TTL Static RAM	1K x 1	45
403	Bipolar PROM (A.I.M.*)	256 x 4	60
405/25	Bipolar PROM (A.I.M.)	512 x 8	70
406/26	Bipolar PROM (A.I.M.)	1K x 4	80
2308	NMOS ROM	1K x 8	450
2316A	NMOS ROM	2K x 8	450

*Avalanche Induced Migration

NEC microcomputers, inc.

REPS: East – C&D Sales 301-296-4306, Contact Sales 617-273-1520, Harry Nash Assoc. 215-657-2213, Tech-Mark 607-748-7473, 716-223-1252, 315-652-6229, Trionic Assoc. 516-466-2300; South – Perrott Assoc. 305-792-2211, 813-585-3327, 305-275-1132, Wolffs Sales Serv. Co. 919-781-0164; Midwest – Electronic Innovators 612-884-7471, W. Pat Fralia Co. 817-640-9101, 817-649-8981, 713-772-1572, K-MAR Eng. & Sales 816-763-5385, R.C. Nordstrom & Co. 313-559-7373, 616-429-8560, Technology Sales 312-438-3300; West – Mike Duffy Assoc. 303-934-7392, Electronic Component Marketing 714-524-9899, 213-649-5374, Spedden Assoc. 714-295-6122, Summit Sales 602-994-4587, Trident Assoc. 408-734-5900, Tri-Tronix 206-232-4993, 505-265-8409; Canada – R.F.Q. Ltd. 416-626-1445, 514-626-8324.

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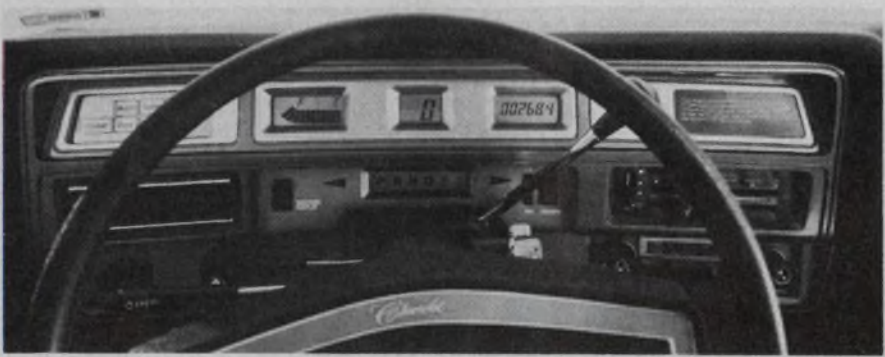
News scope

APRIL 26, 1977

Liquid-crystal panels put car functions on display



A liquid-crystal displays like this one may be used in future cars.

The first full panel of liquid-crystal displays to be installed in an auto draws less power and takes up much less space than conventional gauges and indicators. In addition, the low power and voltage needed by these displays—which are being tested in a General Motors' Research car—make them compatible with CMOS circuits that convert sensor inputs into digital voltages to drive digital or analog-display elements.

The entire panel consumes just 1/3 W. The individual displays are insulated from the panel ground and driven by CMOS circuits that convert car-battery voltage to 256-Hz pulses with a 50% duty cycle. The circuit uses the inherent capacitance of such cells to provide voltage doubling, so that a nominal 12 V is boosted to 24-V peak-to-peak across the cells. Indeed, the cells can even operate with 8-V pk-pk.

The displays are the reflective type with twisted nematic crystals. Indicators show speed, mileage, time of day, fuel level and gear (drive, neutral, etc.). Colored polarizing filters, used in this type of display for the first time, present such operating functions as "CRUISE" control and "BRIGHT" lights in blue letters. Warning indications for alternator, oil pressure and radiator temperature appear in red. Figures and elements for the other displays are black or gray.

Both the speed and odometer displays are tied to the digital clock so that the time base of the clock can be fed to circuits that compute the speed from distance and time. For distance, an optical sensor driven by a LED keeps track of wheel rotation. The CMOS processing circuits convert this rotation to distance traveled. This distance is divided by time to give the vehicle speed, which is then displayed as two large digits.

Since one LCD shows either the odometer reading or the time of day, a driver can select one or the other with one dashboard switch.

The output of the fuel-level sensor (a 0-to-90-Ω variable resistor) is processed to light up the bar-graph-type fuel display progressively towards "F" or "E." The warning sensors are switches that are grounded when a warning condition exists, which turns on the proper red display.

Chips replace software in data-comm systems

Two LSI chips—a multiprotocol communications controller and a programmable interface chip—should go a long way toward simplifying data communications. The former can be used to send and receive digital data over common telephone lines, and can manipulate data streams into either bit-oriented protocols (SDLC, ADCCP) or byte-oriented protocols (BISYNC, DDCMP). The latter can be used to serialize data transmission over telephone lines and, once the data are received, can reconstruct them into a parallel format.

Designated the 2652 by Signetics Corp., Sunnyvale, CA, the MPCC/SDLC chip assumes many of the tasks previously done in software: It generates and compares error-checking characters, inserts and deletes zeroes for the SDLC protocol, and detects short characters. Operating from dc to 500 kbits/s, the 2652 has local and remote loop-back for self-testing, is TTL-compatible and requires only a single, 5-V supply. Price ranges from $27 to $34, depending on quantity.

Its companion device, the 2651 programmable communications interface (PCI), is also implemented in MOS technology. Furthermore, it is interruptable. Should an incoming message arrive while the PCI is serializing an outgoing message, the device will suspend its outgoing operation to accept and reconstruct the incoming message. Then it can pick up where it left off.

Even though the PCI works only in BISYNC protocol, it can support full and half duplex operation, synchronous and asynchronous modes, and even, odd or no parity. Any of 16 different baud rates can be programmed by the host microcomputer. Like the 2652, the PCI is TTL-compatible and requires a single 5-V supply. The cost is $16 to $18, depending on the quantity ordered.

CIRCLE NO. 319

16-bit microprocessor can run the lights, too

Replacing a minicomputer with a 16-bit microprocessor produces a stage-lighting memory system with the same capabilities but half the cost. Exhibited at the National Association of Broadcasters Convention in Washington, DC, the Performance by Kliegl Bros. stores the levels of the stage spotlights for each lighting cue during a production. In addition, the cues can be recalled by pushbutton, and the lighting set to fade from one cue to the next.

Depending on the configuration, the Performance is priced from $25,000 to $50,000.

The microprocessor, a Texas Instruments TMS 9900, manages the system's memories, performs the multiplications necessary to calculate fade levels, and interfaces to such peripherals as a CRT display, a Shugart floppy disc, and a hard-copy printer for written records of lighting programs.

"We selected the TMS 9900 because the system must perform a large number of multiplications, and the 9900 has hardware multiply facilities," says Gordon W. Pearlman, design leader for the Long Island City, NY, theatre-equipment supplier, best known for its Klieglight spotlights. Operating software is stored in EPROMs, and "soft" data such as present lighting levels are stored in 4096-bit static MOS RAMs. The user's lighting program is stored in CMOS RAMs that can be powered either from the line or from back-up batteries—which prevents losing a complex lighting program to a power outage, Pearlman explains.

Lighting levels can be programmed into the Performance with either a rolling-tape mechanism attached to a shaft encoder or slide-wire potentiometers that feed the microprocessor through analog-to-digital converters. In addition, triac dimmers are driven by digital data from the microprocessor that are converted to analog form.

Color monitors can be adjusted on sight

With a color-bar test signal, a technician can use his own eyes to adjust the color saturation and hue as well as the black level on CRT monitors. Developed by CBS Technology Center, Stamford, CT, the technique eliminates costly instruments that measure light levels off the screen, and is aimed at studio color monitors and CRTs such as those used in some automatic test-equipment systems.

"Small chroma drifts can be easily identified at a glance, which encourages their correction before the errors become objectionable," says A.A. Goldberg, who described the system for CBS at the Broadcast Engineering Conference, part of the National Association of Broadcasters Conference in Washington, DC.

Seven color bars—gray, yellow, cyan, green, magenta, red, and blue—are displayed on the monitor screen, along with four color patches—blue below the gray color bar, magenta under the cyan bar, and vice versa. For black-level adjustments, there are two additional patches, one a shade lighter and one a shade darker than the darkest shade normally reproduced on a TV screen, which are set in a black surround.

First, the red and green electron guns are extinguished, leaving only the blue gun energized. Since gray, cyan, and magenta have some blue-light content, they appear as blue—resulting in a test pattern of four blue bars interspersed with black.

Color saturation is correct when the two outer blue bars are equally bright; hue is correct when the blue inner bars are equally bright. Equality is determined by adjusting until the boundary between the color bar and the patch beneath disappears.

Brightness is properly adjusted when the lighter black-level patch is visible and the darker patch invisible against the black surround.

Another system, a digital noise reducer developed jointly by CBS Technology Center and Thomson-CSF Laboratories (also in Stamford) improves the signal-to-noise ratio of color-TV picture transmissions by 15 dB.

An adaptation of a frame-to-frame recursive filter, this noise reducer contains a motion detector that scans every element of a TV picture and decides whether the filter should operate.

Input and output data from the filter are fed into an arithmetic logic unit and compared with data from the previous frame. To avoid smearing the picture, filtering occurs only when there is no motion.

Small computer uses micro, multiprogramming

The newest small computer from Data General features a user-microprogrammable control processor. In addition, it incorporates multiprogramming for users with complex, multifunction applications.

Microprogramming is a technique for writing special instructions into a computer's CPU to obtain high processing speeds for dedicated applications. The microprogramming store of the Eclipse S/130 from Data General, is based on a 56-bit word length with 15 independent control fields. Currently, Hewlett-Packard's 21 MX has a 24-bit word length (which is effectively larger with encoding) and Digital Equipment's 11/60 has a 48-bit word length.

Multiprogramming is a software technique that supports concurrent time-sharing, batch operations and real-time operations under the control of Data General's recently announced Advanced Operating System.

Accelerated processing speed, fast execution of specialized instructions and most-used algorithms, and generating and debugging of extensions to the computer's own instruction set can all be achieved with the user-microprogramming features. For example, the S/130—the smallest member of the Eclipse family that includes the S/230 and C/330—can execute a microcoded, 32-bit floating-point multiply in less than 14 μs, about one-fifth the time it would take if simulated in software. A microcoded character-handling instruction set produces a similar increase in processing speed.

The fast processing is due to several factors: the 15-field microword that allows a number of parallel operations to take place in a single microcycle; a fast 200-ns microcycle; a high-speed scratchpad of 256 16-bit registers; and an unusually powerful arithmetic logic unit.

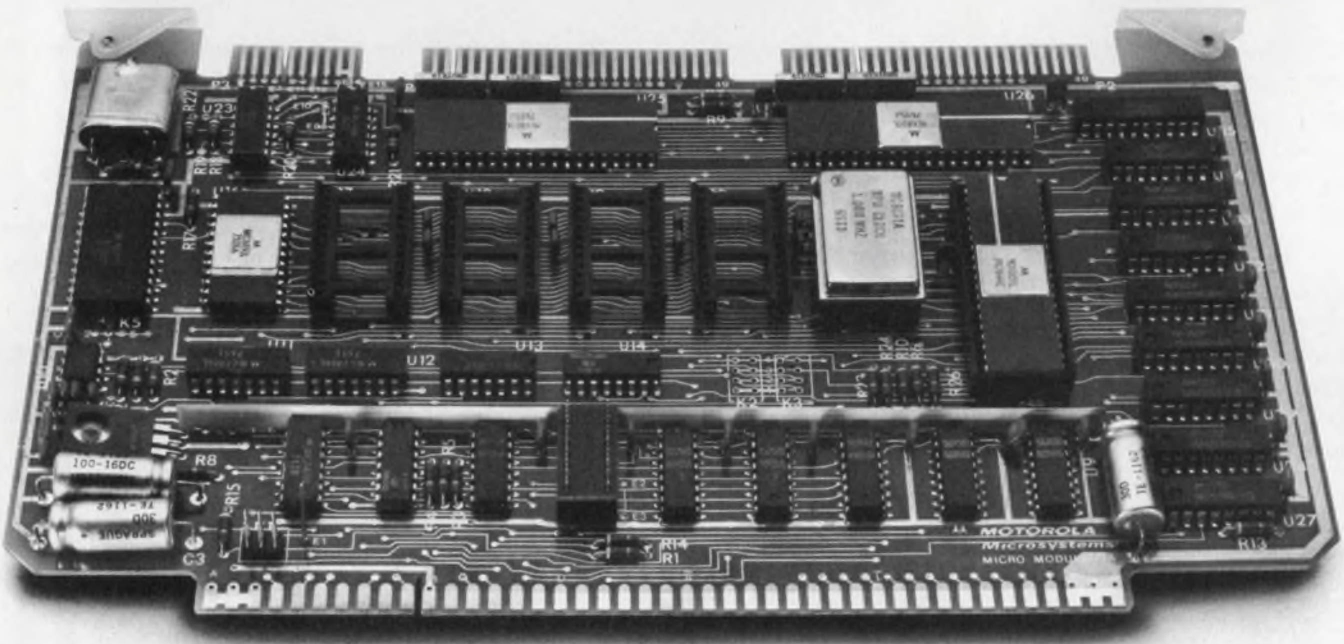
With its Eclipse architecture, the S/130 can be expanded up to 256 kbytes of MOS, core, or mixed main memory. The semiconductor memory modules have 64 kbytes and a cycle time of 500 ns. The semiconductor memories have error correction and optional battery backup. A memory allocation and protection unit provides program and data protection in multi-user environments.

System software includes Data General's AOS and its real-time disc-operating system. High-level languages include globally optimized Fortran 5, Fortran IV, single and multi-user Basic and Algol.

Intel's advanced 80/20 has twice the memory

An advanced version of its SBC 80/20 single-board μC, with double the, memory capacity will be announced by Intel, Santa Clara, CA. The four 2708 DIPs in the current version have been replaced by four 2716 EPROMs, while eight new 2114 static RAMs take the place of the 2113s now used. Meanwhile, current 80/20s can be upgraded merely by plugging in the new double capacity chips and by making jumper changes on the board. RAM capacity becomes 4 kbytes and EPROM goes to 4 kbytes.

When your job calls for a microcomputer,



Motorola's newest Monoboard microcomputer-M68MM01A. $285.00, 100-Up. (US)

Controls? Medical instruments? Communications preprocessors? Yes, for these and countless other new and imaginative applications, the rush to microcomputers is on.

Some users can and do design and build their own, from scratch. Many others, however, would rather buy than build: to speed start-up, to avoid the hassles of in-house design and production, to hasten market entry, or simply to employ the lowest cost approach.

Motorola's Micromodule* Family responds to these requirements, and more, with your choice of Monoboard microcomputers or the mix 'n match modular building block board set.

Monoboard microcomputers. everything on a single compact board

Call them instant microcomputers if you wish, but whatever you call them, all you have to add is the power supply and you're ready to go. The original M68MM01 is designed with all parallel I/O, and the newer M68MM01A features both serial and parallel I/O.

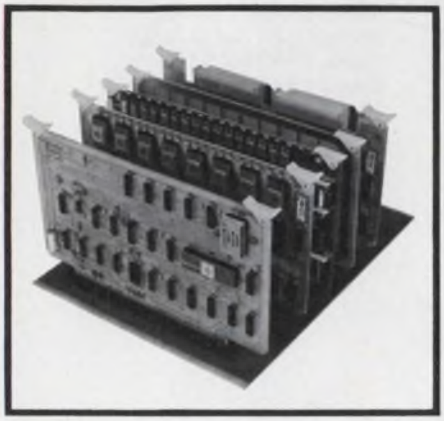
M68MM01A — An Asynchronous Communications Interface Adapter and two Peripheral Interface Adapters provide both programmable serial and parallel I/O

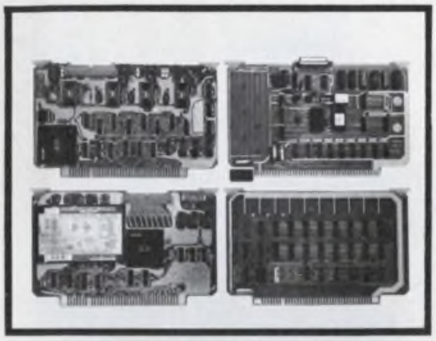
M68MM01 — Three MC6820 Peripheral Interface Adapters for all parallel programmable I/O

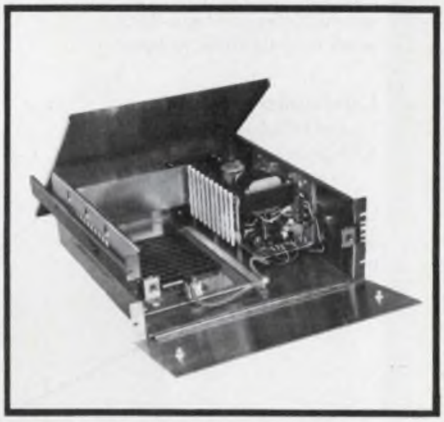
- ☐ MC6800 microprocessor for processing and control power
- ☐ 1K x 8 of RAM
- ☐ Four 1K x 8 EROM/ROM sockets
- ☐ RS232 interface
- ☐ 1MHz crystal controlled clock
- ☐ Bus compatible with EXORciser* and all Micromodule Family modules
- ☐ Powerful, easy to use instruction set
- ☐ Expandable memory and I/O
- ☐ Refresh for external memory

answer with Micromodules.

Mix'n Match, custom microcomputers from standard family Micromodules







Talk about flexible. This is the modular building block approach to your customized system...with standard boards. The heart of this plan is the CPU module, M68-MM02, which comes equipped with the M6800 microprocessor, clock, timing and control signals for DMA, three-state control, halt, dynamic memory refresh, etc. System expansion modules previously available include the M68MM03, 32/32 I/O module, and the M68MM04, 8K/16K EROM/ROM module. All micromodules are EXORciser Bus compatible.

New support modules available

Now five recently introduced additional family modules are also available, increasing the mix 'n match flexibility of the Micromodule Family. M68MM05A is an 8-Channel Differential 12-Bit A/D module, the 05B is a Single-Ended 16-Channel 12-Bit A/D, and the 05C is the analog output module, a Quad 12-Bit D/A.

They are joined by a new 2K RAM module, M68MM06, and the M68MM08 Microbug, a debug module with a firmware monitor program and provisions for communication with either an RS232 terminal or a 20 mA current loop.

Chassis, card cages and power supply wrap up the system

We offer two different rack mount chassis complete with card cage, motherboard and power supply, the short one with a 5-card cage, and the long, with a 10-card cage. For applications which don't require a rack mount chassis, fully equipped short and long card cages are available with provisions for a wide variety of mounting positions.

The Micromodule Family is backed by the total resources of Motorola's system development tools, including EXORciser, EXORdisk,* EXORprint,* and the full complement of software.

Contact your authorized Motorola distributor or Motorola sales office, or send for our Micromodule data brochure. Motorola Semiconductor Products Inc., P.O. Box 20912, Phoenix, AZ. 85036.

The Micromodule Family

Available Now
Monoboard Microcomputers

M68MM01	Monoboard Microcomputer 1
M68MM01A	Monoboard Microcomputer 1A

Micromodule CPU

M68MM02	CPU Module

To be Introduced
System Expander and Support Modules

M68MM09	CMOS RAM Battery
M68MM10	Programmable Timer
M68MM12	GPIB

Available Now
Applicable EXORciser Modules
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System Expander and Support Modules

M68MM03	32/32 I/O
M68MM04	8K/16K EROM/ROM
M68MM05A	8-Ch. Differential 12-Bit A/D
M68MM05B	16-Ch. Single-Ended 12-Bit A/D
M68MM05C	Quad 12-Bit D/A
M68MM06	2K RAM
M68MM08	Microbug

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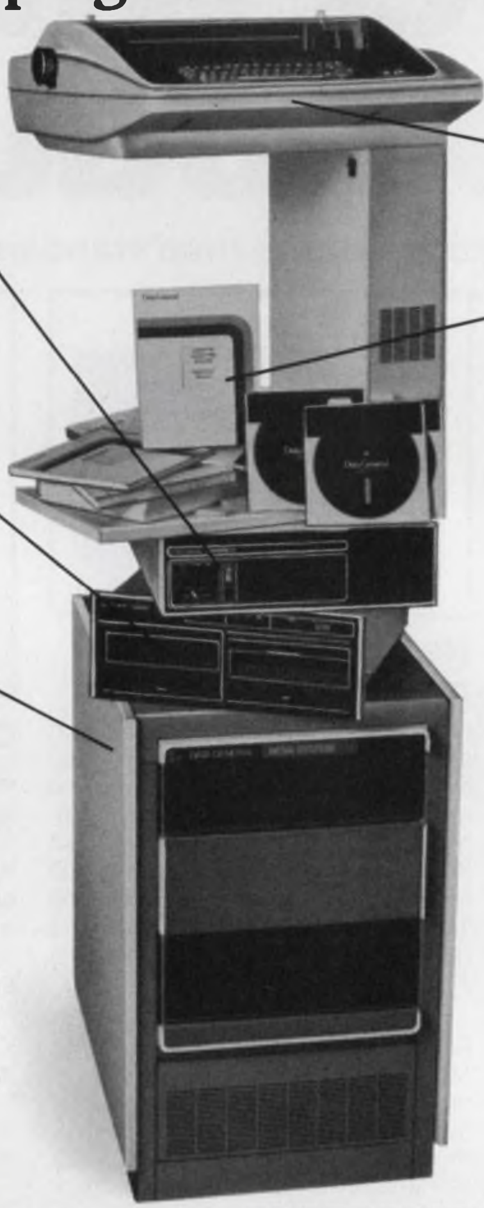
MOTOROLA Microsystems

-making it happen in microcomputers

CIRCLE NUMBER 23

Here's how Data General's microNOVA system stacks up against the competition.



microNOVA Processor:
Fully packaged 9-slot micro-computer, 16K words MOS memory, 2.4-microsecond arithmetic operations, hardware stack facility, multiply/divide, DMA capability. Includes RTC, PF/AR and APL. Supports up to 32K words RAM/PROM memory.

Dual-diskette subsystem:
Integral DMA controller, compact 630KB capacity.

Cabinet:
37 inches high, holds all rack mounted components.

DASHER terminal printer:
30 cps, 132-columns, typewriter keyboard, upper/lower case.

Systems Software:
Multitasking Disc Operating System, Real-Time Operating System, FORTRAN IV, Extended BASIC, Macro Assembler, Utilities.

$10,970
List*

The facts speak for themselves. For $10,970, Data General's new microNOVA gives you more system, software availability and support than any other comparable computer. And we deliver in 60 days.

Any way you look at it, it all stacks up in your favor. For more information and our brochure, call our toll free number, 800-225-9497, or, fill out and return the coupon.

*Additional software fees apply to first system only. Quantity and OEM discounts available.

Data General, Westboro, MA 01581
Sounds like smart business. Send me more information.

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CIRCLE NUMBER 24

We did it. Cheaper.

Here's fantastic news for you cost-conscious perfectionists. Now you can buy the better microprocessor for about the same price as the 8080 or even less.

We've just cut the price of the AMI 6800 to $15 at 100 up. And you know how much easier it is to design your system around the 6800 microprocessor. So by the time you count your savings in power supplies and TTL, you should be way ahead—with a better product, too.

The rest of the AMI 6800 family has also gone on a reducing diet. That includes our RAM, ROM, PIA, ACIA, MODEM, and USRT. And our 4K EPROM is down to a slim $9.95 in 100 up quantity, a lower cost per bit than an 8K EPROM.

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That buys you a very smart CRT, a dual floppy disk, an EPROM programmer, a firmware debug package, and complete software, including file manager, editor and assembler.

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Video games continue to sell big, but EMI/RFI proofing is a problem

The consumer impact of TV video games, besides overshadowing advances in other electronic games, is turning out to be far greater than originally envisioned. For one thing, more than 10-million of these sophisticated electronic products—most of them using dedicated game chips—are expected to be sold this year. And for another, toy and game manufacturers, whose expertise is in mass production and distribution, are turning out products by designers whose electronics expertise doesn't include the one area most critical to marketing the games—EMI/RFI measurements and proofing. As a result, a sizable headache has been created for the manufacturer, who must gain FCC approval before he can even demonstrate, much less market, his video game.

This problem is a fairly recent one. The first-generation TV games, produced by Magnavox in 1972, use a number of bipolar IC chips to generate, control and present the game information on TV screens. Sales were limited by the relatively high cost of such games.

But a standard low-cost game-chip circuit by General Instrument opened the way to mass production of video games by toy and game manufacturers with limited electronics expertise. By the end of 1976, more than five-million of GI's first-generation game chips—the AY-3-8500 for the 625-line European TV system and the AY-3-8500-1 for the 525-line U.S. TV receivers—had been shipped, with U.S. manufacturers clamoring for more.

The 8500-series GI chip—Ball and Paddle I—contains six games: Tennis, Hockey, Squash, Practice, Skeet Shooting and Target Shooting. Each ball-and-paddle game can be played at either fast or slow ball speeds, with

Jim McDermott
Eastern Editor

The first microprocessor-based video game to be marketed was this Fairchild Channel F system with programs in plug-in ROM cartridges.

high or low ball angles, and large or small paddles. Automatic scoring and realistic sounds are also provided.

Today, GI's lead in the game-chip field is being challenged by both National Semiconductor and Texas Instruments. And games from all three suppliers have acquired considerable sophistication.

GI's Paddle I has been followed by Ball and Paddle IA (six games), Ball and Paddle II (eight games) and Ball and Paddle III (16 games). Nine other game-chip circuits totaling 40 new games are also being produced by GI.

A series of competitive game chips are being sold by National Semiconductor. These include its first-generation MM57100, a full-color MOS/LSI game chip with six games, including Hockey, Tennis and Handball. Nine combinations of handicapping can be implemented simply by adjusting the paddle size, along with sound effects, ball speed-up and ball spin, or English.

Extensive background color is designed into the MM57100. Tennis has a green court with a blue border, a yellow net, orange paddles and a light green ball. A low-cost black and white equivalent of the M57100 is also available, the MM5789.

The MM57106, being prepared for sale in June, has six action fields: Tennis, Handball, Hockey, Soccer, Pinball and Wipeout. Twenty-three different games are possible.

Pinball displays 16 rectangles, a moving bonus bumper and four pockets to catch the ball. In Wipeout, 256 dots appear on the screen. After the first 100 dots are eliminated, the remaining dots change in point value.

Texas Instruments has a different chip approach to video games. A set of TTL and CMOS-compatible bipolar ICs called "Universal Game Circuits" provides the basic functions to design a broad range of video games. These chips include the following basic ICs:

- Sync generator—SN76425N.
- Character generator—SN76426N.
- Wall and ball generator—SN76427N.
- Video logic—SN76428N.
- Digital scoring—SN76460/62N.
- Random "English"—SN76423N.

The basic game functions for a simple black-and-white-TV game are shown in Figure 1. These functions are common not only to TI's video games but to all video games.

Video games have common roots

No matter who makes them, video games have the same basic features. A composite video-game signal, which is modulated and fed to the TV antenna, produces the game characters, players and game field viewed on the TV screen. The character may be a simple rectangular paddle or, in the more sophisticated games, a complex figure representing a man or auto or tank. The video-field information consists of a game format, which includes whatever walls and balls are a part of the game as well as goals or fixed obstacles. Interface circuitry for both player and game-action control are included with the circuits generating the character and field information.

The game-playing rules are established with logic circuits that may be dedicated for a single game, designed for a series of similar games, or implemented with programmable logic to expand variations in the types of games and other rules applied.

Basic scoring displays are produced by bar generators or numeric-character generators. The scoring circuit also presents the totals during the game.

Sounds can be inserted at any appropriate point in the game by pulse-detection gating. Changes of state can trigger a sound generator or external device, such as a piezoelectric beeper. The sync generator provides both the vertical and horizontal sync signals needed to generate and time the correct composite signals. In general, voltage-sensitive sync and logic circuits get their power from a regulated dc supply.

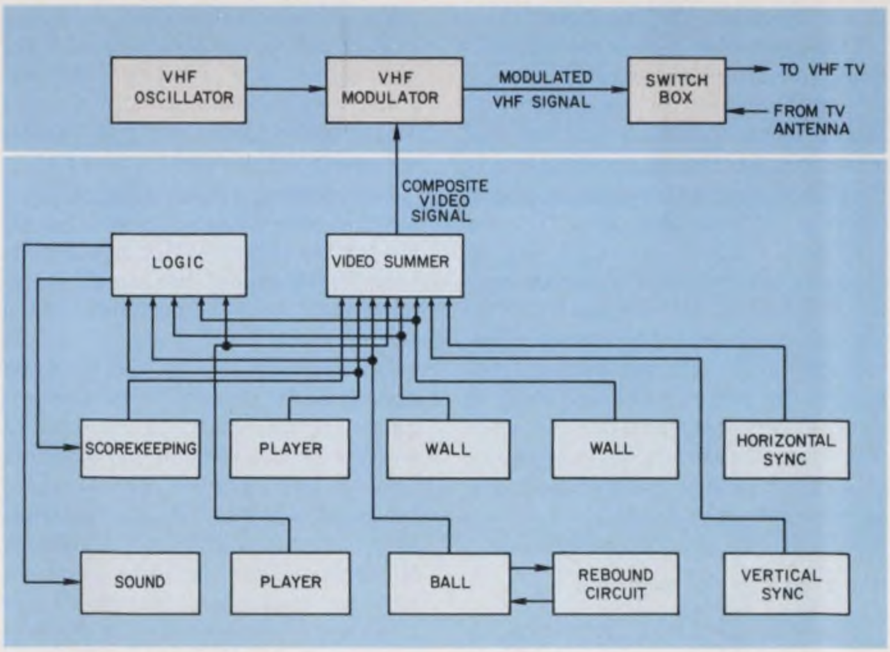
The composite video signal that makes up the game field as well as the paddles, players and balls is obtained at the output of a video summing network. In all games, including those using single-chip devices, this composite signal is fed to a vhf oscillator-modulator combination that is usually provided by the game manufacturer, not the game-IC supplier.

Set for channels 3 or 4, the oscillator output provides the input signal to the TV antenna terminals, through a special isolation switch.

EMI-proofing is a headache

Video games have one big problem. Radio-frequency that is delivered to the antenna terminal, and undesired radiation from both connecting cables and the oscillator(s) on the games' PC board can interfere with televisions in the vicinity. So manufacturers must submit their games to the Federal Communications Commission for Type Approval under part 15 as "a Class I TV device that is coupled to a TV set with a modulated rf oscillator" (see "FCC Swamped with Complaints as Sources of RFI/EMI Increase," ED No.

Four games are contained in this Odyssey 500 unit by Magnavox: Tennis, Hockey, Smash and Soccer. In these games—originated by Magnavox in 1972—the players are represented by on-screen figures.



1. TV games consist of game circuits (lower section) designed by semiconductor manufacturers and interfacing circuits (upper section) supplied by game producers. The latter convert game video signals to vhf-TV inputs. These functions are common to all TV games.

Making EMI/RFI measurements to check the levels of radiation from TV games is only part of the problem of getting video games to pass FCC standards. Here, Dan Norton at Sanders Associates checks on a design fix.

20, Sept. 27, 1976, p. 24).

Many video games fail the FCC test because their design engineers are not experts in EMI measurements and analysis. Or the manufacturer doesn't want to invest a minimum of $200,000 for an EMI test facility.

Whichever the reason, many of the game producers have turned to rf-testing laboratories, like that of Sanders Associates, Nashua, NH. Although Sanders has tested all sorts of military and commercial equipment, EMI-proofing video games has been one of its most challenging measurement and design problems, says Daniel Norton, EMC engineer.

"The new color games are very difficult to EMI-proof because there are two oscillators on the board, the 3.579-MHz chroma oscillator and the vhf oscillator. Another major problem is that the games are packaged in plastic cabinets, without shielding."

Moreover, cables are often used to connect remote hand controls and, when batteries are not used, the ac supply. Another cable connects the game to the TV-antenna switch. Even though the game's PC board itself is carefully shielded, radiation can occur from the cable shields, without careful grounding and bypassing of the cables as they leave the board.

It's a matter of pennies

Two other conflicting requirements make the job tough, says Norton. First, these games are turned out in the millions by the toy and game manufacturers who are concerned about spending even a few cents a game for added shielding and filtering. For this reason, suggestions that the insides of plastic housings be sprayed with low-cost shielding silver, copper or other conductive particles in a resin binder—produced, for example, by Acheson Colloids, Port Huron, MI—are frequently rejected (see "Focus on Adhesives and Coatings," ED No. 23, Nov. 8, 1976, p. 40). "On the other hand," says Norton, "we are faced with the stringent requirement of keeping radiation from these games to less than 15 μV/m."

Another problem is the lack of a standard test configuration. According to FCC policy, the placement of wires and cables is completely random—which makes sense since no one can tell what configuration the game cables will be in when used.

Nevertheless a good configuration of a worst-case condition would benefit the testing industry, Norton suggests. Like MIL-standard testing, all video-game tests would be performed in the same fashion.

Interestingly enough, the radiation standards for Class I TV Devices originated as the result of a rule-making petition by Cartrivision and Motorola for videotape recorders, whose outputs can be attached to TV-antenna terminals. Cartrivision is out of business and Motorola canceled its plans for video-recorder production. Almost all the videotape recorders tested by the FCC are Japanese sets.

But because of their design and high-volume production, the FCC at least acknowledges that video games are in a class distinct from the tape recorders. In addition, the emerging growth of the home-computer industry makes it apparent that standards will soon have to be set for home-computer/TV interfaces. Because of their different end uses, says an FCC spokesman, the Commission will probably issue a rule-making proposal in the coming months to at least distinguish all of these devices.

Even though getting the video game type-approved by the FCC is the game manufacturer's problem, chip suppliers are beginning to help. For example, a small, standard game-board design from National minimizes not only the number of discrete components that radiate, but also the shielding requirements. An 18-pin IC substitute—the LM 1889N—replaces the usual oscillator/modulator's discrete elements. The game video, the audio, and the chroma-oscillator signals are all fed to it. The vhf outputs produced are suitable for channels 3 or 4 (Fig. 2).

A vestigial sideband filter aids RFI suppression even more. The entire circuitry, including game chip, clock driver and regulated power supply, fits on a 2-1/2 × 4-1/2-in. PC board.

Suddenly, another problem

An unexpected problem has shaken up the video-game producers recently—fear of picture-tube damage. According to a consumer-alert bulletin issued by the Canadian Government's Consumer and Corporate Affairs Bureau, "Prolonged use of the games may cause the game pattern to remain as a ghost during regular TV viewing." The alert followed a warning from a Canadian TV dealer that games used over long periods for demonstrations had shown phosphor burns.

The U.S. Federal Trade Commission has been investigating the situation for

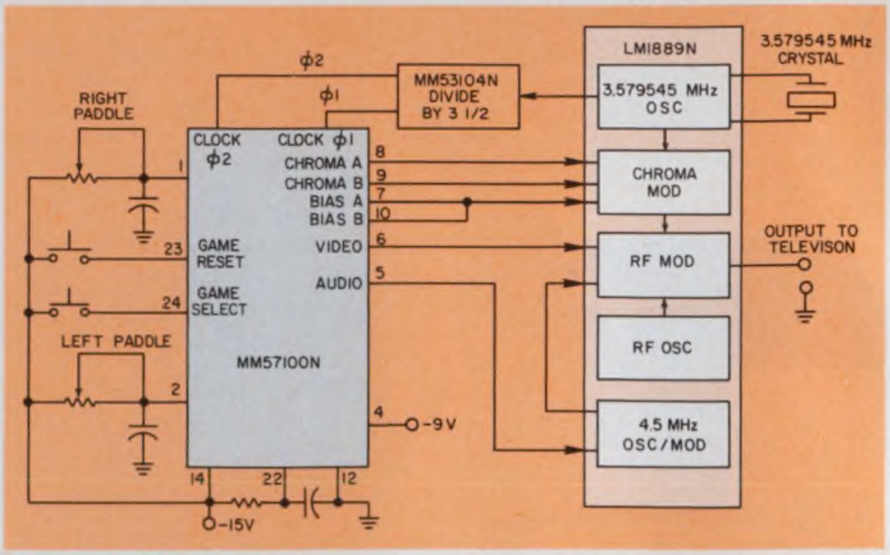
Wipeout, one of the games in National Semiconductor Consumer Products Div.'s Adversary 600, puts on the screen 256 dots that must be eliminated by striking with the players' balls.

the past few months. But evidence from the U.S. game industry indicates that phosphor burns can be easily avoided by proper game design.

Acting on extensive tests of its own TV games and others on the market, National has incorporated circuits in its M57100 game circuit and LM1889 TV modulator chip that prevent phosphor burn on a black and white picture tube by limiting the drive to the TV screen.

Atari discovered that with long exposure, high-brightness levels of the white areas that indicate playing-area boundaries can burn a pattern into the phosphors of black and white tubes upon long exposure. As a result, Atari uses gray game lines for B&W sets.

In addition, a moving pattern is flashed on the Atari screens whenever a game is completed. For more than a year, sets incorporating these features and used on production lines for testing games have shown no flaws.



2. Video-game signals of a system based on National's MM57100 game chip are fed to its LM1889 IC multichannel modulator. This modulator converts the video, chroma and game-sound signals to TV channels 3 and 4.

New games whet interest

Currently, most of the video games employ dedicated chips or chip sets. And most of *these* games are low-cost —from $30 to $100. But because the game chips are dedicated, the user is limited to the types of games designed into the ICs. Faced with having to play the same games over and over, in a relatively short time, he tends to lose interest, the manufacturers have discovered.

One way of preventing this eventual obsolescence has been developed by National. All its game chips are packaged in a standard, interchangeable 24-pin DIP. Once the basic game board is designed with the game chip and the standard outboard circuitry needed to interface it with the TV-antenna terminals, National reasons, the game can be updated simply by plugging a new game chip into the socket before the video game is sold. And for games in the field, the manufacturer can supply new game chips simply by having the game owners bring or send the unit to a factory service center.

A different approach is to design the game so that the chip is contained in a special plug-in cartridge. This feature is incorporated in the Telstar Arcade game from one of the largest game suppliers in the U.S., Coleco Industries of Hartford, CT. The first Coleco cartridge includes Road Race, Quick Draw and Tennis, which can be played in black and white or in color.

For Quick Draw, a photocell-operated revolver is holstered in one compartment of the game. For Road Race, a steering wheel is provided on another face of the game structure. Additional game cartridges will soon be available at $20 apiece.

Higher-cost games having microprocessors as the basic control element and plug-in ROM cartridges to store game sets will soon provide a simple way to acquire new games. The user will buy another cartridge from a game library.

μP games are interactive

But μP-controlled games offer even more significant benefits. Substantially more complex games can be provided. What's more, the μP-controlled games can be made even more useful by incorporating interactive educational games and exercises in their cartridge libraries. And the ability to generate special programs, such as diet schedules and income tax data, make μP games a first step towards the hitherto much discussed home-entertainment and computer-terminal center.

Right now, only Fairchild and RCA market microprocessor games. But many other game manufacturers are preparing to introduce their versions over the coming months. These include Universal Research Laboratories, Elk Grove, IL, which will use its own μP; Magnavox, which will incorporate a Signetics μP; and APF Electronics, New York, NY, which will unveil a product with a MOS μC.

Fairchild's F8 microprocessor is contained in its $170 Video Entertainment System. Produced by the Consumer Products Group in Palo Alto, CA, the game is called Channel F. RCA's μP game, the $150 Studio II, uses that company's COSMAC microprocessor. It is produced by the Distributor and Special Products Div., Deptford, NJ.

Fairchild's Channel F has two resident games, Hockey and Tennis. Its Videocart programmed-ROM cartridges ($20) provide a variety of interactive and noninteractive games. Six cartridges are now available. Videocarts 1, 2 and 3 feature Tic-Tac-Toe, Shooting Gallery, Doddle, Quadra-Doodle, Desert Fox and Black Jack. Cartridges 4, 5 and 6 add Spitfire, Space War and Math Quiz to the repertoire. Spitfire is an airplane dogfight for two players, or for one player pitted against the console's microcomputer. Space War requires two players. Math Quiz challenges young players to correctly add, subtract, multiply and divide numbers randomly selected by the microcomputer.

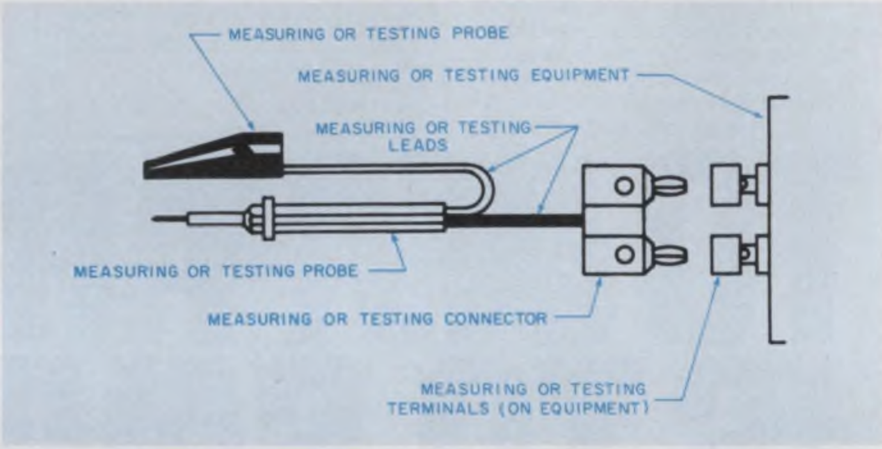
RCA's Studio II has five games built into its control console: bowling, car racing, patterns, doodles and a competitive math game. National distribution of Studio II is scheduled for mid-year. Available RCA cartridges offer TV School House I, Space War and Fun with Numbers. School House I features tests at various education levels in social science and math, among other subjects. Space War includes two missile-target games, while Fun With Numbers comes with three math exercises and puzzles. ■■

Instrument safety standard may come true on the fourth try

If all goes according to schedule, a safety standard from Underwriters' Laboratories for test and measuring instruments should be issued this summer. And if the Occupational Safety and Health Administration endorses this fourth draft of UL 1244 as a consensus industry standard, manufacturers may not be able to sell new instruments without first obtaining a UL label, or certification from a testing lab acceptable to OSHA.

Right now, in Los Angeles and Chicago, among other cities, electrical and electronic equipment that doesn't bear a UL label must be tested by the local product-safety agency before it can be sold. So the standard by which UL might officially examine instruments becomes even more important to instrument manufacturers, who would much prefer a single listing from UL to submitting their products to various city agencies.

What's more, this prospective standard, which is being circulated this week for manufacturers' comments, is certain to affect instrument buyers as well.



Even test probes come under the scrutiny of UL 1244, the safety standard for test and measuring instruments. Each part—the probes, leads, and connectors—has to meet detailed requirements to ensure safe instrument operation.

Clearer tests

"The latest version of UL 1244 makes requirements more clear," says Richard Nute, manager of product-safety engineering at Tektronix Inc. in Beaverton, OR. "For example, UL has traditionally defined 'recognized components' as parts 'suitable for the application.' In the latest draft, that has been changed to refer specifically to component ratings."

UL 1244 now requires that a capacitor have a rated working voltage high enough to withstand foreseeable levels, and that switches have voltage and current ratings consistent with the application. Criteria in earlier versions are much less specific, referring only to "suitability."

In some cases, the latest draft places even fewer burdens on the manufacturer than its predecessors. For example, printed-circuit boards don't have to undergo testing of specific parameters like peel strength. Now UL will accept the manufacturer's word that a PC board meets the standard, but reserves the right to spot-check for compliance.

Probe terms defined

The standard also defines terms that apply to parts of a measuring probe, and sets up requirements for each part. For example, the probe end of the assembly must be insulated to prevent accidental contact with live parts.

On an instrument itself, test terminals that are not connected to the instrument's metal enclosure must be insulated to prevent contact with potentially live parts. The terminal can be adjusted to any possible position when determining accessibility. This requirement may sound simple, but in many designs, standard BNC connectors don't follow the rule.

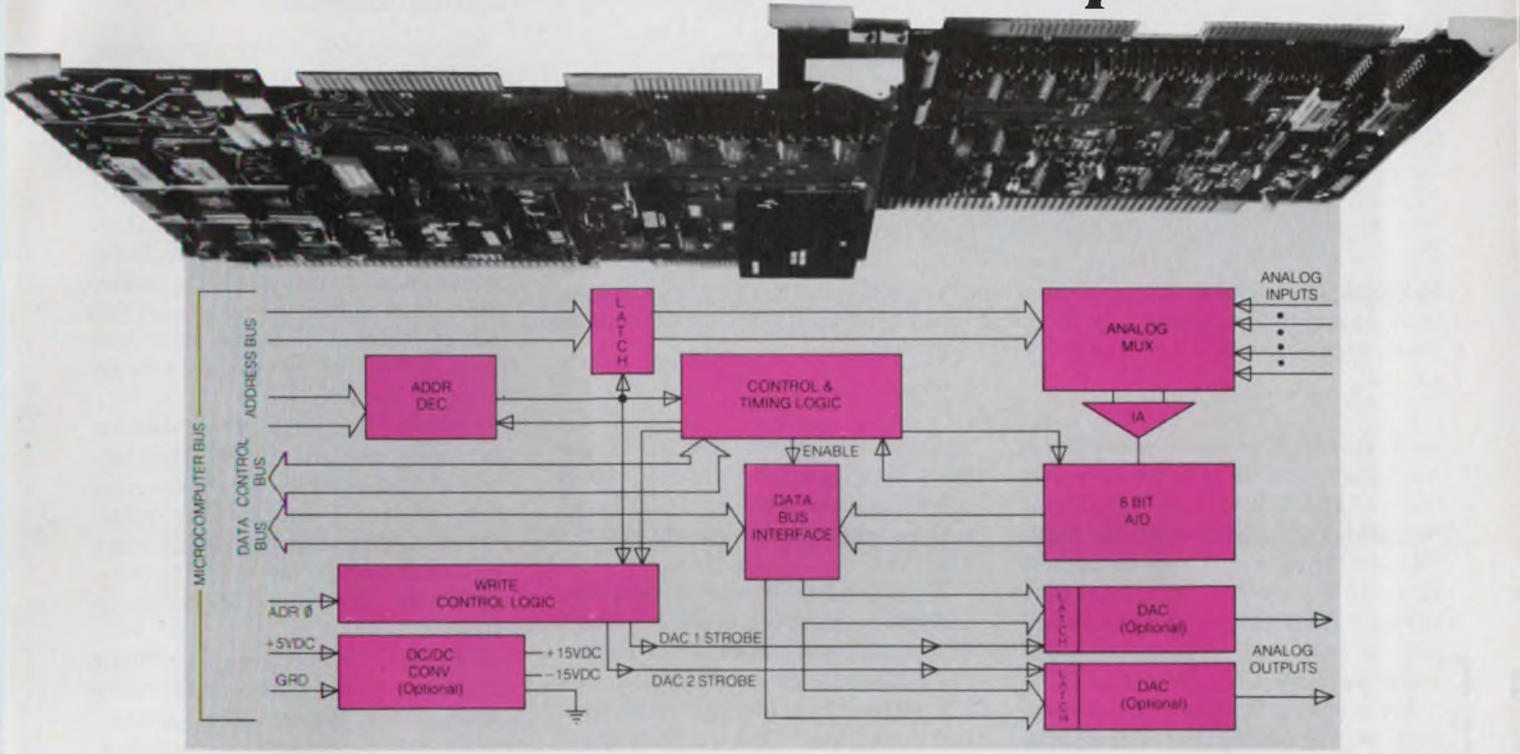
In its fourth draft, UL 1244 follows the margins, indexing, indenting and printing style of IEC 348, a safety standard for test equipment already drafted by the International Electrotechnical Commission. "Because of the large volume of international business, it becomes costly for U.S. manufacturers to produce and distinguish between domestic production and international production," explains Donald Mader, associate managing engineer in the Electrical Department at UL's office in Melville, NY.

Since the International Electrotechnical Commission had already drafted a safety standard for test equipment, notes Mader—and many U.S. instrument makers were applying this standard to products destined for sale in Europe—"it was reasonable that the requirements in UL 1244 not contradict the international standard in any major way." So when some of the test-equipment makers suggested that UL 1244 be drafted into the same format as IEC 348, Underwriters' Laboratories agreed.

But now there are complaints about

Andy Santoni
Associate Editor

Burr-Brown announces the lowest cost Analog I/O Systems for Intel and Motorola microcomputers.



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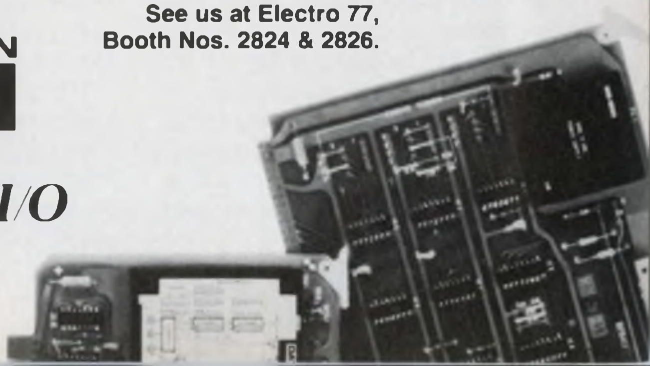

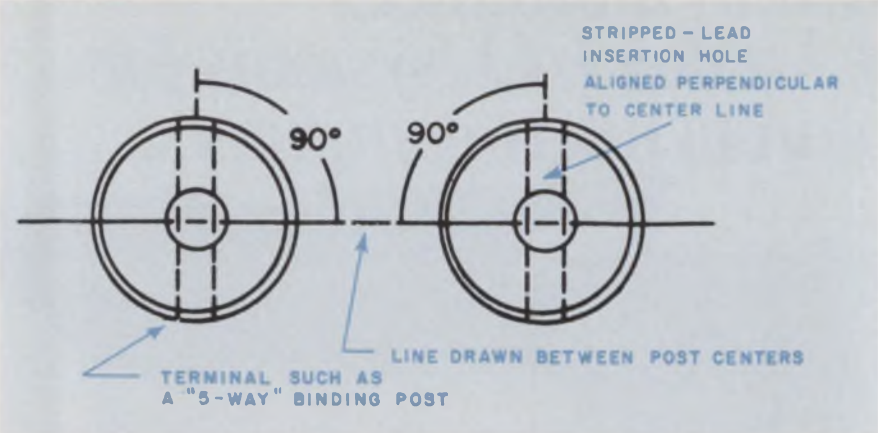

Mounting simple jacks isn't all that simple, according to UL 1244. Where jacks, like five-way binding posts, can accept stripped conductors, the insertion holes must be aligned to prevent accidental short circuits.

the fourth draft as well. For one thing, instrument buyers may be adversely affected by UL 1244, says Walt Riebe, product safety manager at John Fluke Manufacturing Co. Inc. in Mountlake Terrace, WA. Some instruments may have to be made larger, and buyers will have to take that into account when designing systems.

For example, because of more stringent leakage-current requirements, such instruments as digital voltmeters may grow in size. According to UL 1244 the capacitance between a voltmeter's input terminals and ground will have to be less than 900 pF to pass the leakage-current test. But the capacitance in a guarded voltmeter, which has a shield inside the metal outer case, may be much greater—on the order of 1700 pF.

What's more, UL 1244 doesn't even address a common problem, claims Fred Katzmann, president of Ballantine Laboratories Inc., Boonton, NJ. The problem is inadequately insulated test connectors. "Take a multimeter with a 1000-V range and connect it to a high-voltage line," Katzmann explains. "Often, the banana plug pulls out of the front of the instrument just as you make the connection. That leaves a high voltage accessible on a bare banana plug."

UL 1244 does not require that the test connector be fully insulated.

Seeking solutions

But some manufacturers are looking for ways to provide this protection anyway. A recessed banana plug is used on the face of some instruments from Triplett Corp. in Bluffton, OH, and the mating connector is a fully insulated banana jack. Designs from other instrument makers are being developed to provide the same protection without shifting to a configuration that is reversed from the norm, and incompatible with test leads commonly found in the lab.

Problems and solutions concerning test-probe assemblies will be considered in a separate document being prepared by UL and industry representatives. Explains Tektronix's Nute, "one document is not going to cover everything." There is work yet to be done.

Katzmann has an even more basic complaint. "In this standard, we're looking for a consensus of manufacturers, not of engineers, and that's bad. The specifications should have been generated by a society like the IEEE, not by UL and company representatives."

Nute disagrees: "Maybe industry is to be chided for not immediately going to the IEEE, but it really doesn't make a lot of difference." Futhermore, says Nute, the IEEE didn't step up and take on the task of writing the standard, and UL was willing to commit funds to the project. Since most of the industry comments on UL's drafts were coming from the West Coast, the Western Electronics Manufacturers Association was chosen to coordinate industry efforts. But Nute wouldn't have objected to some other coordinating body.

In any case, says Katzmann, "safety is not a matter of consensus, it's an absolute. I think good things will come out of all this, but I wish it had been done in a more professional manner."

At any rate, indications are that instrument designers and buyers will finally have a definitive safety standard. After this round of industry discussion, UL 1244 will have moved one step closer to taking its place alongside the IEEE-488 and Camac interface standards, the EIA/IEC rack and cabinet standards, and the many other documents that determine how instruments are built.■■

A changing story

The real saga of UL 1244 began three drafts ago after instrument makers approached Underwriters' Laboratories to find out how test and measuring instruments could obtain a UL listing. UL drafted a standard and submitted it to a group of instrument makers for comment.

The response to the first draft was quick and loud: Unnecessarily complicated and severe.

"We were a bit off target," admits Robert W. Seelbach, managing engineer in the Electrical Department at Underwriters' Laboratories' Chicago headquarters.

"We had adopted a lot of the requirements out of UL 492 for television-receiving devices, thinking that the circuitry was somewhat comparable," Seelbach explains. But instrument makers convinced UL that test equipment is different enough from consumer-electronic products to demand a different approach to safety testing. So UL made a second attempt.

The second draft of UL 1244, industry representatives agreed, was a step in the right direction. So after relatively minor changes, a third draft was written.

"One of the major comments we then received from industry was that safety should be an international, not a national, concern," says Donald Mader, associate managing engineer at UL's Melville, NY, office. The standard should agree with International Electrotechnical Commission documents.

UL took on the task of rewriting their standard to make it international in scope. They produced a fourth draft, the version now ready for another round of industry comments and fine-tuning.

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Washington report

NASA's future depends on a space station

The National Aeronautics and Space Administration's space program will reach a critical crossroads within the next two years. The Space Shuttle will essentially have been developed, and a decision will be needed on whether to proceed to the next logical step, a permanent manned station in space. "Yes" could touch off a new space boom. "No" could lead to another depression in the industry—like the one that followed the Apollo project.

A decision is essential because in two years funding will begin to decline for the reusable Space Shuttle. The Ford Administration increased the proposed fleet of orbiting Shuttle spacecraft from two to five—a decision that the Carter Administration has endorsed. Although shuttle spending is currently running at $1.3-billion a year, it is due to dip to $1.1-billion in fiscal 1979 and slide sharply to just over $100-million by fiscal 1982.

The major hope for the future, the space station, is the main ingredient of a five-year plan prepared by NASA earlier this year, the first such plan in the agency's 19-year history. That blueprint calls for a steady buildup of spending from the $4-billion requested for next year to $4.7-billion in fiscal 1982. The Pentagon is projecting similar growth over the same period for its military space activities—from $1.5-billion to at least $2.2-billion.

Electronics share would be high

If the Carter Administration does not overturn these plans—both agencies must update their five-year forecasts every year—there should be $32-billion available for space over the next five years. The electronics industry's share may be as high as $14-billion: The Electronic Industries Association estimates that 44% of all space spending goes into electronics (39% of procurement and 55% research and development). All sums are expressed in constant 1978 dollars to eliminate the impact of inflation.

But regardless of any buildup in spending for the space station—hence, the space agency—spending for the Shuttle will decline. So NASA must spell out for Congress and the public the economic benefits of a permanent facility in space. At the moment, the leading candidates for useful projects to be carried out in a space station are orbiting-manufacturing facilities that use the inherent zero-gravity and hard-vacuum properties of space, and solar-energy collectors that would beam electrical power to earth via microwave links. Both projects are in the early planning stage.

Work is already under way

Meanwhile, NASA is optimistic enough to have two study contractors at work defining what the space station should be: Grumman Aerospace Corp., builder of the Apollo lunar module, and McDonnell Douglas Astronautics, the space agency's study contractor on an earlier ill-fated space station attempt known as the Manned Orbiting Research Laboratory. In their preliminary reports, the firms estimate that a basic station accommodating a crew of four to six and costing $1-billion can be flying by 1985, and that the mission payloads would cost another $2-billion ("Washington Report," ED No. 5, March 15, 1977, p. 43).

Military space spending is up

Lurking beneath the surface, however, is the space application nobody talks about officially: military operations in space. The Soviet Union last year conducted four tests of "hunter-killer" spacecraft with its own satellites as targets ("Washington Report," ED No. 5, March 1, 1977, p. 35). In response, the Pentagon has doubled its defense development program from $61-million this year to $126-million for fiscal 1978. Another doubling, to $265 million, is projected for fiscal 1979.

As a result, NASA and Air Force participation in the Space Shuttle program has become intertwined. The Air Force has begun to build a launch complex of its own, and is developing a new rocket stage to be used from the Shuttle to place military payloads in higher orbits. The new complex at Vandenberg Air Force Base, CA, will permit Air Force missions to achieve polar orbits that can pass over the Soviet Union several times a day. The rocket, known as the Interim Upper Stage, will place 5000-lb payloads into synchronous orbits.

But without a space station, the NASA budget will start declining by 1980 —just as it did in 1966, when Apollo spending peaked at more than $6-billion a year even though the manned lunar landing was still three years away. NASA missed a golden opportunity to capitalize on the Apollo success—partly because the war in Vietnam was draining national resources and partly because the NASA management and Congress could never agree on what the agency's follow-on mission should be.

Government attitude looks encouraging

So far the Carter Administration has supported the space program. While slicing the Pentagon budget by $2.8-billion for fiscal 1978, the administration has tacked on another $15-million to the $4-billion request by NASA—an extra $10-million for the next Viking mission to Mars in 1984 and another $5-million to build a backup satellite for the Landsat-D earth resources survey program. What's more, none of the cuts in the Pentagon budget affect its military-space efforts.

Congress has also lent its support to the space program—thus far. The House passed the full $4-billion NASA authorization request, including President Carter's amendments, by 338 to 44. The bill now goes to the Senate, which in the past has treated the NASA request even more favorably. However, both houses still have to appropriate the funds, and traditionally appropriations fall slightly below the authorization level.

The other ingredients in NASA's five-year plan will advance scientific knowledge to some extent, but won't, unfortunately, do much for business. The projects include: a spacecraft to rendezvous with Halley's Comet in 1982, a Venus orbiter with an imaging radar in 1983, infrared and ultraviolet space telescopes in 1983 and 1985, and orbiter/probes of Saturn and Uranus in 1985 and 1986.

Configurability at a price you didn't figure on

Here's a really multi-functioned digital multimeter: Six functions—dc and ac voltage, dc and ac current, resistance and dB (both dBV and dBm)—in one compact, 3½-digit DMM for just $250*. It's called the DM 502 (Option 2) and it has the configurability to interface with a full range of test and measurement instruments in the TEKTRONIX TM 500 line.

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One typical configuration, the Audio Travel Lab**, combines the DM 502 (or the DM 502, Option 2) with an SG 502 Audio Oscillator, a DC 504 five-digit Counter/Timer, and an SC 502 15-MHz Dual-Trace Oscilloscope within a TM 515 Traveler Mainframe. This lab-quality instrument configuration looks like carry-on luggage and provides comprehensive audio measurement capability which you can take anywhere.

So the next time you're looking for a 3½-digit DMM with all the functions you need and with the configurability to work with the rest of your test equipment, select the DMM that is also priced right for you: DM 502. Or, for similar functions and 4½-digits, look into the configurable DM 501; you'll be pleased with its price, too.

For more information on configurable instruments, call your local Tektronix Field Engineer or write Tektronix, Inc., P.O. Box 500, Beaverton, OR 97077. In Europe, Tektronix Limited, P.O. Box 36, St. Peter Port, Guernsey, Channel Islands.

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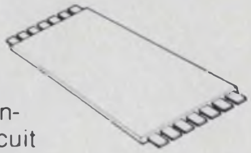

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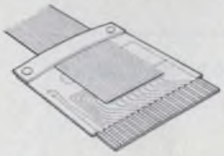

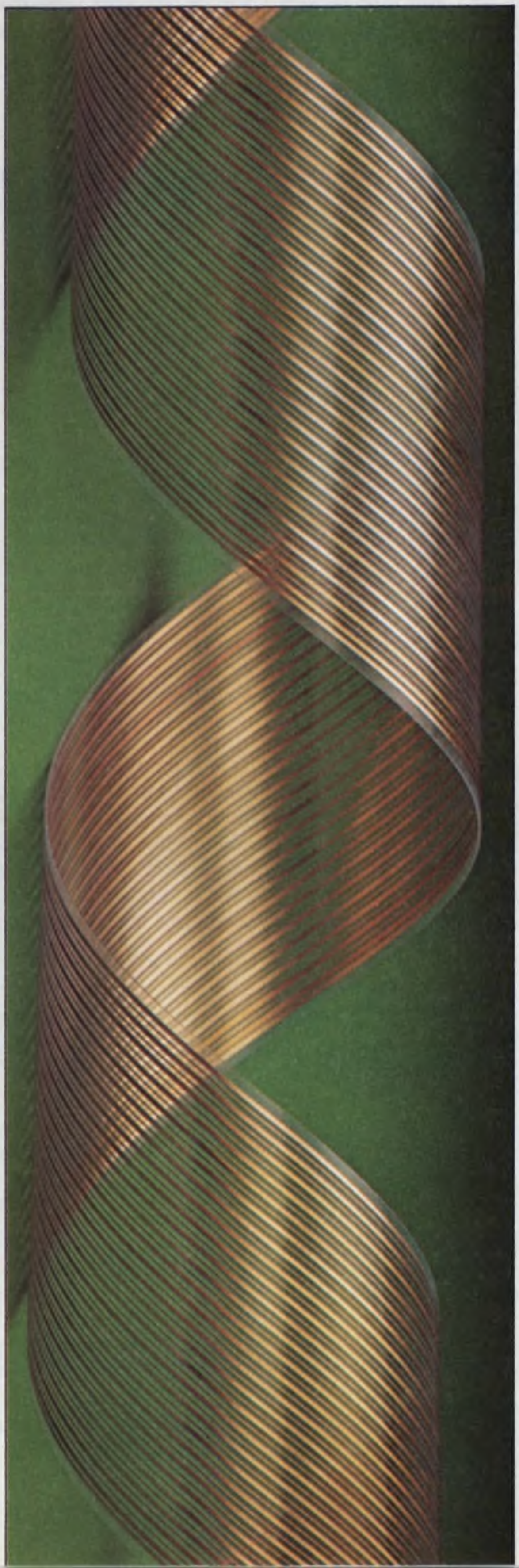

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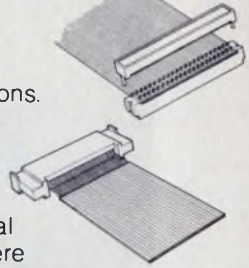

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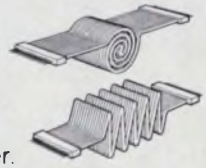

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CIRCLE NUMBER 36

Outguessing the boss

Charlie felt that it wasn't his job to make decisions for his staff. It was up to his engineers to decide what specs to build into their instruments, how to organize the front panels, and even what colors to use. But there was great unpleasantness if their ideas didn't coincide with his.

If the engineers designed a grey front panel with toggle switches, Charlie let them know how stupid they were for not making it powder blue with rocker switches. If they used LED displays, he let them know that liquid crystals consumed less power.

But Charlie was a reasonable man. His engineers could always defend their choice; they could point out that they had already evaluated the relative merits of LED and LCD, grey panels and blue ones, and toggles and rockers. Why, then, did they make the wrong choices, Charlie challenged.

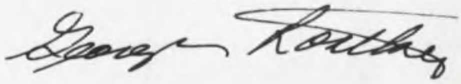
Very quickly, the engineers, who were quite willing to cater to Charlie's inclinations, learned that it saved time and anguish if they could find out what Charlie liked. Unfortunately, Charlie wouldn't tell. It was, after all, *their* job to make these decisions.

Since Charlie wouldn't tell them if he preferred grey or blue, LED or LCD, toggles or rockers, they were forced to guess. So they spent lots of design time —not designing to satisfy customers, but guessing what Charlie would prefer.

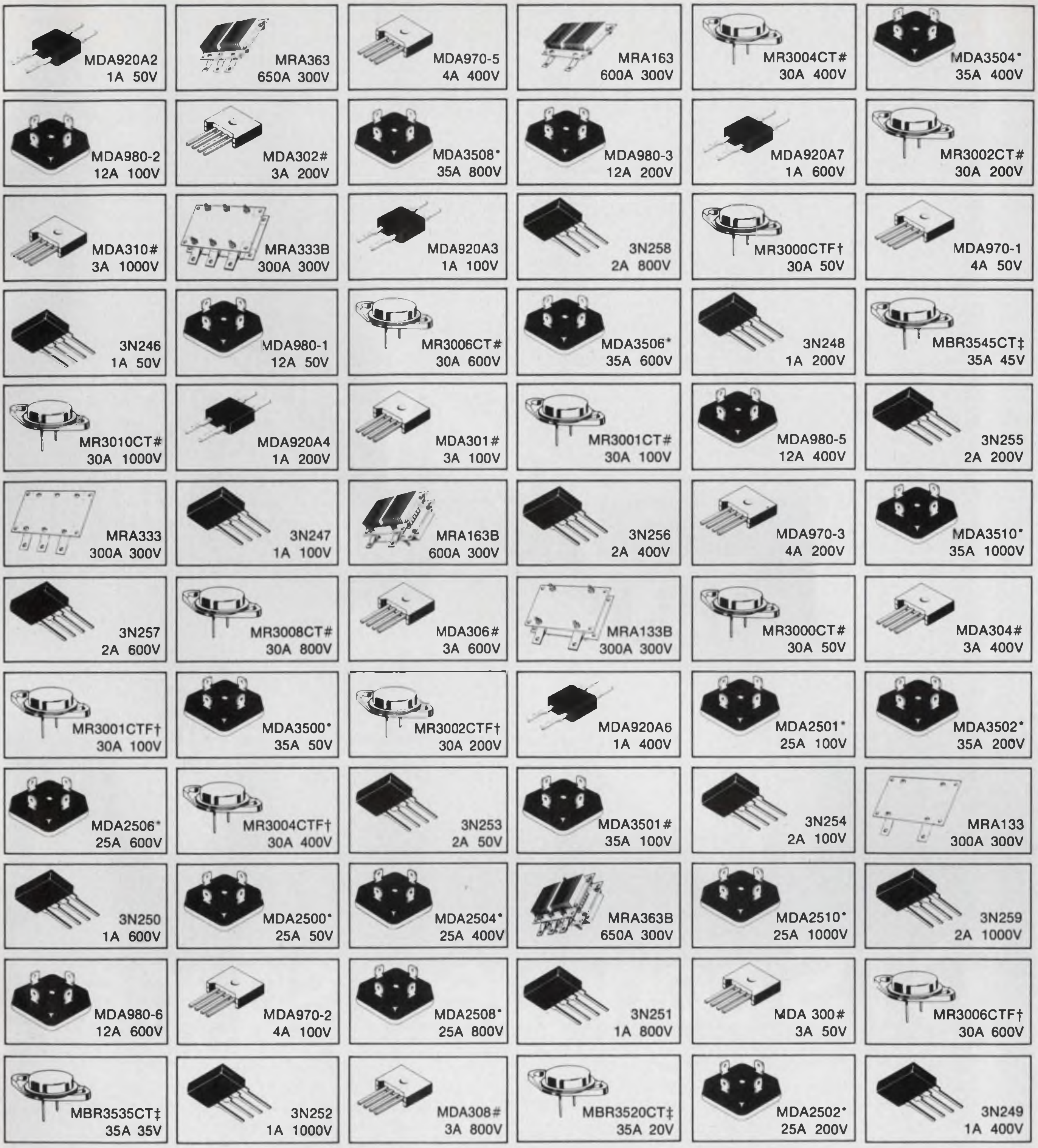
That didn't work either. Charlie, it's sad to say, was a poor barometer of customer preferences. So when the engineers designed for *him*, they weren't necessarily designing for the customers. To add to the sadness, it turns out that one of the reasons Charlie wouldn't disclose his preferences in advance is that he really didn't know. He would never admit it, even to himself, but he wasn't sure of what he wanted until the engineers completed their design. He knew he didn't like *that*.

So the engineers would redesign to please Charlie. But the product wouldn't sell because the customers didn't like it, engineering and rework costs drove up the price, and the product reached the market late. This was proof again Charlie knew, that his engineers weren't very bright.

"But we made it the way you wanted it," they would point out. "I don't remember any such thing," Charlie would scoff. Clearly, Charlie's memory was superior, as was his design sense. After all, he was the boss.



GEORGE ROSTKY
Editor-in-Chief



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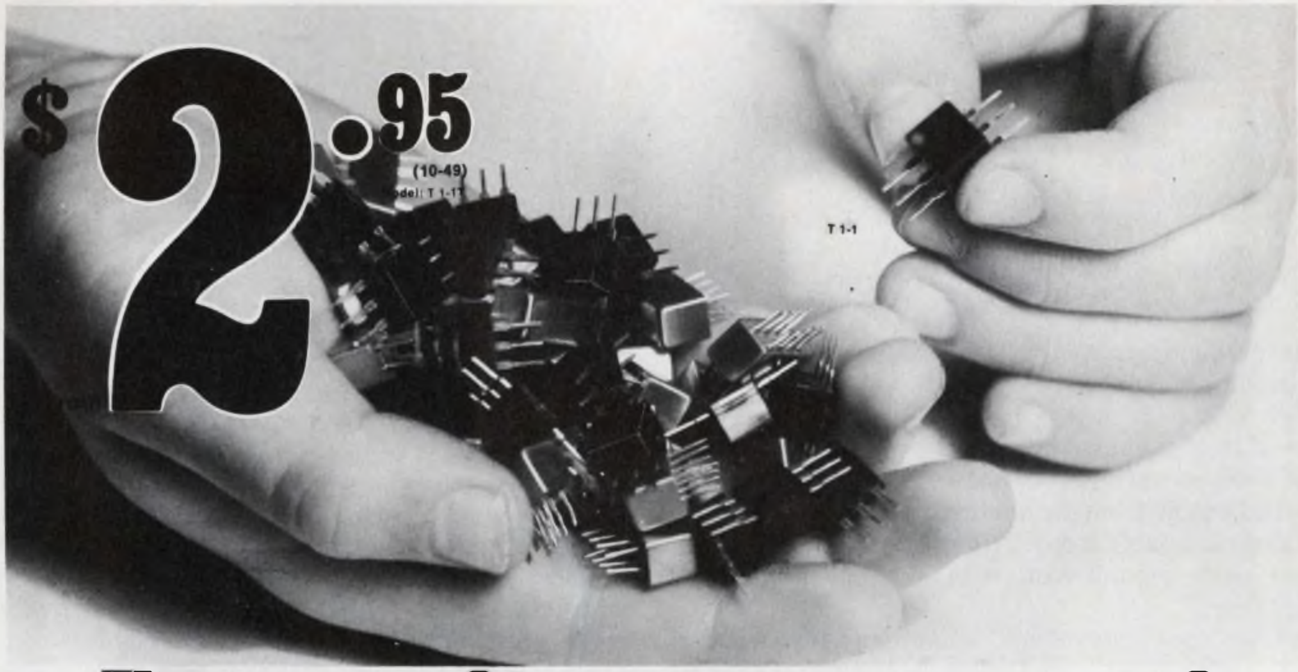
CIRCLE NUMBER 38

RF TRANSFORMERS



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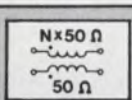
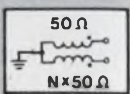


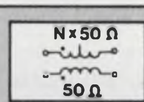
Model						
Metal Case	TMO 1-1	TMO 1.5-1	TMO 2.5-6	TMO 4-6	TMO 9-1	TMO 16-1
Plastic Case	T 1-1	T 1.5-1	T 2.5-6	T 4-6	T 9-1	T 16-1
Freq. Range, MHz	.15-400	.1-300	.01-100	.02-200	.15-200	.3-120
Impedance Ratio	1	1.5	2.5	4	9	16
Max. Insertion Loss	MHz	MHz	MHz	MHz	MHz	MHz
3 dB	.15-400	.1-300	.01-100	02-200	.15-200	.3-120
2 dB	.35-200	.2-150	.02-50	05-150	.3-150	.7-80
1 dB	2-50	.5-80	.05-20	1-100	2-40	5-20
Price, Model TMO	$4.95	$6.25	$5.95	$5.95	$5.45	$5.95
(10-49) Model T	$2.95	$3.95	$3.95	$3.95	$3.45	$3.95

UNBALANCED PRIMARY & SECONDARY



Model					
Metal Case	TMO 2-1	TMO 3-1	TMO 4-2	TMO 8-1	TMO 14-1
Plastic Case	T 2-1	T 3-1	T 4-2	T 8-1	T 14-1
Freq. Range, MHz	015-600	5-800	.5-600	.15-250	.2-150
Impedance Ratio	2	3	4	8	14
Max. Insertion Loss	MHz	MHz	MHz	MHz	MHz
3 dB	015-600	.5-800	2-600	15-250	2-150
2 dB	.02-400	2-400	.5-500	25-200	5-100
1 dB	.05-200		2-250	2-100	2-50
Price, Model TMO	$5.45	$6.25	$5.45	$5.45	$6.25
(10-49) Model T	$3.45	$4.25	$3.45	$3.45	$4.25

DC ISOLATED PRIMARY & SECONDARY CENTER-TAP SECONDARY



Model							
Metal Case	TMO 1-1T	TMO 2-1T	TMO 2.5-6T	TMO 3-1T	TMO 4-1	TMO5-1T	TMO 13-1T
Plastic Case	T 1-1T	T 2-1T	T 2.5-6T	T 3-1T	T 4-1	T 5-1T	T 13-1T
Freq. Range, MHz	05-200	.07-200	01-100	05-250	2-350	3-300	.3-120
Impedance Ratio	1	2	2.5	3	4	5	13
Max. Insertion Loss	MHz	MHz	MHz	MHz	MHz	MHz	MHz
3 dB	.05-200	.07-200	.01-100	05-250	2-350	3-300	.3-120
2 dB	08-150	1-100	.02-50	1-200	35-300	6-200	.7-80
1 dB	2-80	5-50	.05-20	5-70	2-100	5-100	5-20
Maximum Amplitude Unbalance MHz							
.1 dB	5-80	1-50	1-20	1-70	5-100	10-100	5-20
.5 dB	05-200	.07-200	01-100	05-250	2-350	3-300	.3-120
Maximum Phase Unbalance Degrees MHz							
1°	5-80	1-50	1-20	1-70	5-100	10-100	5-20
5°	05-200	.07-200	01-100	05-250	.2-350	3-300	.3-120
Price (10-49)							
Model TMO	$5.95	$6.25	$6.25	$5.95	$4.95	$6.25	$6.25
Model T	$3.95	$4.25	$4.25	$3.95	$2.85	$4.25	$4.25

Primary Impedance: 50 ohms
Total Input Power: ¼ watt

	TMO-series	T-series
	25 cu. inches	02 cu. inches
	07 ounces	.01 ounces

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22 Rev orig

CIRCLE NUMBER 40

FOCUS on Flat Flexible Cable

The problem with flat, flexible cable (FFC) is less one of troublesome specs and more one of filtering out the right cable from the hundreds of kinds available today. After that, most FFC problems settle around cost, reliability and production headaches.

In fact, the virtues of FFC are so many, it's a wonder that conventional round cable is not yet a distant memory—especially after you've listened to the FFC manufacturer's claims.

There's no doubt that the FFC can save weight and space. It can carry more current per cross-section, and it has lower propagation delay than conventional wiring. It's usually easy to clean, to install, to inspect. And it's as tough as it is flexible.

But . . .

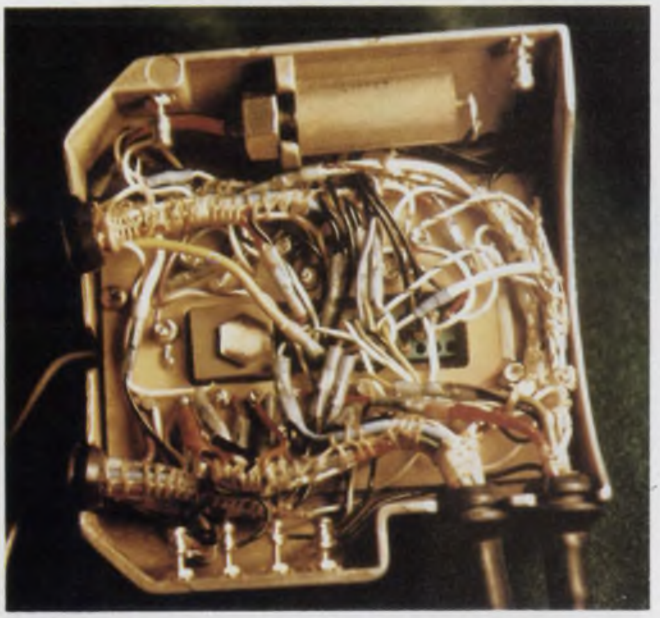
No one FFC can improve on round cables in every respect. And test methods for FFCs are not yet standardized. Nevertheless, FFC users are enthusiastic and show little quarrel with specs, quality, even price—once they've chosen the right cable.

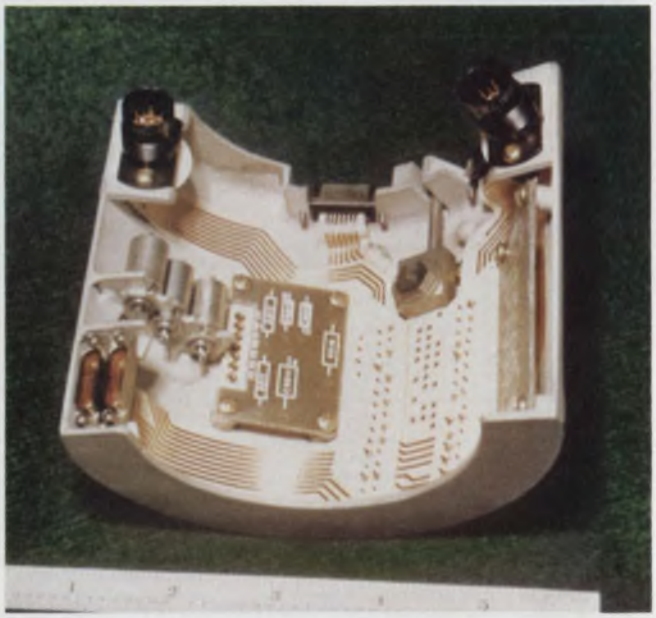
Max J. Schindler
Associate Editor

Just five years ago, FFCs were largely custom-made. Now, the shelves of dozens of vendors are heavily laden with hundreds of styles. Five years ago, specifications were often vague and many characteristics unknown. Today, vendors are happy to supply reams of test data to support published specs.

Yet, the explosive growth of FFC applications did not come about because FFC technology improved dramatically. Rather, it was the development of the mass termination that brought FFC into its own.

As long as FFC had to be interfaced with round connectors, it remained largely an aerospace curiosity. The tedious stripping and soldering of each conductor





Flexible circuit boards convert a tangled mess into a neat assembly as in this example from Teledyne.

to either the connector or a special interface device negated much of the labor-saving potential, and wiring errors remained.

In mass-termination systems, the connector makes contact with all the conductors of the FFC in one single operation. Two major approaches are available. In the crimping technique the usually flat conductor is pressed into a U-shaped channel that cuts through the insulation, and is then bent inward until its upper edges dig back into the conductor.

The other technique is used with both round and flat conductors. Contact is established on the inner edges of a fork that actually cuts into a round conductor, and deforms a flat conductor into a U. A variant of this technique is Ansley's Tulip contact in which the fork is transformed into a slotted, hollow cylinder, so that the number of contact points is doubled to four.

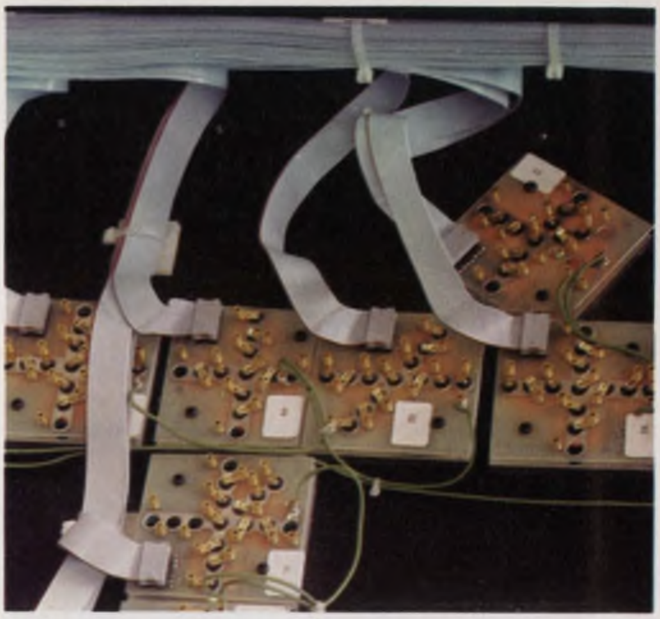
Shielded flat-conductor cable is not as easily mass-terminated. But Ansley will come out shortly with a shielded 25-mil-pitch FFC and a connector that will automatically tie all ground lines to the shield. Thus the signal lines can be mass-terminated with the standard FFC conductor spacing of 0.050 in.

Before FFCs came of age, a connector known as "D Subminiature" was developed to terminate up to 50 conductors. This still popular connector, unfortunately, requires 52-mil spacing, and is therefore incompatible with the standard FFC configuration. Recently special D-Subminiature connectors have become available that permit mass-termination of cables with a 50-mil pitch.

All FFCs are not alike

Construction techniques for flat, flexible cable are as diverse as the applications. Many varieties were developed specifically to optimize certain characteristics. Nevertheless, the profusion of FFCs evolve from two distinct technologies.

At one end of the spectrum are bonded "ribbon" cables; at the other extreme, flexible cable board.



The 3M Scotchflex cable harness in this equipment simplifies routing to a multitude of terminal boards.

Ribbon cables simply consist of regular round "hook-up" cable with stranded conductors. Laid side by side, the cables are held together either by fusing or bonding of the insulation.

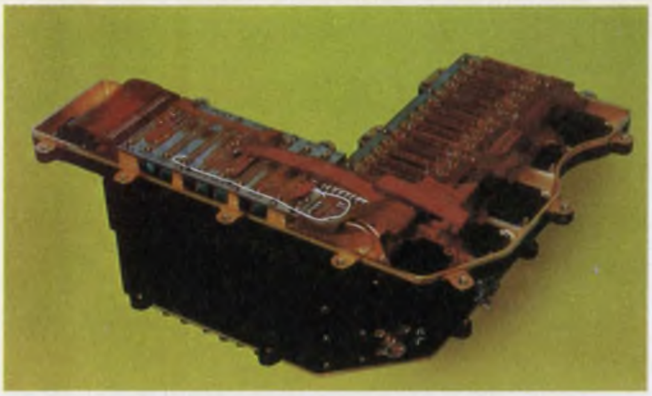
Flexible circuit board is produced by etching, and it is often used to carry components as well as provide interconnections. After the conductors are etched, a "coverlay" is applied to provide insulation on the top side of the circuit. When used for interconnection alone, the etched FFC is often called "flextape" and is rarely used in lengths over 20 in. Etched flexible circuits are usually more expensive than other FFCs, but when connecting points are widely scattered and distances between groups of connecting points are small, flextape offers the only alternative to conventional wiring.

FFC insulation comes not only in a rainbow of colors, but also in a wide spectrum of materials. Vinyl is the least expensive, but has a limited temperature

Table 1. Insulating-material characteristics

Characteristic	Polyimides (Kapton)	Polyesters (Mylar)	Fluoroethyl (Teflon)	Polyvinyl-chloride	Polyethylene
Min service temp. (°C)	−60	−60	−60	−40	−20
Max service temp. (°C)	400	150	250	85	80
Specific gravity	1.42	1.40	2.15	1.25	0.91
Dielectric constant	3.5	3-3.5	2.1	3.6-4	2.2
Dielectric strength (kV/mil)	7	7	2.8	0.8	0.6
Tensile strength (psi)	25,000	20,000	3000	3000	2000
Water absorption (% in 24 h)	3	0.8	0.01	0.1	0.01
Flammability	self-extinguishing	poor	inflammable	self-extinguishing	flammable
Bondability	good	good	Note 1	good	good

Note 1: good after special treatment



An interconnection box with hundreds of terminal points, such as this one made by Hughes, would be impractical with conventional wiring methods.

Table 2. Substrates for flexible printed circuits

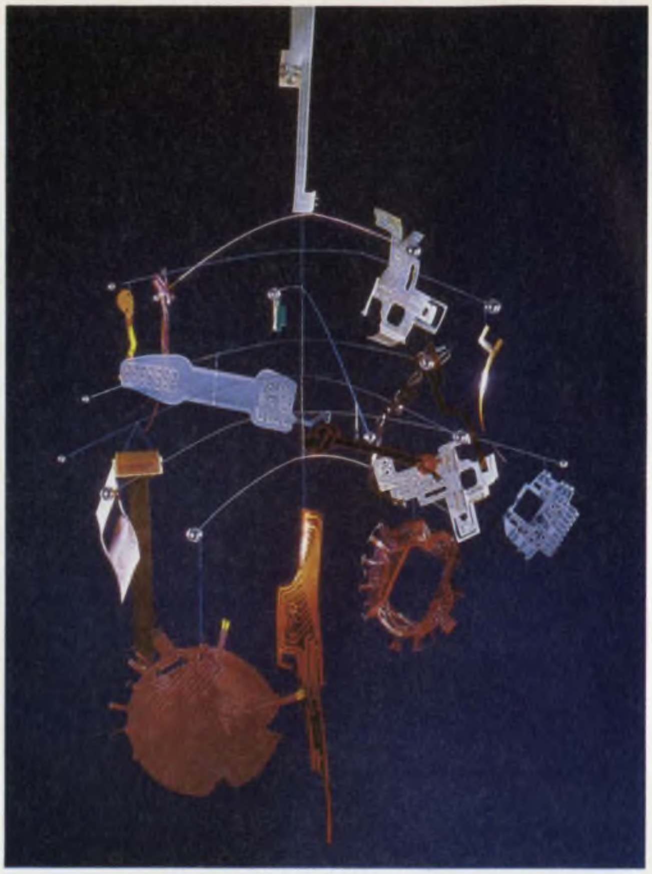
Material	Service temperature (°C)	Dielectric constant	Bondability to itself
TFE plastic	−200 / 250	2.2	good
TFE glasscloth	−70 / 250	2.5 to 5	poor
FEP plastic	−200 / 200	2.1	good
FEP glasscloth	−70 / 200	2.5 to 5	good
Polyimide film	−200 / 300	3.5	poor
PCTFE	−70 / 125	2.5	good
Epoxy Dacron	−20 / 100	2.5 to 4	good
Polypropylene	−55 / 100	2.0	good
Polyester film	−60 / 105	2.8 to 3.7	poor
Polyvinylchloride	−30 / 85	3.6 to 4.0	good
Polyethylene	−20 / 60	2.2	good

range of 2 to 60 C. The costliest of the common insulations is Kapton, which can tolerate as much as 400 C. Silicone rubber is also excellent at high temperatures, but rarely used because of its softness. At very low temperatures, Viton (polyester and synthetic rubber) retains flexibility the best.

Depending on your requirements, you can chose the most suitable insulator from Table 1. Use the table only as a guide, because jacket materials are constantly being improved. Not included are less popular materials like polyamide, fluorocarbons and polyvinylfluoride. If you plan to use cable with dual insulation, make sure you get full specs for both insulating materials from the manufacturer. Extruded flat cables have the advantage that groups of wires can easily be separated when breakouts are required.

For flexible circuits and other bonded FFCs, the service temperature range is given in Table 2. Because of its poor flexibility, glass-epoxy is no longer used very much for FFCs—even though it has the best dimensional stability of all flextape substrates and tolerates temperatures from −55 to 150 C.

For bonded construction, the service temperature may well be determined by the adhesive. Mylar, for



Striking a balance between PC boards and flat cables, etched flexible circuit boards, like these made by Rogers Corp., fit diverse applications.

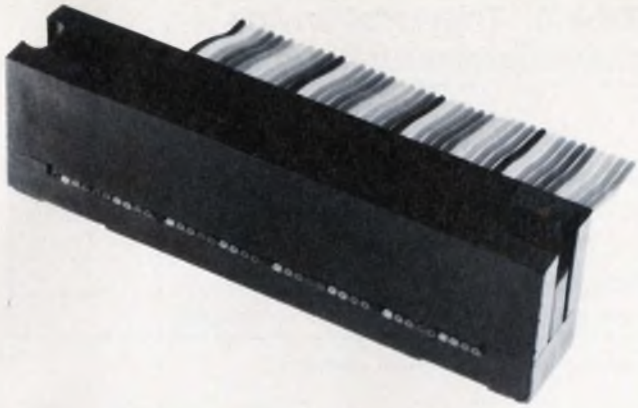
instance, can be bonded by brush-on adhesives like 3M's EC1099 (−160 to 120 C), a paste adhesive like Dow-Corning's Silastic 140 (−160 to 100 C), or adhesive films like Fasson's S-277 (−25 to 100 C). None of these however, attains the full temperature range of Mylar (−60 to 150 C), and thus the adhesive becomes the limiting factor.

Flat conductors have the edge

Flat cables with round conductors can turn a tangled mess into a neat harness, but electrically they act pretty much like any cable with round conductors. Flat-conductor cable, on the other hand, has some impressive advantages. In flexible circuits, flat conductors are produced by etching. If rolled stock is used, the insulation can be bonded or extruded.

Because of the large surface area available for cooling, flat-conductor cable can carry more current for the same cross-sectional area. When carrying 3 A per conductor, a flat cable with 25 conductors of 4 × 40-mil cross section (corresponding to AWG 27) heats up to 50 C in air, and 110 C in vacuum. Under the same conditions a bundle of AWG 27 round cables heats up to 110 C in air, and well over 250 C in vacuum.

Because flat-conductor cables require less copper, weight savings are possible that range from 5 to 30% for AWG 20 and reach 60 to 70% for AWG 30. In a missile or fighter plane, such savings are quite signifi-



Insulation-displacement connectors (IDCs), such as this one from Stanford Applied Engineering, make contact through the insulation. The flat cable simply ends in a straight cut, flush with the connector.

cant. Interestingly, the space-saving feature of flat-conductor cable led to the first flat-conductor patent—in 1884! Table 3 permits you to convert flat-conductor cross sections to equivalent AWG at a glance. Design curves are available from NASA (see bibliography).

Even though a flat-conductor cable is usually wider than a round harness, as you add more conductors, the safe current per conductor still diminishes—although less than for round conductors. A typical flat-conductor derating curve, setting the rated current of a single conductor at 100% for one conductor, declines to 75% for 10, 65% for 20, and 60% for 30 conductors.

Table 3. AWG equivalent for flat conductors

Thickness (mils) \ Width (mils)	25	50	75	100
2	31	29	27	26
4	29	26	24	23
6	27	24	23	21

Chances are, however, that you will want to carry signals rather than power in your wiring. Of course, any flat cable allows you to separate interfering signals by placing the signals on the two edge conductors. But how do flat-conductor cables stack up as transmission lines?

Since only the narrow edges of the conductors face each other in flat-conductor cable, the capacitive loading is relatively small, and the impedance somewhat higher than for round-wire cables. So the flat-conductor cable's propagation delay ranges from 1.1 to 1.3 ns/ft, compared with 1.8 ns/ft for a typical 0.2-in. coaxial cable.

Flat-conductor losses are lower too. Attenuation at 200 MHz for AWG 31-equivalent flat conductors is 2.2 dB for 10 feet, whereas a ribbon cable with round AWG 31 conductors measures 5 dB and a twisted pair, even with AWG 26 conductors, shows a loss of 7 dB.

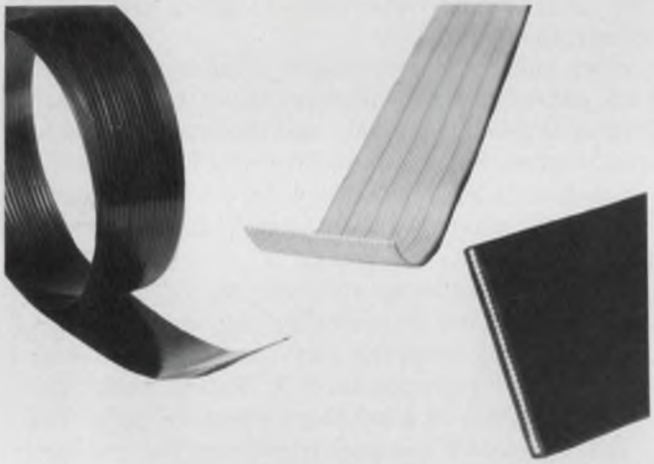
When crosstalk is a major problem, flat-conductor cable again has the edge over conventional and ribbon

Design flexibility is the "fourth" dimension of flexible cables and circuits. This Parlex component is used in a projectile, and greatly simplifies assembly. It replaces five PC boards, jumpers and connectors.

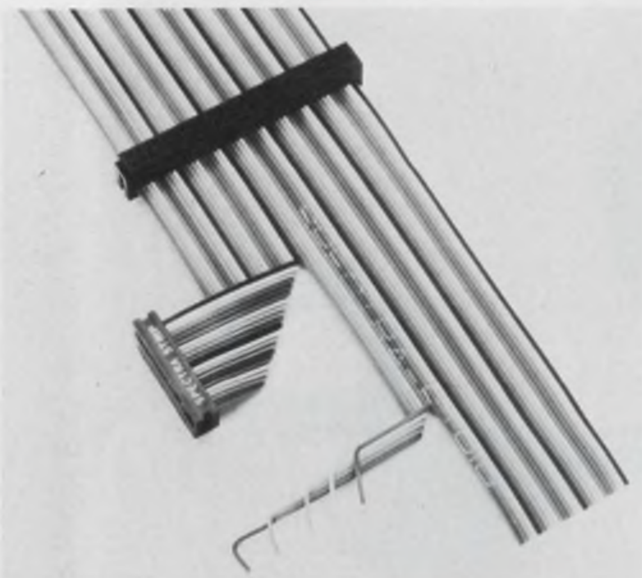
cable because of its lower capacitance. A 4 × 40-mil flat-conductor cable with 35-mil spacing measures only 6.5 pF/ft, which can be reduced to 0.05 pF/ft by applying a shield on both sides. However, the shield capacitance, C_s, is high—190 to 290 pF. Why such a large range? Because C_s is very sensitive to the conductor-shield spacing, which has a tolerance of ±0.5 mil. If the tolerance is doubled, C_s could range from 160 to 360 pF/ft.

The high shield capacitance can, however, be reduced. Ansley's Signaflow cable, for instance, is available with alternating flat and round conductors, which reduces the signal-line capacitance, and crosstalk with it, but keeps ground capacitance low.

A further improvement is achieved with the application of a PVC jacket over a polyethylene core. The



Flat-cable constructions differ widely, as demonstrated by these Ansley cables. Flat-conductor cables (left) are often laminated, round-conductor cables (center) extruded for the most part. An additional jacket (right) improves electrical and mechanical performance.



Breakouts in flat, flexible cables are easily accomplished in this harness from Spectra Strip. Insulation-displacement connectors can be placed in the middle as well as at the ends of a harness.

Table 4. Transmission-line characteristics for flat-conductor cable

Action	Result			
	impedance	capacitance	propagation velocity	inductive loss
Increase pitch	decreases	decreases		increases
Add insulation	increases		decreases	
Widen conductor	increases	decreases		
Increase ϵ	increases		decreases	

Example: Increased pitch decreases capacitance

jacket reduces the crosstalk 80%, compared with that of unjacketed flat cable; compared with bundled, twisted pairs, crosstalk is reduced nearly an order of magnitude. Some of the major transmission-line parameters for flat-conductor cable are summarized in Table 4.

But can you afford it?

When you decide between FFC and conventional wiring, cost is a major factor. A few years ago, FFCs cost substantially more per foot of conductor than regular round cable. Today, thanks to the large selection off the shelf, cost per foot is no longer the decisive factor. The important figure is installed cost, and that depends on your application. If you are working on a large system, FFC will cost you much more than round cable in the design stage. But you quickly cash in on direct labor.

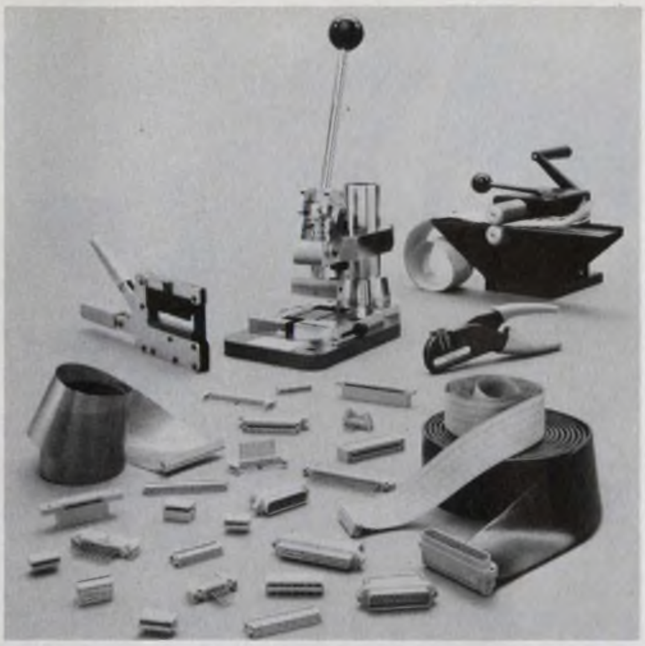
For example, a weapons-system harness with 300 wires developed by Westinghouse required 120 engineering hours, 60 drafting hours, and 632 manufacturing hours for the prototype. With FFC, it took 180 engineering hours, 360 drafting hours, and eight manufacturing hours. If you can use a computer to automate routing design and drafting, development costs can be much lower.

For a small system, the tradeoffs shape up differently. Interconnections within an equipment enclosure often require many breakouts of small conductor groups. So, you may have to decide between point-to-point hand wiring and a flexible circuit board.

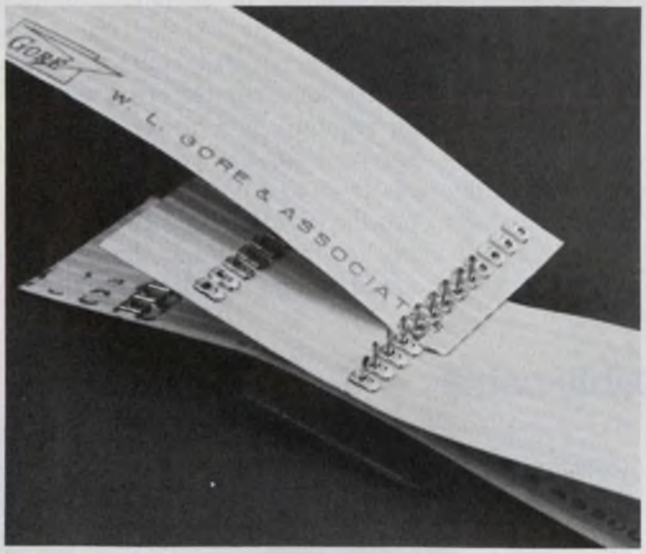
If you have the space, wire-wrapped connections are a good bet. They cost about 4¢ per point and are extremely reliable. Bell Telephone has made billions of such connections, with very few failures. Bell has found wire-wrapped connections to be 34 times more reliable than solder joints. Although point-to-point hand wiring is often less expensive, it is error-prone.

In contrast with hand wiring, flexible circuits need practically no space and eliminate most wiring-error rework. But these circuits, which are produced like PC boards, have a reputation for being expensive, especially if revisions become necessary. This reputation is largely undeserved, according to Herbert Pallade, President of Parlex.

Pallade states that jumper wires can be used for



The system concept for flat, flexible cables is typified by Ansley's Blue Macs line. You can buy a complete harness, or make your own from the large selection of available connectors, cables and tools.



Jumper cables without connectors are possible by attaching the contact pins directly to this flat-conductor cable assembly made by AMP.

modifications, just as in regular PC boards. Tooling costs can be kept low by more generous tolerances, and a competent manufacturer can make a flexible circuit competitive for as few as 10 units. Nevertheless, some aerospace engineers have misgivings based not only on the greater cost, but also on the reliability of flexible circuits.

If crossovers can't be avoided, double-sided circuits are necessary. But on thin substrates, plated-through holes are a problem. If you must stack several flexible circuits, the problem is compounded. Eyelets improve reliability, but add to the cost. One company, Teledyne, solves the problem by soldering rather than plating through the hole.

Recent improvements in flexible-circuit technology let you mount some components directly on the circuit. And you can design complex circuits in such a way that all solder joints are on the same side, then fold the circuit over several times to give you high packaging density. Such stacks are inexpensive to produce because all the solder joints are made at once.

Belling-Lee (Enfield, England) offers some hints to keep flexible-circuit costs down, and reliability up:

- Make conductors at least 25 mils wide, and give profiles a ±25-mil tolerance.
- Leave as much copper as possible on the "board," and blend the track into your terminal pads.
- Use 12-mil stiffening rather than rigid boards.
- Make autopositive copies of your artwork to avoid distortion problems.
- Above all, work closely with your vendor, and avoid the "overs" and "unders" of specifying.

Striking the proper balance

Overspecification can cost you a bundle, not only on etched flexible circuits, but also on other types of flat, flexible cables. For instance, a few more degrees in maximum operating temperature can force the vendor to use a dielectric or construction that doubles or triples the price.

Insist on an over-all width tolerance of ±0.010 in. on a 50-conductor cable, and you'll pay for a lot of measuring and sorting at the vendor's plant. By the time you get the cable, temperature and storage will have changed that critical width anyway.

Use a grooved cable with a matching connector, and the individual wires will self-center. For 12 to 36 conductors, ±0.015 in. width tolerance is reasonable, and for 40 to 60 conductors ±0.02 in. Another costly mistake is to specify 500-ft lengths of bonded cables, which are normally made in 100-ft runs. In production, such a cable then often gets chopped into 10-ft pieces.

If you specify all the mechanical dimensions as well as the materials, then you have tied down the electrical characteristics as well. Specify impedance or crosstalk also and you place the vendor—and yourself—right on the horns of a dilemma, because you have already determined impedance with your dimensions. When you select an FFC from a catalog, consider the given characteristics as a guideline only, and work out the details with the vendor.

Underspecification, on the other hand, is even more fraught with danger. The surest candidate for disaster is a product designed at one end of a tolerance range and manufactured at the other end. That product is usually never shipped. It's usually best to define all the electrical characteristics and the environmental constraints realistically, and let the vendor propose the most cost-effective solution, in terms of materials and dimensions.

Don't forget to include such "incidentals" as the termination or potting to be used, chemical resistance to solvents, flex radius and tension, folding requirements, shielding (be specific about frequency range and pulse shape) or flammability. If your vendor assumes you are planning to use insulation-displacing connectors, but you decide to solder instead, you may wind up with a cable that curls under the heat. What looks like a good connection suddenly opens during vibration.

If you need 100-million flexes, you may think that only stranded cable can do the job—only to find out later that flexible circuits have been improved to take the same punishment and save you assembly labor. Don't preclude alternate designs just because your first vendor prefers his own approach. Table 5 can get you started to find the best source.

Be specific. If you specify only a 600-V rating, the vendor may give you a cable that's satisfactory under MIL-W-16878, type B. But should it turn out that you need UL approval, you will need twice the insulation thickness for the same 600-V rating.

Above all, don't let your cable design drag on until everything else is cast in concrete. The more sophisticated the wiring, the earlier its details must be taken into account. Otherwise, you may paint yourself into an expensive corner.

There's one in every crowd

In addition to flexible circuits, extruded flat cable and laminated flat-conductor cable, some "specialty" constructions may be of interest in your application. The oldest family in the specialty group—the woven cable—is itself as diverse as the FFC.

The woven hangs on because it is flexible not only in space, but also in another sense: You can specify

Twisted wires minimize crosstalk, but are difficult to terminate. By alternating twisted sections with flat sections, this cable from Alpha Wire Corp. (right cable) can be mass-terminated like other flat cables.

any assortment of single-wire, stranded, coax—and even no-conductor lines—and get them woven into a ribbon. While conventional FFC is limited to the AWG-26-to-30 range, woven cables can accommodate as heavy a power line as AWG 10 or as fine a wire as AWG 40.

Conductor-less spacers can be included to keep sensitive circuits separated or to fold the cable lengthwise, like a pleated skirt. Breakouts are made automatically, and, with some connectors, the woven harness presents an economical solution.

An insulating matrix is another way to combine different conductors (down to AWG 46) into a ribbon. Storm Products embeds wires in silicone-rubber to form a super-flexible, low-torque ribbon that's almost totally limp, with conductor spacing down to 0.025 in.

Table 5. Who makes what in flat flexible cable

Company	Round conductors		Flat conductors	Etched conductors	Connectors	Harness assemblies	Comments
	solid	stranded					
Alpha Wire		✓			✓		Twisted w. flat sections
Ansley	✓	✓	✓	✓	✓	✓	Shielded, twisted/flat
AMP			*	✓	✓	✓	*only as part of harness
Belden		✓					extruded and laminated
Belling-Lee	✓	✓				✓	
Burndy					✓	✓	
Daburn	✓	✓					
Electroweave	✓	✓				✓	woven, incl. shielded
Haveg	✓	✓					woven
Huber & Suhner			✓				
Hughes	✓		✓	✓		✓	
3M		✓		✓	✓	✓	
Parlex	✓	✓	✓	✓		✓	
Rogers				✓		✓	
Stanford	✓	✓			✓	✓	
Storm					✓	✓	silicone rubber, coax, twisted

If your application requires inches, rather than feet of FFC, then silicone ribbon may provide a high-temperature solution despite its higher cost.

Although FFC can be made with very low crosstalk, under some conditions that parameter can be reduced even further by assembling twisted pairs into a ribbon. The catch: such a cable is hard to terminate. Spectra Strip offers a solution by providing flat sections every 18 in. With this geometry, mass termination is a cinch.

Get a running start

If you are just getting into flat, flexible cable, here is a list of helpful design aids, both software and hardware:

- A "Design Questionnaire" from Ansley helps you write a comprehensive FFC specification.
- A design guide from Minco Products designated FC300 helps you with flexible circuits.
- A cable-connector system from Alpha, which permits inspection of the connectors before covering and crimping, is available in kit form.
- A kit from Rogers Corp. helps you prototype flexible circuits ($25).
- A Blue Macs design kit from Ansley offers $500 worth of cables and connectors for $395.
- A universal arbor-press fixture (and a press) from Vector Electronics works with Alpha, AMP, Ansley, Berg, CW, JAE, 3M, SAE, and of course, Vector's own connector systems.

Judge for yourself if this kind of wiring suits your application, with Rogers' flexible-circuit kit.

- MIL-Specs 55543 and 55544 are indispensable to most engineers working with flat-conductor cables and connectors. ■■

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"Printed Wiring Design Guide," Institute of Printed Circuits, 1717 Howard St., Evanston, IL 60202.

"Survey of Flat Conductor Cable Technology," Report A951795, Lockheed Missile and Space Co., 6201 E. Randolph St., Los Angeles, CA 90040.

Need more information?

For further information on flat, flexible cables, readers may consult the manufacturers listed here by circling the appropriate numbers on the reader service card. More vendors and information may be found in electronic Design's GOLD BOOK.

Alpha Wire Corp., 711 Lidgerwood Ave., Elizabeth, NJ 07207. (201) 925-8000. (M. Klakis) **Circle No. 501**

AMP Inc., Harrisburg, PA 17105. (717) 564-0101. (J.T. Pletcher) **Circle No. 502**

Ansley Electronics Corp., Old Easton Rd., Doylestown, PA 18901. (215) 345-1800 (J. Rocks) **Circle No. 503**

Augat Inc., 34 Perry Ave., Attleboro, MA 02703. (617) 222-2202. (R. Grubb) **Circle No. 504**

Belden Corp., P.O. Box 1100, Richmond, IN 47374. (317) 966-6661. (M. La Porte) **Circle No. 505**

Belling & Lee Ltd., Great Cambridge Rd., Enfield, Middlesex, England EN1 3RY. 01-363-5393. (H. Pinkus) **Circle No. 506**

Brand-Rex Co., P.O. Box 498, Willimantic, CT 06226. (203) 423-7771. (G. Graeber) **Circle No. 507**

Buckbee-Mears Co., 245 E. Sixth St., St. Paul, MN 55101. (612) 228-6371. **Circle No. 533**

Burndy Corp., Richards Ave., Norwalk, CT 06856. (203) 838-4444. (J. F. Bradley) **Circle No. 508**

Calmont Engineering & Electronics Corp., 420 E. Alton St., Santa Ana, CA 92707. (714) 549-0336. (V. George) **Circle No. 509**

Cicoil Corp., 9324 Topango Canyon Blvd., Chatsworth, CA 91311. (213) 882-2021. (A. Hershkowitz) **Circle No. 510**

Daburn Electronics & Cable Corp., 2360 Hoffman St., Bronx, NY 10458. (212) 295-0050. (B. Danziger) **Circle No. 511**

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W. L. Gore & Associates, Inc., 555 Paper Mill Rd., Newark, DE 19711. (302) 738-4880. (R. S. Kauffman) **Circle No. 514**

Haveg Industries Inc., Wire Div., Box 7, Winoosik, VT 05405. (802) 655-2121. (J. Brooks) **Circle No. 515**

Huber & Suhner AG, Degersheimerstr 14, 9100 Herisau, Switzerland. 071 531515. (M. C. Cappis) **Circle No. 516**

Hughes Aircraft Co., Connecting Devices Div., 17150 Von Karman Ave., Irvine, CA 92714. (714) 549-5701. (W. D. Morris) **Circle No. 517**

ITT Wire & Cable Div., 172 Sterling St., Clinton, MA 01510. (617) 365-6331. (C. Generre) **Circle No. 518**

Methode Electronics, Inc., 7447 W. Wilson Ave., Chicago, IL 60656. (312) 867-9600. (M. Andrei) **Circle No. 519**

Minco Products Inc., 7300 Commerce Lane, Minneapolis, MN 55432. (612) 786-3121. (L. G. Hanson) **Circle No. 520**

3M Co., Electronic Products Div., 3M Center, St. Paul, MN 55101. (612) 733-1110. (R. Barker) **Circle No. 521**

New England Electric Wire, 365 Main St., Lisbon, NH 03585. (603) 833-6628. (C. McKenzie) **Circle No. 522**

Parlex Corp., 145 Milk St., Methuen, MA 01844. (617) 685-4341. (M. Kotler) **Circle No. 523**

Philips Cable Div., P. O. Box 26, Delft, Holland. Telex 31024/31051. **Circle No. 524**

Rogers Corp., 77 Main St., Rogers, CT 06263. (203) 774-9605. (H. Brooks) **Circle No. 525**

Sanders Associates, Grenier Field, Manchester, NH 03103. (603) 669-4615. (L. Travis) **Circle No. 526**

Spectra-Strip Inc., 7100 Lampson, Garden Grove, CA 92642. (714) 892-3361. (D. Ebling) **Circle No. 527**

Stanford Applied Engineering, 340 Martin Ave., Santa Clara, CA 95050. (408) 245-2910. (M. Austin) **Circle No. 528**

Storm Products Co., 112 S. Glasgow, Inglewood, CA 90301. (213) 776-8141. (G. E. Heisler) **Circle No. 529**

Teledyne Electro-Mechanisms, 29 Crown St., Nashua, NH 03060. (603) 889-6191. (V. St. Amand) **Circle No. 530**

TRW Co., Holyoke Div., 775 New Ludlow Rd., South Hadley, MA 01075. (413) 533-3961. (G. Miles) **Circle No. 531**

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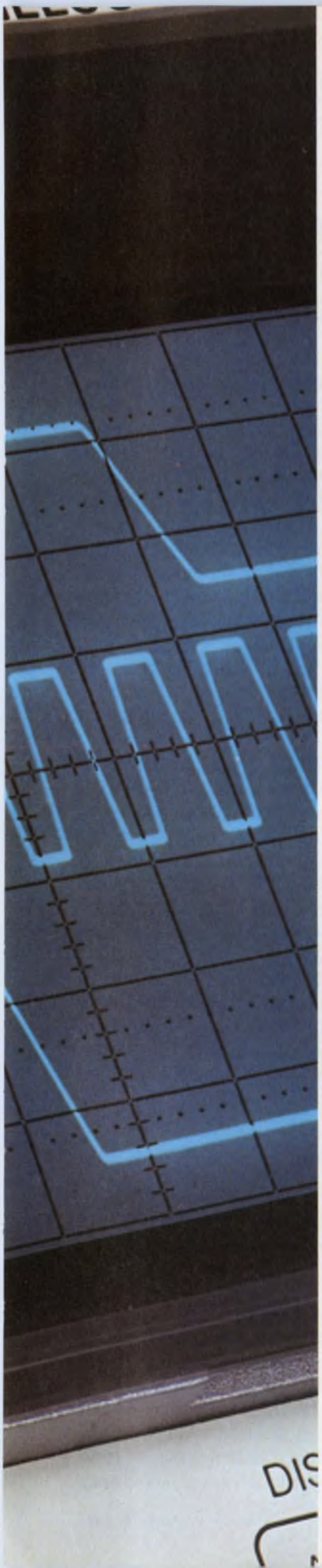

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CIRCLE NUMBER 41

The design of a home security system

lets you apply the concepts of 'top-down' programming. The assembly code is written for an 8080-based microcomputer.

Most microcomputers are used in dedicated control operations: The computer reads a number of sensors, manipulates the inputs according to the program instructions, and as a result activates output devices. A practical example of such an operation is a home security and alarm system, which employs many I/O techniques. You can develop a program to implement this system with an 8080-based microcomputer.

The complete program is fairly complex, but by using a "top-down" design procedure, and the structured programming techniques described in Parts 1 through 4 of this series, you can break the problem down into small blocks that are easy to implement.

The first step in top-down software design is to formulate a complete specification for the security system, which serves a typical three-bedroom, single-story house with a two-car garage. Fig. 1 shows the floor plan and the location of fire or smoke detectors, control panels and sensors that monitor two entry doors (garage door and patio door) and 13 windows. The window and door sensors can be activated only when the security system is enabled.

Once the system is armed, it monitors all sensors continuously. If it detects an entry, the alarms are activated.

One for fire, two for intrusion

The output devices of the system are one fire alarm and two intruder alarms. The fire alarm is loud enough to awaken family members sleeping anywhere in the house. The first intruder alarm is large and noisy. If the system is armed, the alarm is activated by any entry violation. Or you can press the Alarm Test button on the main console.

The second intruder alarm is part of the main control panel, and designed to wake you without setting off the general alarm. If the security system has been armed from the main control panel, the second alarm is activated by an intruder; what's more, you can check the status board to decide whether to call the police, activate the main alarm, or take other action.

Remote-control points at the front and garage doors allow you to activate the entry-detection part of the system when you leave the house, and deactivate it when you re-enter. Each remote site has an indicator to show when the system is active, and a mechanical keyboard. Activate the system by pressing a single key, and deactivate it by punching a user-selected five-digit code.

A remote-control unit (Fig. 2) consists of two control buttons, a 10-key keyboard, and two indicator lights. Press the Arm button when leaving the house. The system then checks to make sure all doors and windows are closed and turns on the System Armed indicator. If a door or window is found open, the System Fault indicator turns on. You can then check the main control panel to find the open door or window.

The master control panel (Fig. 3) consists of several control buttons and an outline of the house perimeter, with an indicator light for each sensor. The Arm button performs the same function as the Arm buttons on the remote units. The Disarm button deactivates the intruder sensors and turns off all active alarms except for the fire sensors, which are always active. The Test button turns on all the panel lights until the Disarm switch is pressed.

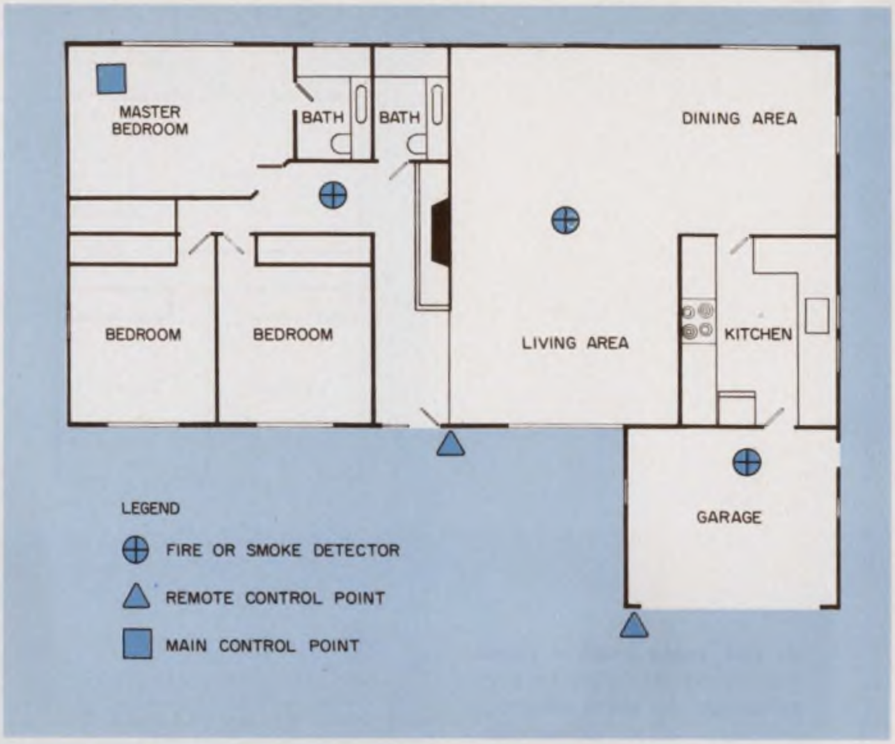
The Status button permits you to check for any open door or window. When you press "Status," the system turns on the proper indicator light(s) and keeps them on until the Disarm button is pressed. The Alarm button activates the system alarms, which remain on until deactivated by the Disarm button.

Off to the corner byte shop

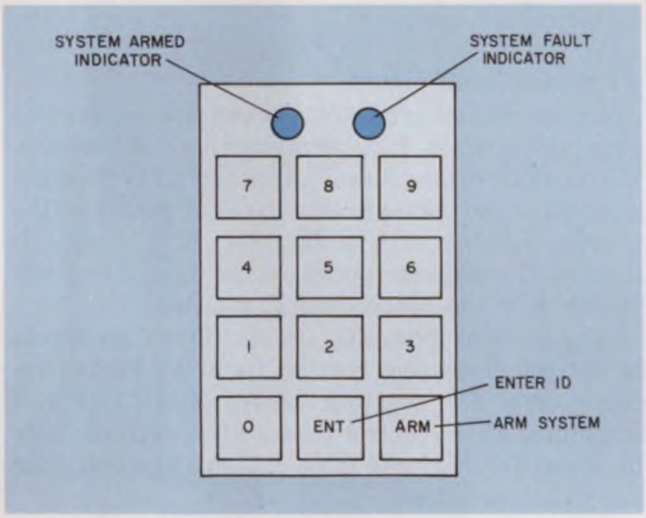
The hardware design for this system is straightforward, because many 8080-based microcomputers have enough parallel I/O ports, and several new versions will soon be available. So most of the hardware design is taken care of. You just have to wire the sensors, control panels and alarms.

To minimize the number of wires running around the house, use scanned-input operations (see box). All fire or entry sensors must be identifiable so that they can be properly displayed on the status display. All key entries must be decoded to check them against the valid entry code. The Arm, Disarm, Test, Status, and Alarm inputs, on the other hand, are detected only

Robert W. Ulrickson, President, Logical Services Inc., 711 Stierlin Rd., Mountain View, CA 94043.



1. **The floor plan of a typical home** shows three fire sensors and 13 windows to be monitored. The security system's main control is in the master bedroom, and two doors have remote panels.



2. **Remote-control panels** permit you to arm the security system when you leave, and disarm it by entering an identification code.

to initiate a control sequence.

The output system requires enough output ports to energize the indicators on the main control panel and drive the Arm and Fault indicators at the remote sites. Each indicator is a single device driven directly from the output port.

The input detectors are organized as a scanned matrix; each system input is assigned a position in the matrix. All remote control stations are wired in parallel.

Fig. 4 shows the matrix layout for the system. Note that not all the matrix positions are used. The fire and entry sensors are located in blocks to permit easy expansion. Each indicator light is a single LED.

The low-volume intruder alarm has adjustable volume, and can be made from an inexpensive radio. A good high-volume external alarm would be a surplus crash alarm from a World War II destroyer.

The basic output hardware is shown in Fig. 5, using an 8-bit microcomputer. The system's Arm and Fault indicators, alarm actuators, and entry indicators are all on separate output ports. Sufficient output ports for expansion are included.

To complete the hardware design, assign the I/O ports to be addressed in your 8080-based microcomputer as follows:

INPUT PORT NAME	I/O ADDRESS, BITS	FUNCTION
COLUMN	10H, BITS 0-7	SWITCH MATRIX COLUMN INPUTS
ROWS	10H, BITS 0-7	SWITCH MATRIX ROW OUTPUTS
STATUS	11H, BIT 0	SYSTEM ARMED INDICATOR
	BIT 1	SYSTEM FAULT INDICATOR
ALARM	12H, BIT 0	FIRE ALARM ACTUATOR
	BIT 1	OUTSIDE INTRUDER ALARM
	BIT 2	INSIDE INTRUDER ALARM
IND 0	13H, BIT 0	FIRE SENSOR 25 (GARAGE)
	BIT 1	FIRE SENSOR 25 (LIVING ROOM)
	BIT 2	FIRE SENSOR 26 (BEDROOMS)
	BITS 3-7	OTHER FIRE SENSORS FOR LATER USE SENSORS 32-39
IND 2	15H, BITS 0-7	STATUS INDICATORS FOR SENSORS 40-47

(continued on page 72)

3. **The main control panel** has an indicator light for every sensor to show where a problem exists. Other controls permit you to check out the system.

(continued from page 71)

IND 3	16H, BITS 0-7	STATUS INDICATORS FOR SENSORS 48 AND 49 (50-55 AVAILABLE FOR LATER USE)
IND 4	17H, BITS 0-7	STATUS INDICATORS FOR SENSORS 56-63 AVAILABLE FOR LATER USE

Block out the software

Continuing with the top-down design procedure, you must now define the major software blocks (Fig. 6) After initialization, the program continually scans the sensor matrix for any closure transitions. Because several sensors may be active at the same time (e.g., several open windows) and because you want the system to respond to the most recent change, you must keep an image of each sensor position.

Once a closure transition is detected and debounced (see box), it is decoded and control transferred to the appropriate response routine. This is a good application for a table-driven Select Operation structure, where the key position code determines which process to execute. You can develop, code, and debug the major software blocks individually, then integrate them and debug the whole system.

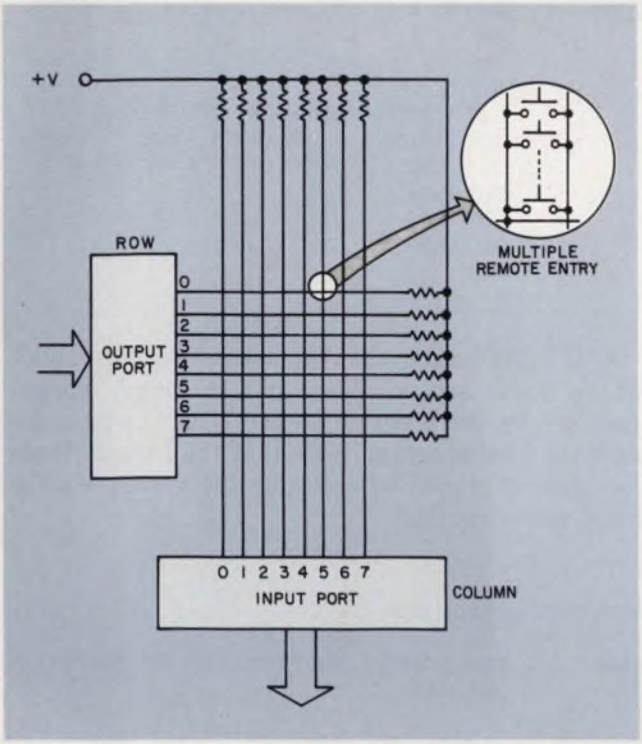
Fig. 7 shows the logic for beginning the program, in more detail. The reset button clears all indicators in the status display, deactivates all alarms and initializes all status flags to indicate that the system is disarmed and quiescent. The program then begins to scan the input matrix.

Since several other program blocks also require this scanning operation, it is performed by a subroutine, SCAN, which determines if any sensors have become active since the previous scan cycle. If none has, the program returns with a flag set. If a closure is detected, the program performs the debouncing and returns with the sensor-matrix position.

Using this sensor position, the decode routine selects the correct processing routine from the system-response table. The program labeled MAIN in Fig. 7 determines where control passes after each of these functions. The response table contains one entry for each valid operation:

* ARM SYSTEM FROM MAIN PANEL
* ARM SYSTEM FROM REMOTE PANEL
* DISARM SYSTEM FROM MAIN PANEL
* DISARM SYSTEM FROM CODE ENTERED BY REMOTE PANEL
* CONTROL FIRE ALARMS
* CONTROL INTRUDER ALARMS
* TEST ALL ALARMS
* DISPLAY SYSTEM STATUS
* TEST DISPLAY

Because the program is meant to run in a small, dedicated system, it is primarily stored in ROM. The ROM will contain 512 bytes from 0-1FFH. Assume there are also 256 bytes of RAM from 200-2FFH. When all sensors are inactive, all image bytes are ZERO. And if the system is armed from the master panel, the panel flag is ZERO. The storage is allocated by, and the temporary-storage locations defined in, the following part of the program:



4. **A matrix for sensors and keyboards** minimizes the amount of wiring and the number of I/O ports the system requires. The table indicates matrix assignments.

Matrix position assignments

Matrix point	Switch number	Function
0,0	0	Arm
0,1	1	Disarm
0,2	2	Test
0,3	3	Status
0,4	4	Alarm
0,5	5	Remote arm
0,6	6	Remote entry
0,7	7	Unused
1,0	8	Code key 0
1,1	9	Code key 1
1,2	10	Code key 2
1,3	11	Code key 3
1,4	12	Code key 4
1,5	13	Code key 5
1,6	14	Code key 6
1,7	15	Code key 7
2,0	16	Code key 8
2,1	17	Code key 9
2,2-2,7	18-23	Unused
3,0	24	Garage fire input
3,1	25	Dining area fire input
3,2	26	Bedroom fire input
3,3-3,7	27-31	Available for other fire sensors
4,0-6,1	32-49	Sensor inputs
6,2-7,7	50-63	Available for other sensors

```
            ORG 200H
;
;FLAGS
;
ARM:        DS 1        ;SYSTEM ARMED FLAG
PANEL:      DS 1        ;REMOTE/MAIN PANEL ARMED
;
;MATRIX
;IMAGES
;
SWITCH:     DS 8        ;SENSOR IMAGES FOR CONTROL
                        ;BUTTONS
KEYS:       DS 10       ;KEY SWITCH INPUTS
NULL:       DS 6        ;UNUSED
FIRE:       DS 8        ;FIRE SENSORS
SENSOR:     DS 32       ;ENTRY SENSORS
```

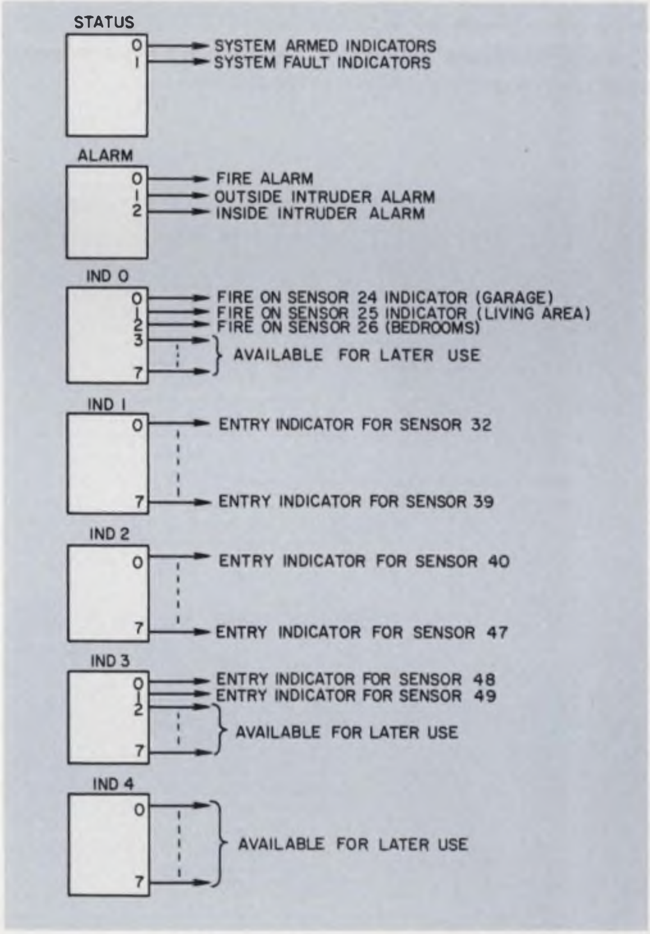
The 8080 instruction set was discussed in Part 1 of this series (ED No. 1, Jan. 4, 1977, pp. 95-96) and in Part 2 of μP Basics (ED No. 10, May 10, 1976, pp. 85-89). "ORG" and "DSxx" are pseudo-instructions. All entries following a semicolon are merely comments, and the 8080 disregards them.

The initialization program follows the flow chart of Fig. 7. The jump at location 0 to location 40H leaves some locations available for the 8080 interrupts (RST1-7).

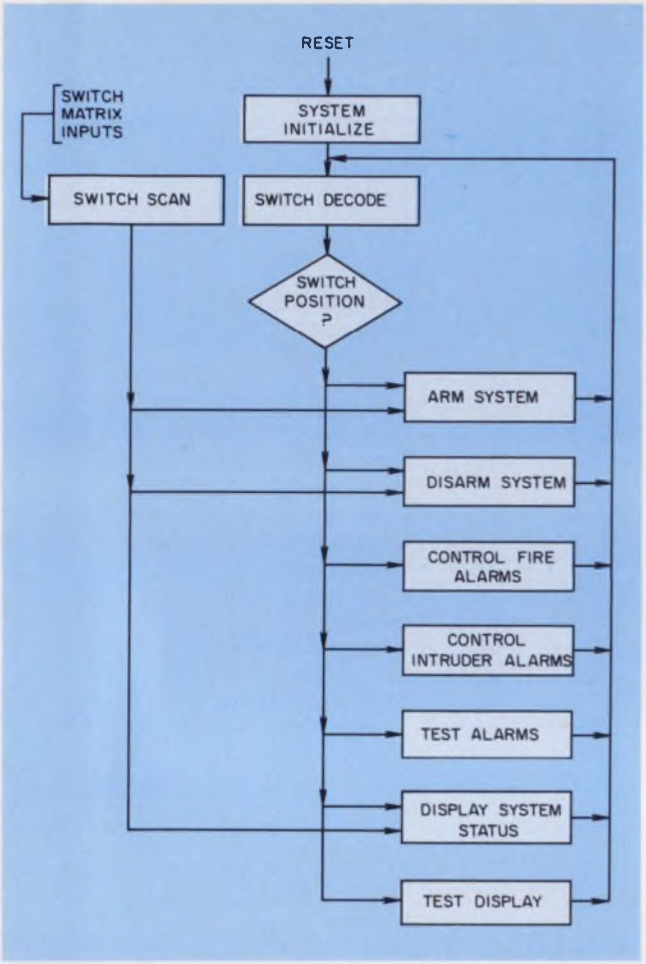
```
            ORG 0       ;RESET VECTOR
            JUMP INIT

            ORG 40H
INIT:       MVI A, 0    ;INITIALIZE SYSTEM
            LXI H, ARMS ;START OF SWITCH IMAGES
            MVI C, 64
```

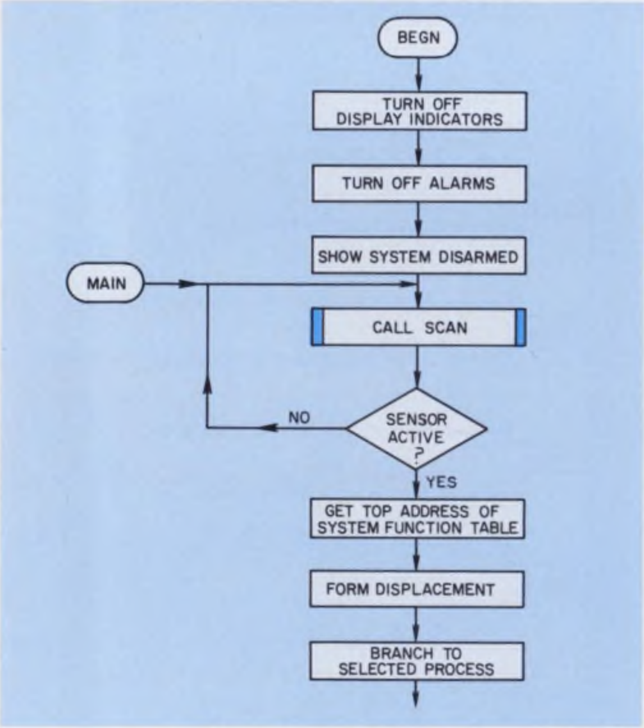
(continued on page 74)



5. **Seven output ports are required** for the security system, which includes space for possible expansion.



6. **Major software blocks** for the security system summarize all essential software functions.



7. **The logic for system initialization and command decoding** is expressed in a standard flow chart.

```
ILOOP:    MOV M, A
          INX H
          DCR C
          JNZ ILOOP
          OUT STATUS   ;TURN OFF INDICATORS
          OUT ALARM    ;TURN OFF ALARMS
          OUT INDO     ;TURN OFF STATUS BOARD
          OUT IND1
          OUT IND2
          OUT IND3
          .
          .
```

After initialization, the system enters a loop to wait for an active sensor. When one is found, control transfers to the program sector MAIN, which determines further action. Note that the Disarm function is accomplished by resetting the system via the initialization routine.

```
;
;MAIN PROCESSING LOOP
;
MAIN:     CALL SCAN    ;WAIT FOR CLOSURE TRANSITION
          JNC MAIN
;
;CLOSURE CODE NOW IN A
;
          CPI 32       ;SENSOR?
          JP SENSOR    ;YES, IF A ≥ 32
          CPI 24       ;FIRE?
          JP FIRE      ;YES, IF A ≥ 24
          CPI 7        ;OTHERS?
          JP MAIN      ;IGNORE THOSE BETWEEN
                         7 AND 23
;
;A = 0-6. FORM TABLE DISPLACEMENT
;
          MOV H, A     ;SAVE A
          ADD A        ;A = A * 2
          ADD H        ;A = 3 * A
          LXI H, CTBLE ;GET TABLE ADDRESS
          ADD L
          MOV L, A     ;ADD 3 * A TO ADDRESS
          JNC HERE     ;SKIP INR H IF NO CARRY
          INR H
HERE:     PCHL         ;JUMP TO JUMP TABLE
;
;COMMAND TABLE
;
CTBLE:    JMP MARM     ;MASTER ARM
          JMP INIT     ;DISARM
          JMP TEST     ;TEST DISPLAY
          JMP STATUS   ;SHOW SYSTEM STATUS
          JMP ALERT    ;TEST/ACTIVATE ALARMS
          JMP RARM     ;REMOTE ARM
          JMP RENT     ;REMOTE ENTRY
```

SCAN walks the beat

The SCAN routine tests the sensor matrix to determine which sensors have changed from open to closed, or closed to open, since the last scan. The current state of each sensor must be saved in memory. If a sensor goes active, the matrix position is computed and a flag set before control returns to the main program for appropriate action. If there are no transitions, SCAN continues through the matrix until all rows and columns have been scanned, then returns

Develop a routine for scanned I/O devices

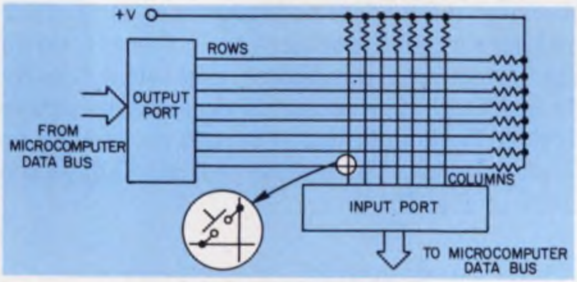
Scanned I/O devices are all around you. Take a simple keyboard, consisting of a matrix of wires with a normally open pushbutton switch at each intersection. The matrix reduces 64 individual key inputs to eight inputs and eight outputs—only two I/O ports on an 8-bit microcomputer.

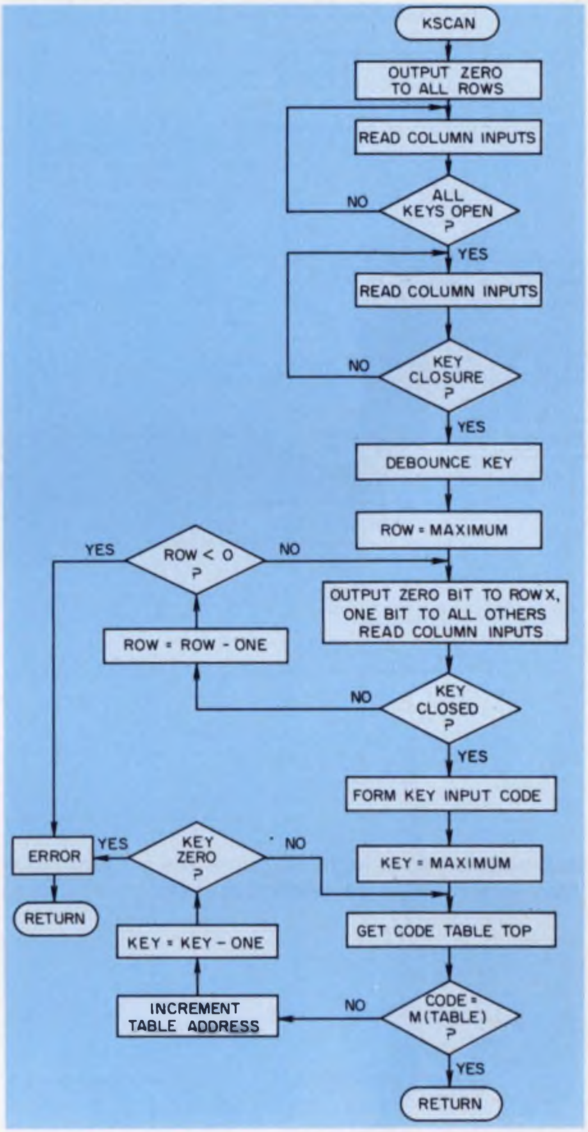
A program to accept keyboard entries must determine whether a key has been depressed and, if so, which one. The problem is complicated by the fact that most keys bounce for several milliseconds before the closure is complete. Another problem is multiple key depressions (N-key rollover), which you can solve by forcing the program to wait for all keys to be open between key closures.

To develop the scan logic, start by setting all the output port bits LOW. Until a key is depressed, the input port bits are all HIGH. You can detect a key closure by looking for a LOW on the input port. After detecting a key closure, your program requires a delay that is longer than the bounce time of the switch. Then you can scan the matrix to determine which key is closed.

A simple scan algorithm drives the first row low and all others high, then reads the input port representing the column lines. If there is a zero in the input, its location tells you which key is depressed. If no zero is found, you drive the next row low and repeat until you find the closed key.

After exit from the scan routine, you know the row number and the column bit pattern. The combination of these two values identifies the closed key with the help of a table that has one entry for each key. Search the table for a match with the I/O port images, and exit with the proper key code, which can then be used in the program. The logic diagram shown is general enough to be used with matrix keyboards of almost any size.



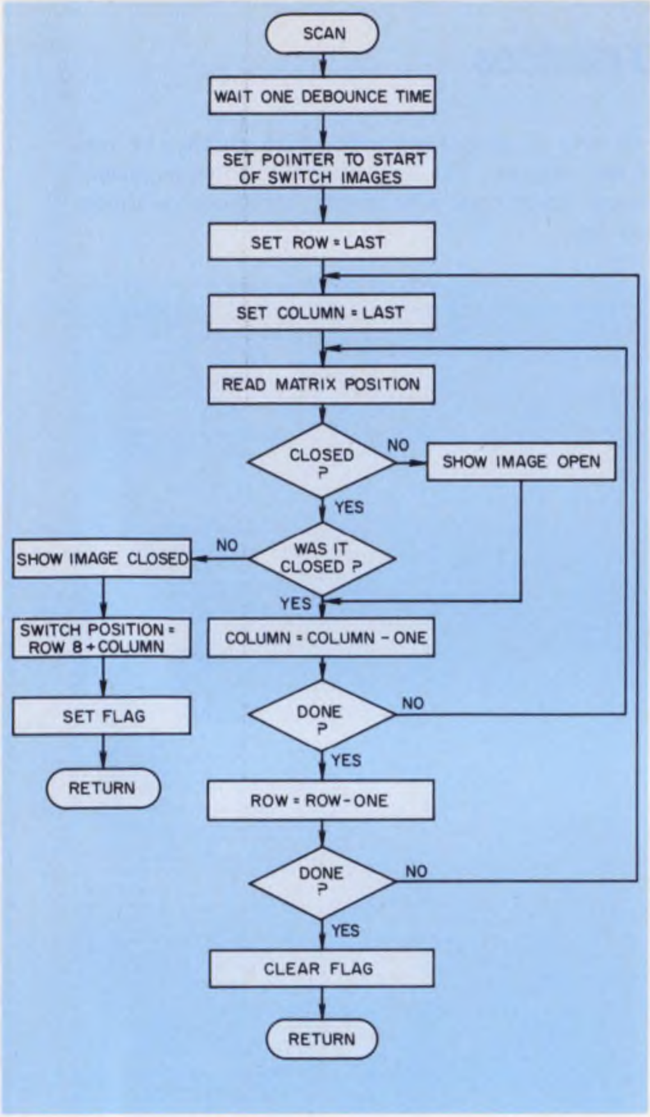


with the transition flag cleared. The program logic for SCAN is shown in Fig. 8.

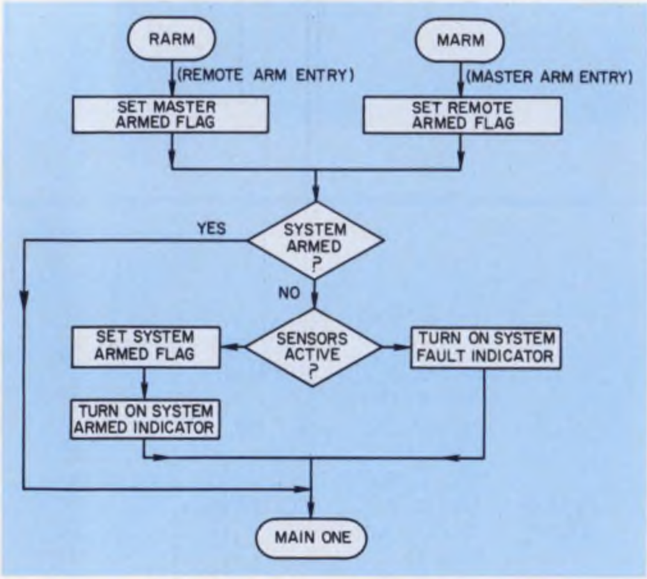
To implement this flow chart in 8080 assembly language, make the carry bit the transition flag. The row and column counters are stored in BC, and the input and output port images in DE. The delay subroutine DBOUNCE tests for true switch closure.

```
        PUSH H
        PUSH D
        PUSH B
        CALL DBOUNCE
        LXI H, SWITCHES + 63
                        ;LAST SWITCH IMAGE
        MVI B, 7        ;ROWS = 7
        MVI D, 7FH
        MOV A, D        ;SET UP ROW IMAGE
        OUT ROWS
        MVI E, 80H      ;SET UP COLUMN MASK
CLOOP:  MVI C, 7        ;COLUMNS = 7
ILOOP:  IN COLUMN
        ANA E
        JZ CLOSED       ;IF 0, CLOSURE
```

(continued on page 76)



8. **Switch-position scan logic** describes the program segment that interrogates all system sensors.



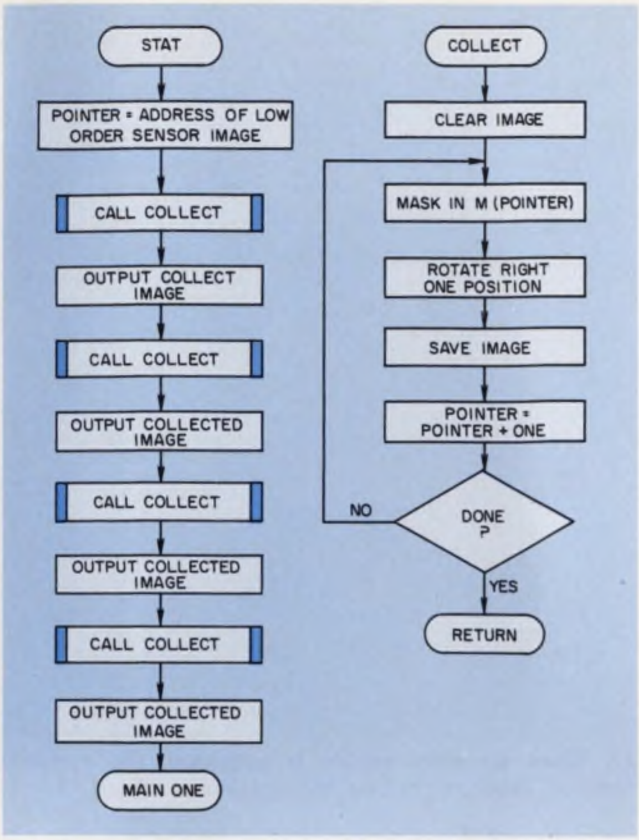
9. **The intruder-detection subsystem** is armed by the routine outlined in this flow chart.

```
           MVI M, O        ;SHOW IMAGE OPEN
           JMP NEXT C
CLOSED:    MOV A, M        ;GET IMAGE
           ORA A
           JNZ NEXT C      ;ALREADY CLOSED
           MVI M, A        ;SHOW CLOSED
           MOV A, B        ;GET ROW NUMBER
           RLC             ;ROW * 2
           RLC             ;ROW * 4
           RLC             ;ROW * 8
           ANI 38H         ;MASK OFF EXTRA
           ADD C           ;ADD IN COLUMN
           STC
           POP B
           POP D
           POP H
           RET
NEXTC:     DCR C
           JM NEXT R       ;NEXT ROW
           DCX H           ;NEXT IMAGE
           MOV A, E
           RRC             ;NEXT BIT
           MOV E, A
           JMP JLOOP
NEXTR:     DCR B
           JM DONE         ;IF MINUS, ALL DONE
           DCX H           ;NEXT IMAGE
           MOV A, D
           RRC
           OUT ROWS
           MOVE D, A
           JMP OLOOP
DONE:      ORA A           ;CLEAR FLAG
           POP B
           POP D
           POP H
           RET
```

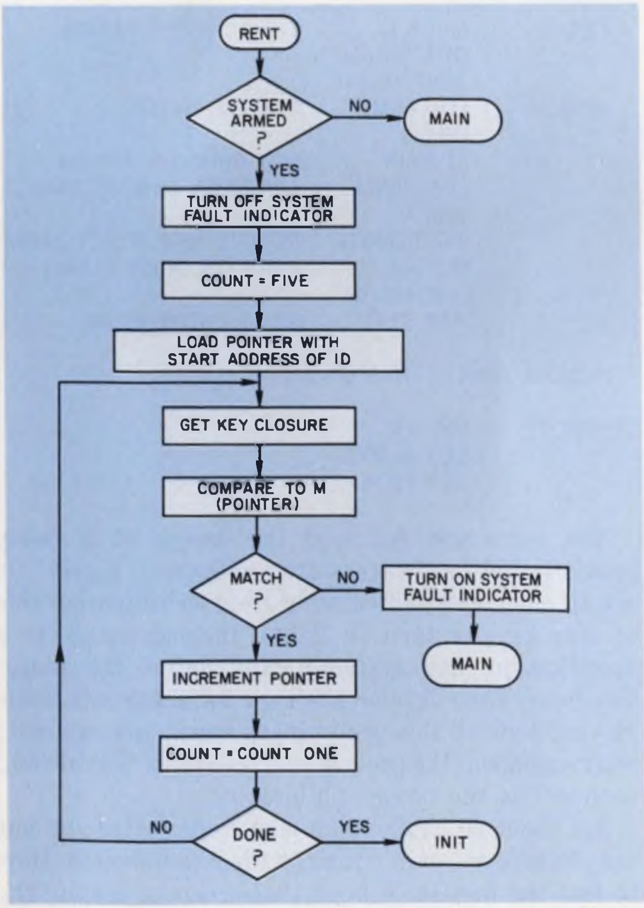
Arming your electronic watchman

The arming logic (Fig. 9) consists of saving a flag for the remote-input panel or the master control panel, checking the system to make sure it is disarmed, making sure all the sensors are quiescent, turning on the System Armed indicator, and setting the System Armed flag. If a sensor is detected as active, the System Fault indicator is turned on and the system is left disarmed. The arming program follows the flow chart of Fig. 9:

```
;
;SYSTEM ARMING CONTROL
;
MARM:    MVI A, 0      ;SHOW ARMED FROM MAIN PANEL
         JMP TESTS
RARM:    MVI A, 1      ;SHOW ARMED FROM REMOTE PANEL
TESTS:   STA PENL      ;SAVE ARMING FLAG
         LDA ARMS
         ORA A         ;ALREADY ARMED?
         JNZ MAIN1     ;IF SO, IGNORE SWITCH
         LXI H,
           SENSOR      ;START OF SENSOR IMAGE AREA
         MVI C, 32     ;CHECK SENSOR IMAGES
TLOOP:   MOV A, M      ;GET IMAGE
         ORA A         ;TEST FOR ZERO
         JNZ TERR      ;IF NOT ZERO, ACTIVE SENSOR
         INX H
         DCR C         ;CONTINUE
         JNZ TLOOP
;
;SYSTEM CLEAR. ACTIVE
```



10. **Testing for display and system status** is straightforward, as indicated by these logic diagrams.



11. **To disarm the system from an entrance,** the program compares five punched-in digits with "pointer M."

```
;
        MVI, A, 1
        STA ARMS
        OUT STATUS   ;TURN ON ARMED INDICATOR
        JMP MAIN1
;
;SYSTEM HAS ACTIVE SENSOR
;
        MVI A, 2
        OUT STATUS   ;TURN ON FAULT INDICATOR
        JMP MAIN1
```

Testing the display status is simply a matter of turning on all the panel's indicator lights so that you can detect and replace any bad ones. The lights stay on until the system's Reset or Disarm inputs are activated. Use the same procedure to turn on the alarms, when the Alarm button is pressed, by outputting ONEs to all the bits in the alarm output port. The alarms remain on until the system is disarmed.

Testing system status is also fairly simple. Just scan through the sensor images and turn on the indicator for any active sensor. But there is one problem: The output indicators are controlled by parallel output ports (eight indicators per output port) while the sensor-input images are saved as sequential one-bit flags. So you collect eight sensor images into a single byte and output the value to the appropriate port.

The logic for the status output is shown in Fig. 10 and the program segments for display test (subroutine TEST), alarm actuator (subroutine ALERT), and status display (subroutine STAT) follow.

```
TEST:      MVI A,OFFH
           OUT IND0
           OUT IND1
           OUT IND2
           OUT IND3
           OUT IND4
           JMP MAIN
           .
           .
           .
ALERT:     MVI A,OFFH
           OUT ALARM
           JMP MAIN
           .
           .
           .
STAT:      LXI H,SENSOR ;ADDRESS OF LOW ORDER
           CALL COLLECT ;SENSOR IMAGE
           OUT IND1     ;OUTPUT TO INDICATORS 32-39
           CALL COLLECT
           OUT IND2     ;OUTPUT TO INDICATORS 40-47
           CALL COLLECT
           OUT IND3     ;OUTPUT TO INDICATORS 48-55
           CALL COLLECT
           OUT IND4     ;OUTPUT TO INDICATORS 56-63
           JMP MAIN
;
;COLLECT BITS INTO OUTPUT PORT IMAGE
;
COLLECT:   MVI C,0
           MVI B,8
CLOOP:     MOV A,M      ;GET BIT
           ORA C        ;MASK INTO IMAGE
           RRC          ;ROTATE TO NEXT PLACE
```

(continued on page 78)

(continued from page 77)

```
            MOV C,A      ;RE-SAVE IMAGE
            INX H
            DCR B
            JNZ CLOOP
            RET
```

Is that you, dear?

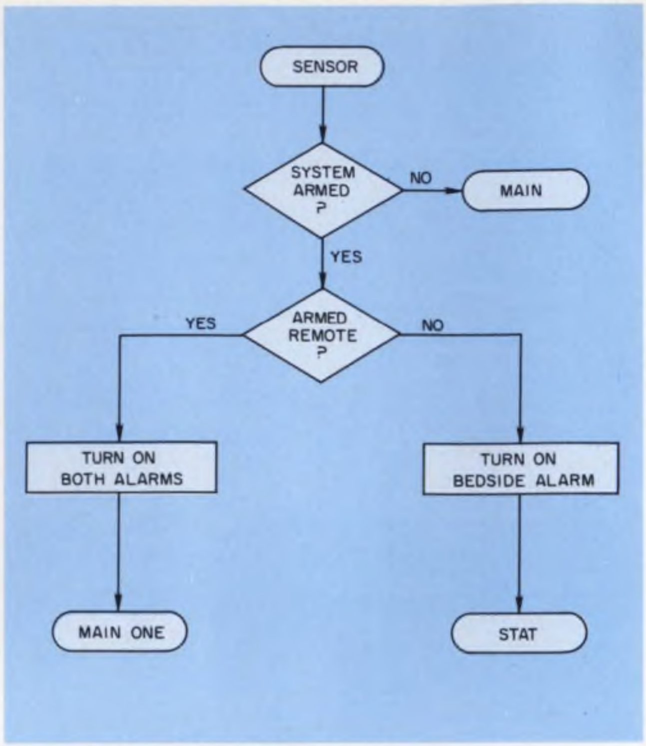
To get into the house when the system is armed, press the Ent key, and enter a five-digit entry code. If the punched code matches that stored in the computer, the system is deactivated, and the System Armed indicator light goes off. If the code does not match, the System Fault indicator comes on, and the system remains armed. The entry code allows 100,000 combinations. At one try per second, that's 28 hours of punching. Prowlers rarely have that much time. You can program the system to set off the alarm after a certain number of incorrect attempts to match codes.

The logic in Fig. 11 first verifies that the system is armed, turns off the System Fault indicator, sets a pointer to the start of the ID code string, and sets a counter to five. It then enters a loop, which picks up key closures and compares them to the position saved in the string. If the entire string matches, the system is disarmed via the initialization routine. If the string doesn't match, the System Fault indicator goes on, and the system remains armed.

```
;REMOTE ENTRY DISARM
;
RENT:       LDA ARMS     ;TEST FOR ARMED
            ORA A
            JZ MAIN      ;IF 0 NOT ARMED
            MVI A,1      ;TURN FAULT OFF
            OUT ISTATUS
            MVI C,5      ;SET COUNTER
            LXI H,KEY ID ;START OF KEY STRING
RELOOP:     CALL SCAN
            JNC RELOOP   ;WAIT FOR CLOSURE
            CMP M        ;COMPARE CLOSURE TO STRING
            JNZ ERROR
            INX H        ;NEXT KEY
            DCR C        ;DECREMENT COUNTER
            JNZ RELOOP
            JMP INIT     ;MATCH. RE-INITIALIZE
;
;ERROR. TURN ON FAULT INDICATOR
;
ERROR:      MVI A,2
            OUT STATUS
            JMP MAIN
```

The system's response to a fire-sensor HIGH is simple: It turns on the fire alarm. But what happens if the system finds an intruder? Fig. 12 has the answer. If the system is armed from the main panel, the wake-up alarm is activated, and the status board shows the entry point. You can then decide on the appropriate action. If the system is armed remotely, the old destroyer horn goes off as well.

Note that the correct indicator is activated in Fig. 12 simply by jumping to the status subroutine after turning on the alarm. The SCAN routine has saved the image of the active sensor, which can now be sent to the display. The program for this segment follows:



12. **When an entry sensor is activated,** the system's reaction depends on how the system is armed.

```
FIRE:       MVI A,1      ;TURN ON FIRE ALARM
            OUT ALARM
            JUMP MAIN1
SENSOR:     LDA ARMS     ;SYSTEM ARMED
            ORA A
            JZ MAIN      ;NOT ARMED IF ARMS 0
            LDA PANEL    ;ARMED BY REMOTE PANEL?
            ORA A
            JNZ REMOTE   ;REMOTE ARM IF NOT ZERO
            MVI A,4      ;TURN ON QUIET ALARM
            OUT ALARM
            JMP STAT     ;SHOW ENTRY POINT
;
;REMOTE ARMED. TURN ON ALL ALARMS
;
REMOTE:     MVI A,6
            OUT ALARM
            JMP MAIN
```

You have now followed the design of a fairly sophisticated hardware/software system. Again: Do not sit down and immediately start writing programs to scan keys or turn on lights. Instead, establish a specification, and systematically define the major functions. Then develop the logic for these functions. Having done all this preliminary work, you can start worrying about the programming details. "Divide and conquer" is the proper philosophy.

But the most challenging part comes after you put the pieces together and turn on the power switch. How to find the inevitable bugs that creep in despite the most systematic and consistent design procedure will be a future topic. ■■

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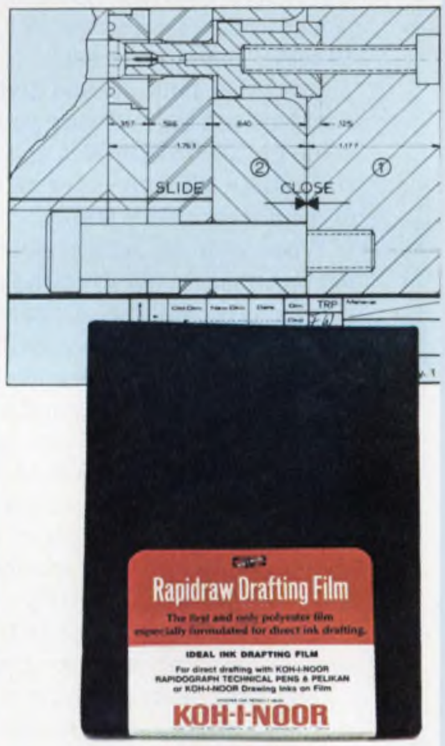

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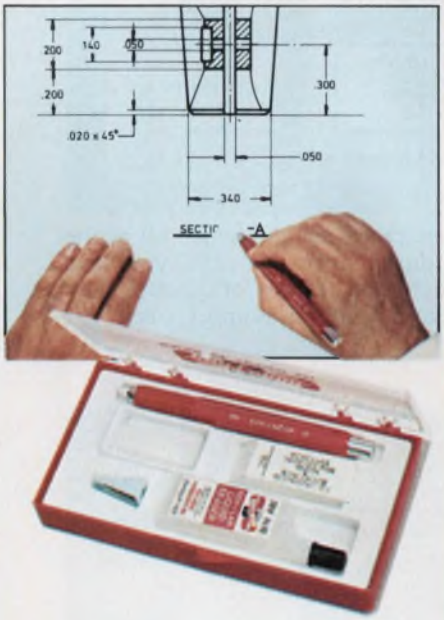

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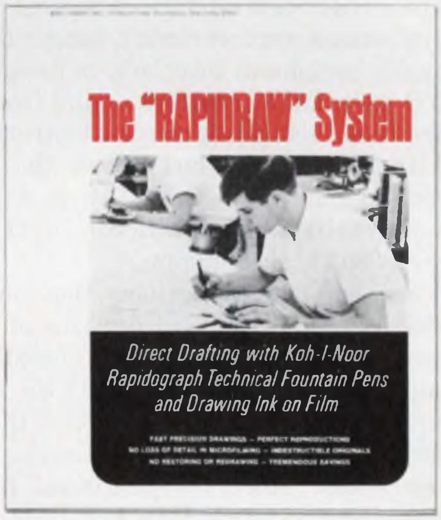

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CIRCLE NUMBER 47

Cut a/d conversion costs by using

software and d/a converters. Memory-mapped I/O helps eliminate the interface circuits normally needed.

Although the microprocessor is usually considered a flexible replacement for discrete logic, most μP-based instruments still use numerous isolation and support packages to convert from analog to digital. But now you can create a software-controlled a/d converter input for your μP system—with software, a processor and a digital-to-analog converter.

An 8080A μP and a DAC-08 eight-bit d/a converter can be used to build an 8-bit a/d converter that doesn't need any 8080A peripheral isolation circuits. And you can easily expand this technique to 10 or 12 bit converters or to other μPs that have separate address and data buses.

Know the μP interface requirements

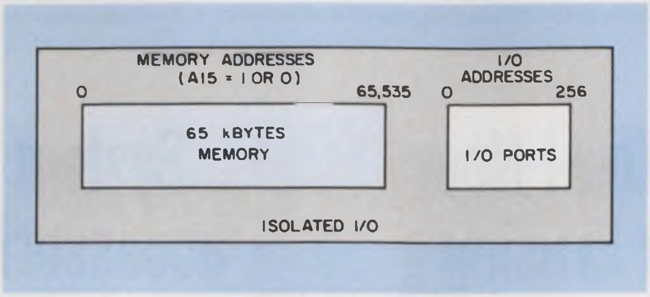
To communicate with any peripheral circuit, the 8080A must first be able to distinguish between its normal memory array and the particular I/O device. There are two basic techniques that can be used by the 8080—and each has its own pros and cons.

For most large systems with 32 k or more of memory, each peripheral is assigned to an I/O port. The I/O device is effectively isolated from the memory bus because another circuit, usually the 8255 programmable peripheral interface, is designed to act as an I/O port. Data transfers to and from the peripheral are then enabled by special instructions, In or Out. Although this method allows the full memory to remain undisturbed (Fig. 1), it requires additional support circuits. In addition, all data must go through the 8080A's accumulator.

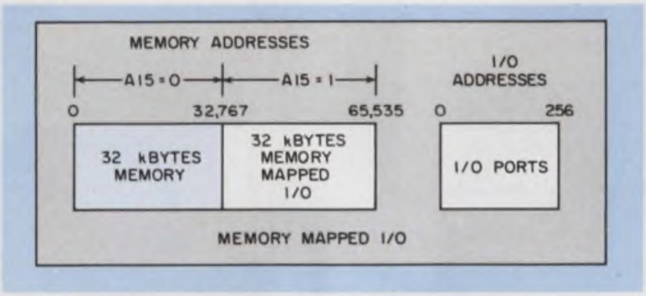
For smaller applications that don't use the full 8080A memory, unused portions of the memory address space can serve for I/O operations (Fig. 2). Not only does this scheme minimize extra peripheral circuits, but it also lets you exploit the full instruction set used to control the memory. But there is a restriction: Since the peripheral now looks like a memory, it must conform to memory-bus signals and timing.

Conventionally, you establish memory-mapped I/O by assigning address line A_{15}, the most significant

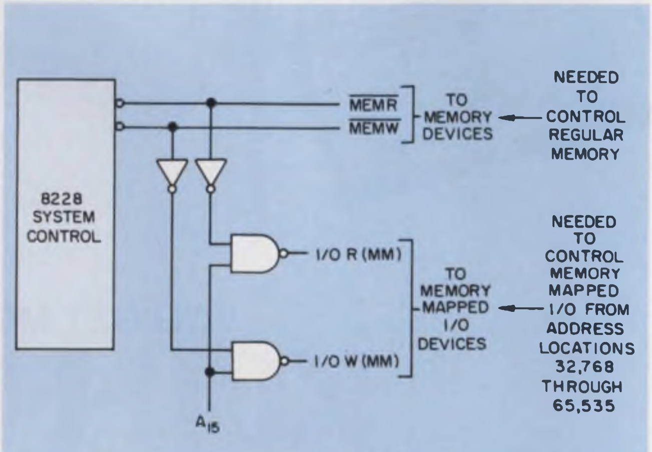
Wes Freeman, Senior Technician, and **Will Ritmanich,** Senior Application Engineer, Precision Monolithics, 1500 Space Park Drive, Santa Clara, CA 95050.



1. **When peripheral support circuits are used** to provide the I/O in a μP system, the entire memory can remain undisturbed and available for storage.



2. **By using a memory-mapping scheme** when all of the main memory of a computer isn't being used, you have available an almost unrestricted amount of I/O capability that doesn't need special peripheral support circuits.



3. **You can tap all the a/d-converter control signals** directly from the 8228 system controller. Only two signals are needed to control the memory-mapped I/O devices.

address bit, as the I/O control flag—A_{15} permits full addressing of 32 kilowords of main memory. So if A_{15} is Zero, the memory is active; if A_{15} is One, the I/O is active.

To manipulate the mapped I/O, you must generate appropriate control signals. Gating the $\overline{MEMR}$ and $\overline{MEMW}$ signals with A_{15} creates the I/O read and write signals (Fig. 3). This scheme has no effect on the bus and permits manipulation by all instructions.

Use the μP to do the conversion

For the best tradeoff involving speed, hardware and software complexity, apply the successive-approximation a/d conversion scheme. Operation is similar to the pan balance, as shown in Fig. 4.

To measure an unknown weight, place the weight in one of the balance pans. By successively applying binarily weighted counterweights to the other pan, you can effectively "balance" the scale. The number of "trials" is equal to the number of counterweights available, and starts with the heaviest counterweight. The weight is retained or rejected, depending on how it compares with the unknown weight—if less than, it is retained; if more than, rejected. Continue this process for the next heaviest weight until all weights have been tried.

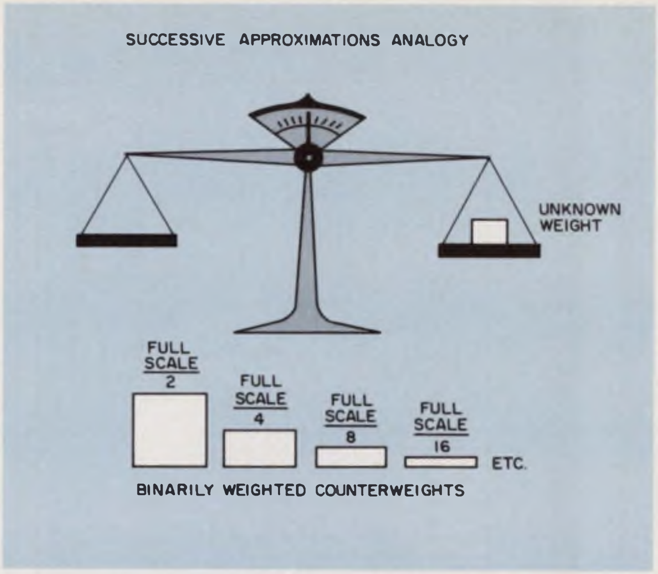
This measurement can be simulated electrically by sequentially comparing the output of a d/a converter and some analog input (Fig. 5). A conversion begins with the MSB of the d/a converter being turned on by the successive-approximation register (SAR), which produces an output from the d/a equal to one-half the full-scale value. The converter's output is then compared to the analog input by a comparator, and if the d/a converter's output is greater than the unknown input, the MSB is turned off and the next bit tried.

If the converter output is less than the unknown input, the next bit is still tried but the MSB remains on. This process repeats itself, much like the three-bit decision tree shown in Fig. 6, until all bits are determined.

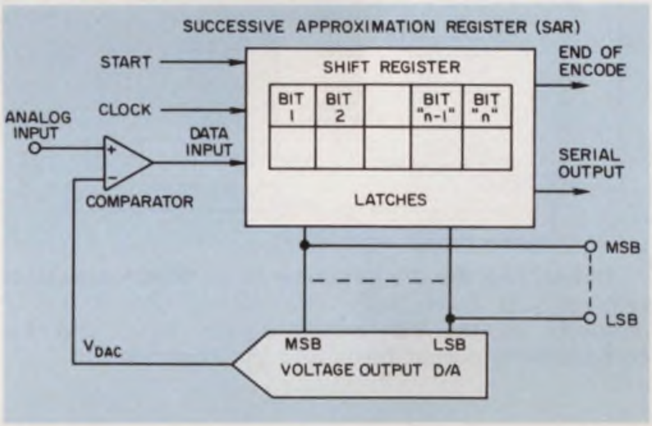
When the 8080 doesn't have to operate at full speed for other jobs, it can often replace the SAR. The eight lowest-order address bits control the data-bit inputs to the d/a converter, and the comparator controls the 8228 system controller (Fig. 7). The entire conversion requires only two decisions, and the program only 16 lines of assembly code (Fig. 8).

The d/a converter is accessed like a 256 × 1 ROM, which minimizes conversion time, hardware-interface circuitry and program length. Combined, the settling times of the DAC-08 and CMP-01 are shorter than the processor-cycle time (Fig. 9). No-wait states or no-operation instructions are required for the program to execute.

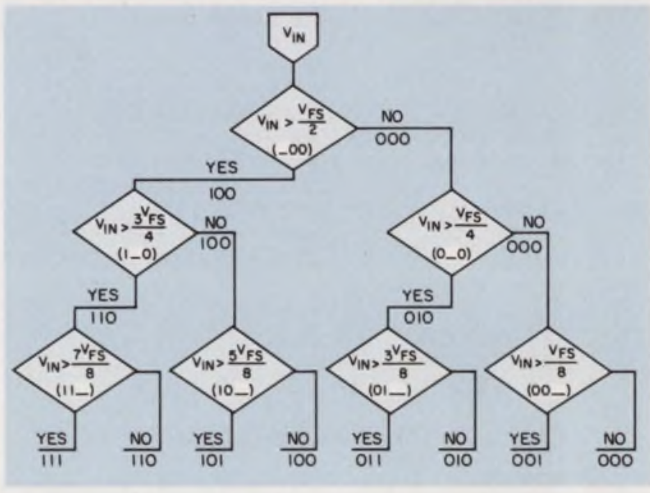
The d/a converter's input code is established when instruction MOV L,A moves the test value to the L register (memory-address register), which controls



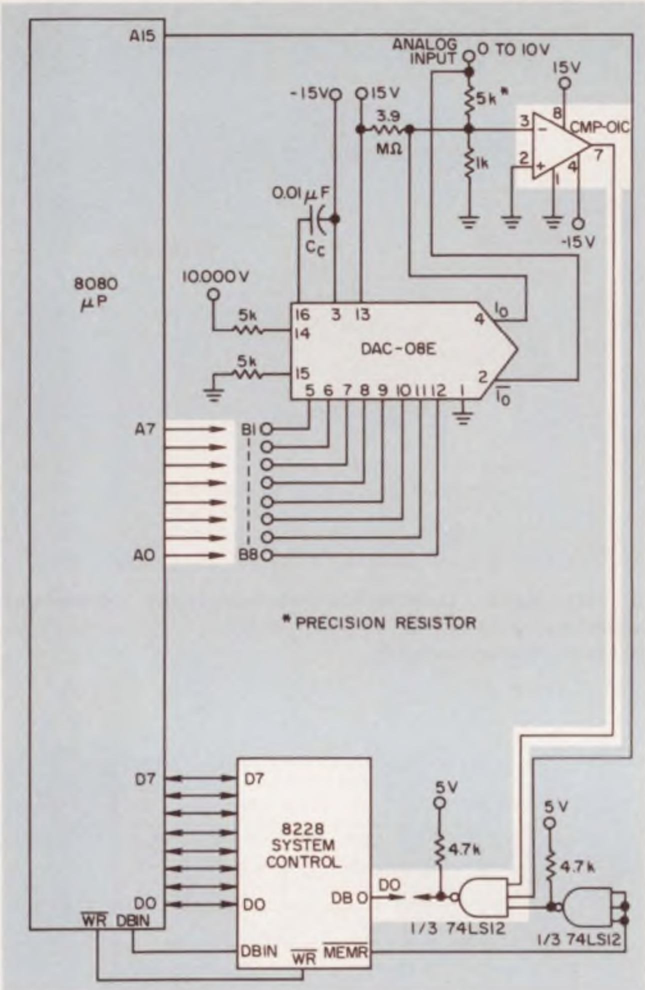
4. **The basic successive-approximation conversion scheme** can be likened to a simple scale balance that uses binarily related weights.



5. **To make a successive-approximation a/d converter,** the output of a d/a converter must be fed back through a comparator. The comparator, in turn, controls a special register that turns the d/a converter bit inputs on or off.



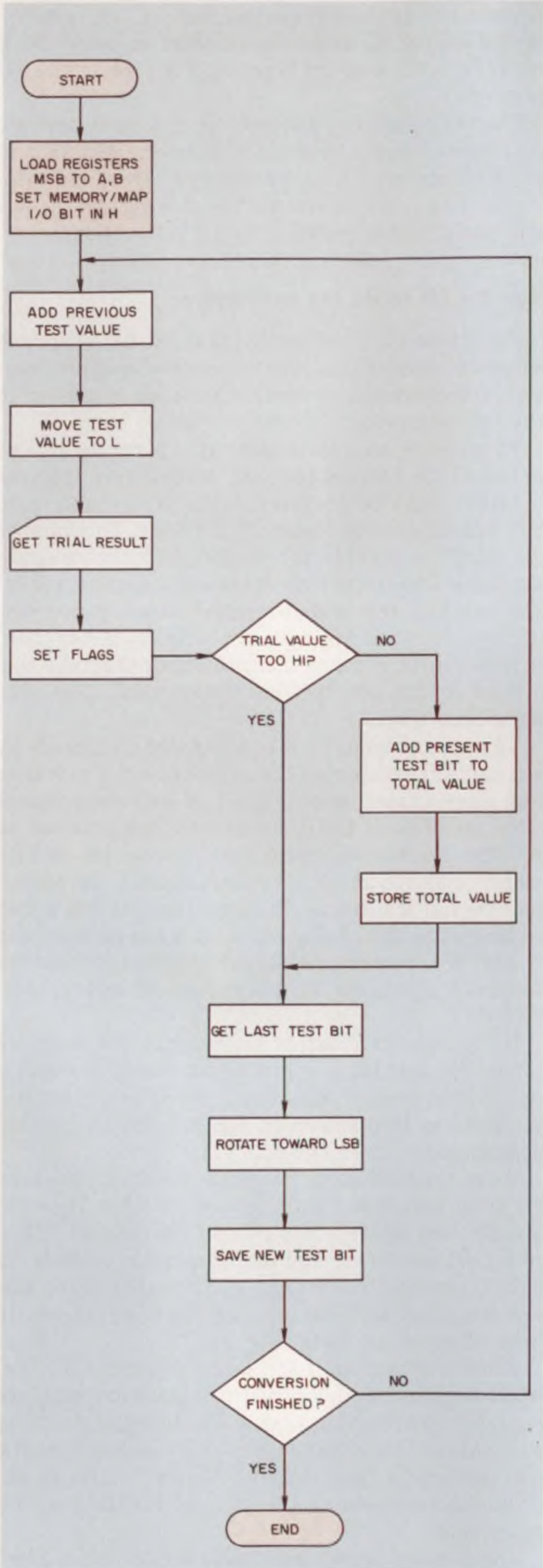
6. **The conversion sequence can be broken down** into a flow diagram and simplified so that it becomes a sequence of decision points.



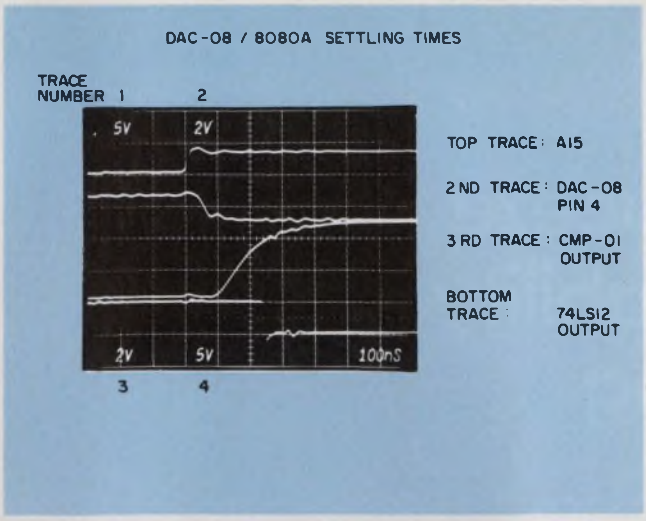
7. **Connecting the d/a converter to an 8080A processor** requires just a few lines. The address bus of the µP connects to the converter's digital input, and the comparator's output feeds into the controller.

```
;DAC 08 A/D CONVERSION ROUTINE
START:  LXI   B,08000H  ;LOAD MSB IN B, CLEAR C
        MOV   A,B       ;MSB TO ACC
        MOV   H,A       ;SET MEM/MAP I/O
TEST:   ORA   C         ;ADD LAST TEST VALUE
        MOV   L,A       ;MOVE PRESENT TEST TO L
        MOV   A,M       ;GET COMP OUTPUT
        ANA   A         ;SET FLAGS
        JPO   TOOHI     ;DISCARD PRESENT TEST BIT
        MOV   A,B       ;GET PRESENT TEST BIT
        ORA   C         ;ADD TOTAL SO FAR
        MOV   C,A       ;SAVE TOTAL
TOOHI:  MOV   A,B       ;GET LAST TEST BIT
        RAR             ;ROTATE TOWARD LSB
        MOV   B,A       ;SAVE NEW TEST BIT
        JNC   TEST      ;JUMP IF NOT FINISH
        END             ;FINAL VALUE IS IN C
```

```
P=3
0 BLOCK01 0
0 START 00000H
0 TEST   00005H
0 TOOHI 0000EH
 $
:10000000100087867B16F7EA7E20E00B14F781F3C
:0400100047D20500CE
:00000001FF
```



8. **The program necessary to do a/d conversion** requires only two decision points and one major loop (right). Only 16 lines of assembly listing are necessary to perform the a/d conversion (left).



9. **When an 8-bit conversion is performed, the settling time of the d/a converter** is less than 500 ns—shorter than the cycle time of the 8080 processor for a 2-MHz clock. Thus the μP doesn't have to waste time with no-ops.

the eight lowest-order address bits. Then the comparator compares the d/a converter's output with the analog input, and a MOV A, M instruction gates the comparator's output into the 8080A's accumulator.

Time and memory demand little

After the processor receives the input, it completes the conversion by continuing to perform the logical operations and to modify the contents of the address bus. Only 21 bytes of memory are needed for an 8-bit a/d conversion, and a time requirement of 235 to 285 μs (for a 2-MHz clock). The time depends on the analog input because saving the trial bit, if necessary, requires extra program steps. Quantizing is done over an analog input range of 0 to 10 V, but you can set the converter for other ranges.

Expanding the technique to 10 or 12-bit a/d conversion simply requires you to employ a 10 or 12-bit d/a converter and connect the MSB inputs to the corresponding address lines. Since multiple latches and byte-moving operations are eliminated, the savings in hardware and software are significant. For a 10-bit a/d converter, the d/a converter "looks" like a 1024 × 1 ROM and a 12-bit d/a looks like a 4096 × 1 ROM. In general, the settling time of the 10 or 12-bit d/a converters is greater than the cycle time of the 8080A. However, with an 8080A Ready line to insert wait states, you can accommodate the settling time of any d/a converter.■■

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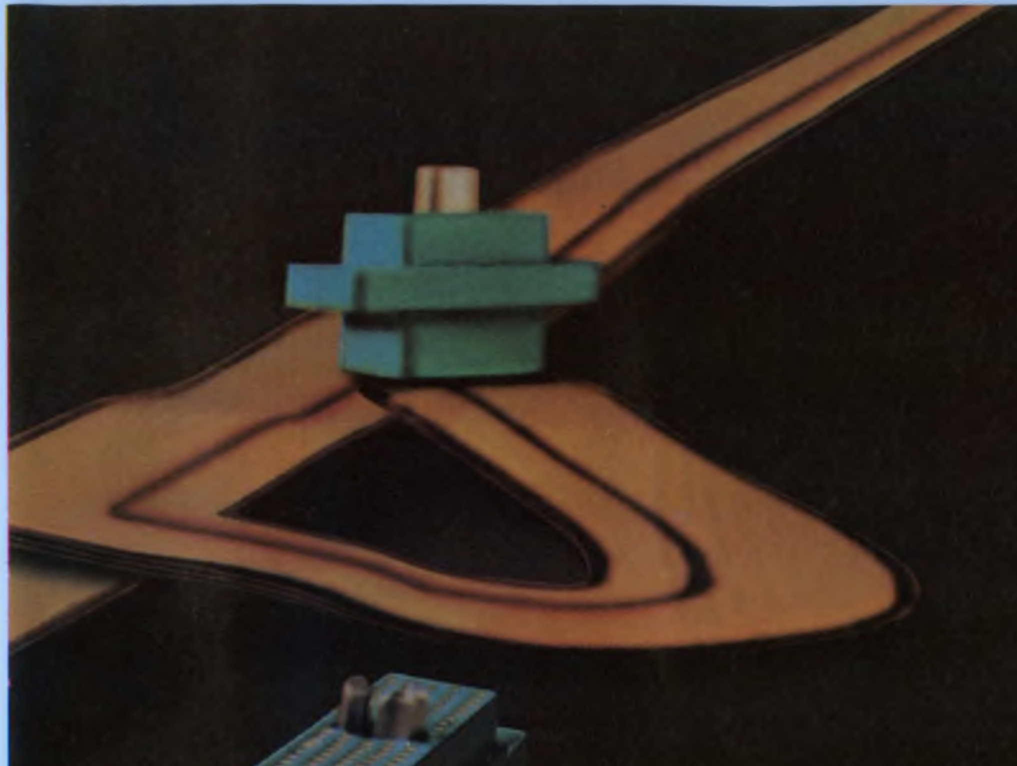

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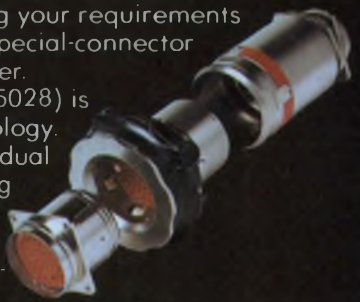

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CIRCLE NUMBER 296

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ROUND AND RACK/PANEL MULTIPIN CONNECTORS

The sixth installment of *Electronic Design's* 1977 FOCUS series will appear in the June 21 issue. The topic: Multipin Connectors.

Connectors are as crucial to a successful electronic system as the more exotic components. Associate editor Morris Grossman takes an in-depth look at round and rectangular multipin units, including rack/panel types. The report examines zero-insertion-force (ZIF) connectors, mass-termination connectors, and multiple-lead fiber-optic connectors.

As with all FOCUS reports, emphasis is placed on the significant specs readers should watch for and how to avoid pitfalls in connector selection and use. More than 61,000 *Electronic Design* subscribers specify or authorize purchase of connectors. If you're one of them ... mark June 21 on your calendar. It's a report you'll want to keep for months to come.

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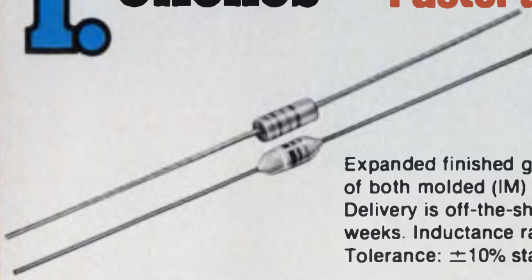

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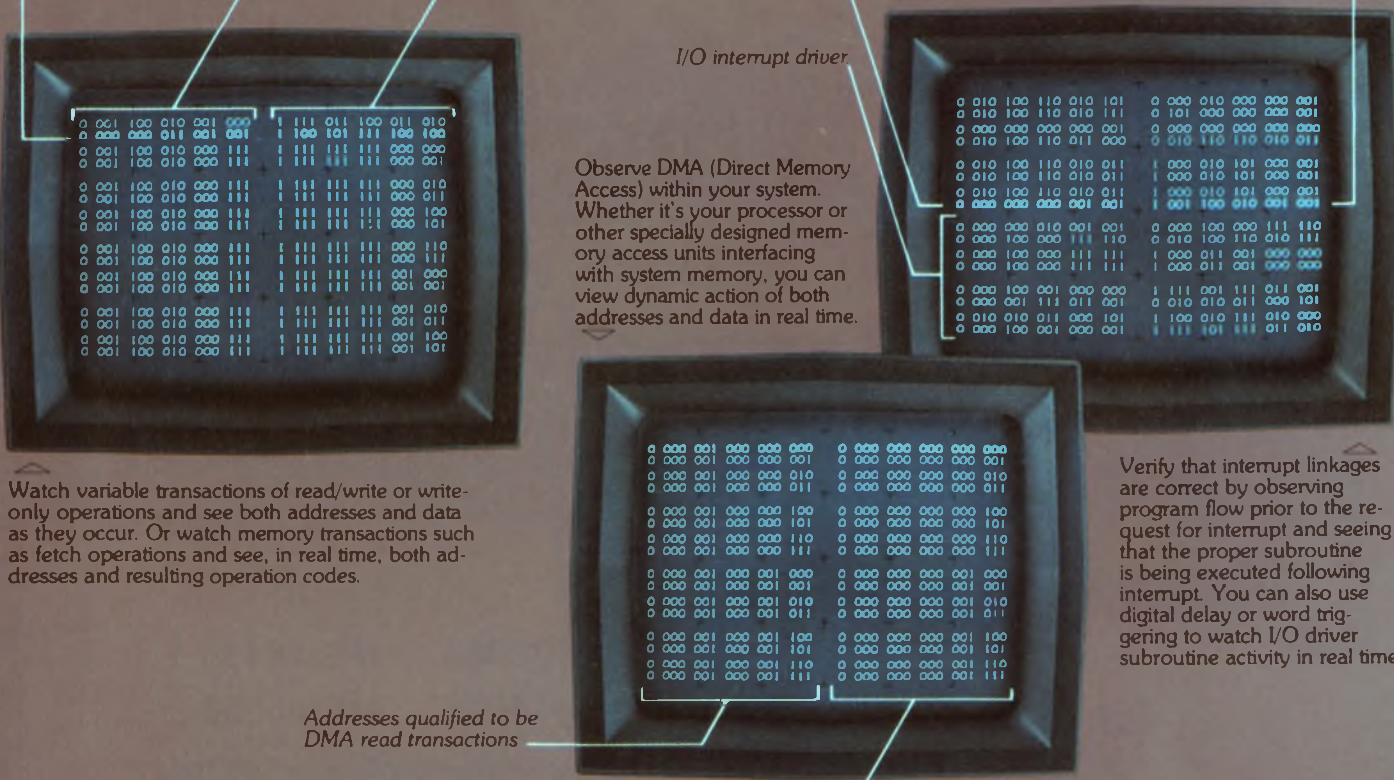
CIRCLE NUMBER 51



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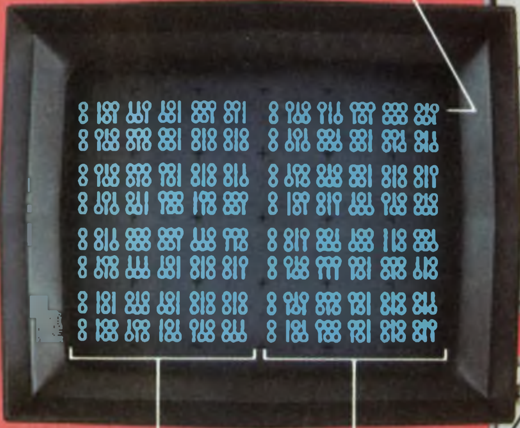
Cursor

Dynamic real time photograph (time exposed) of incrementing counter used as system clock

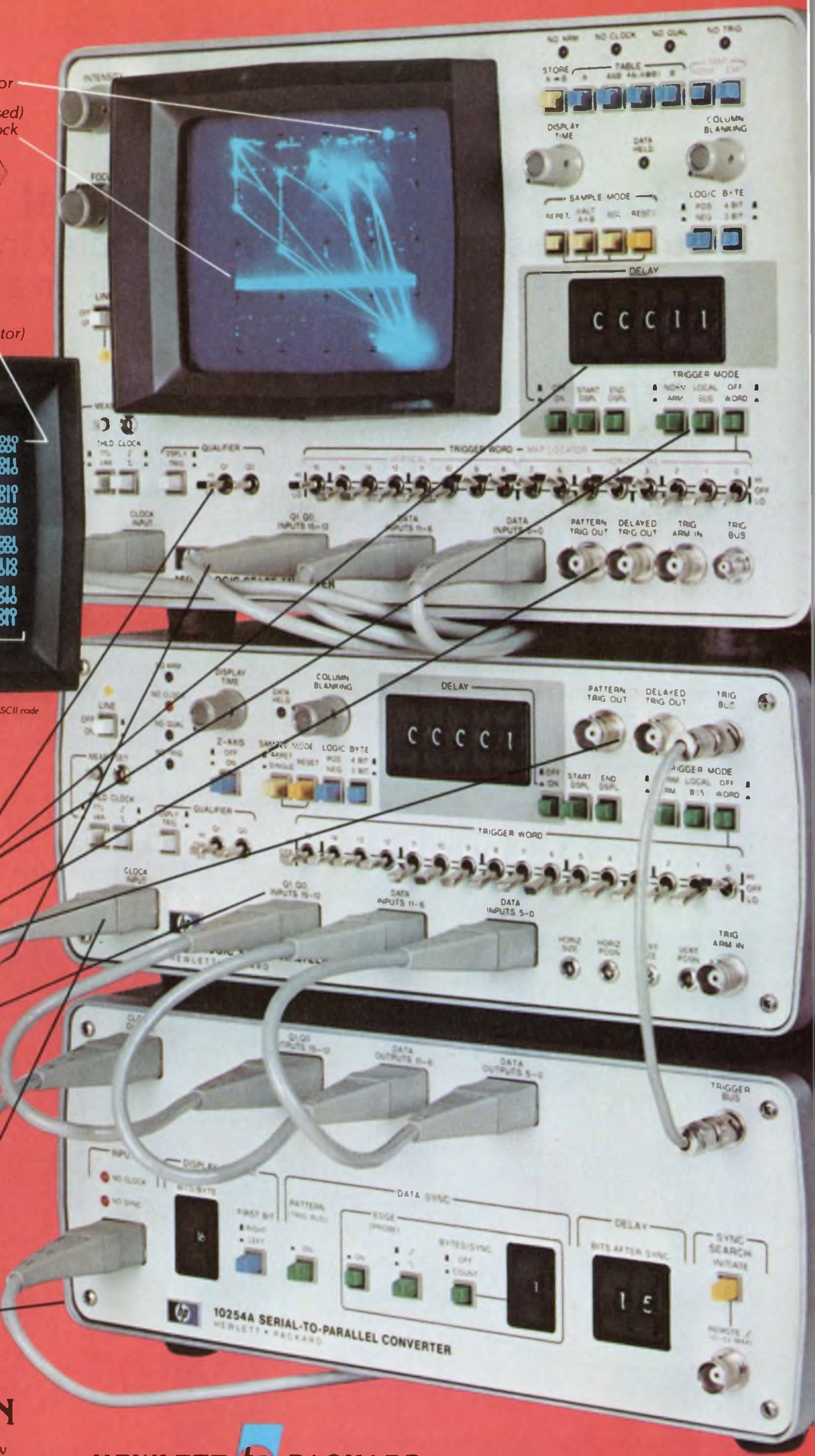
Get a system overview with this memory map. It shows how your memory is being utilized in an operating program. If you know how your memory is organized, the map tells you at a glance what your program is doing and the relative time being spent in any one memory location. That makes it easy to spot things that shouldn't be happening, or to determine that part of your program isn't being implemented.

Disc address (cylinder, head, sector)



Parallel data inside computer — *Serial data from 10254A*

ASCII code



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CIRCLE NUMBER 52

Exchange data between digital systems

simultaneously with a simple full-duplex interfacing circuit. Echo the message back or scramble it, in a half-duplex mode.

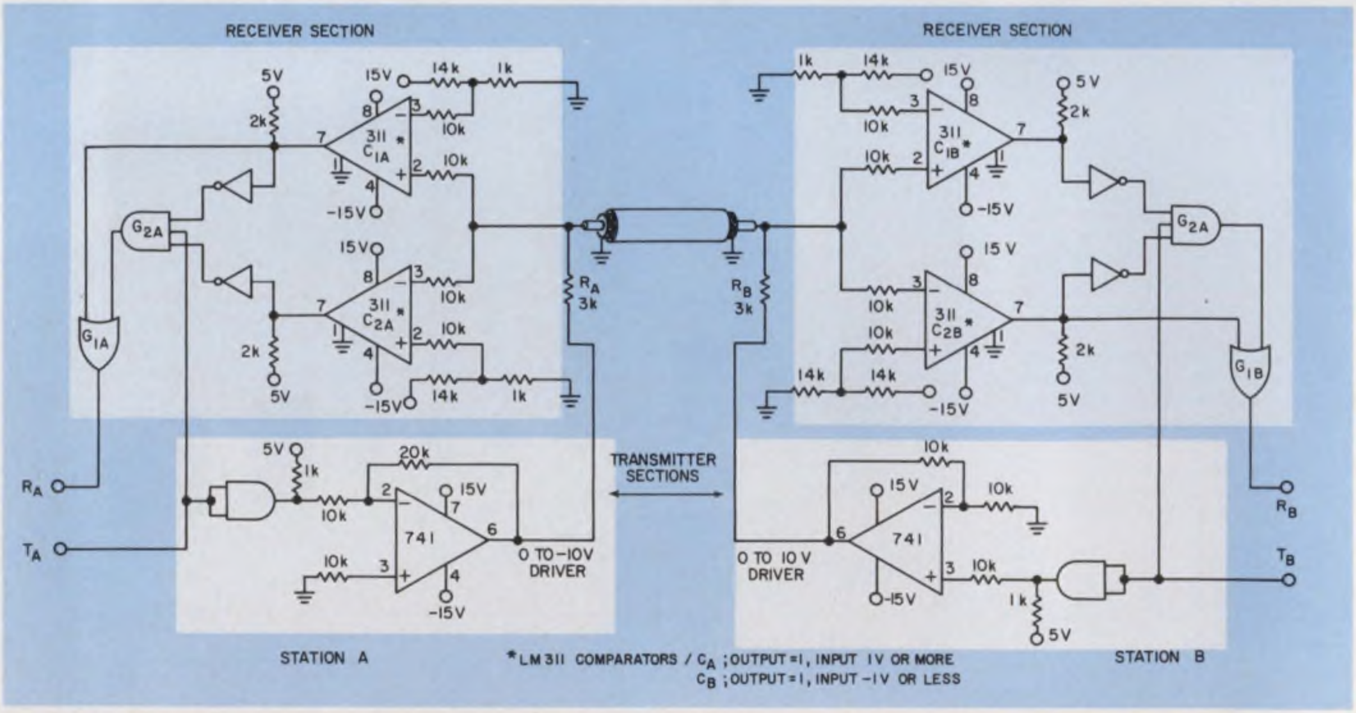
For data rates to 300 baud at distances up to one mile, or 4800 baud at up to 500 feet, there's little need to connect data systems with elaborate data modems. The simple interface circuit of Fig. 1 does a superb job. Even for very short distances, you can profitably replace the bundle of wire needed for an RS232-C interface with the same circuit. And there's no need for synchronous or special frequency relationships between the data terminals. An RG 59-U coaxial cable with low-cost BNC connectors is all you need. And for short distances in relatively noise-free environments, you can use a twisted pair.

Two data systems can "talk" simultaneously to each other—full-duplex operation without fancy hybrids or balancing circuits. Or, the receiving end can use its transmitter section to supply a masking signal to "scramble" the message on the line and protect it from unauthorized monitoring. Another useful operating mode of the circuit retransmits, or echoes, the received message back to the originating end, where the message can be monitored immediately for accuracy.

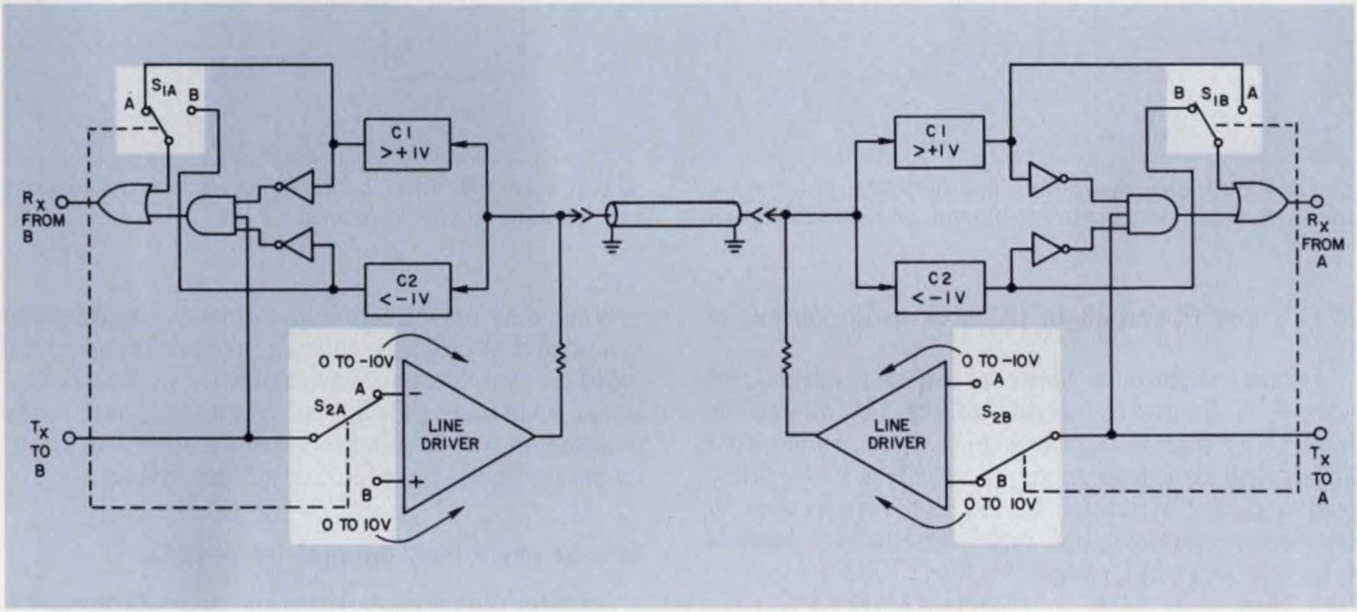
Charles R. Smiley, Senior Project Engineer, Interdyne, 14761 Califa St., Van Nuys, CA 91411.

The line voltage has three states

The cable between two data systems forms a summing junction and can have three signal states: +5, −5 and 0 V. One system's transmitter, station A, drives the line to −5 V for a ONE input to its circuit, and the other, station B, drives it to +5 V. When both transmitters send a ONE simultaneously, the line is at zero volts. The combination of the cable's state and the transmitter's input state, T_X, at each data terminal determines the state of the received bit at the terminal's output, R_X. For data, R_A, received at station A from the transmitter signal, T_B at station B, the truth table is the following:



1. **This simple bidirectional communications interface** allows the simultaneous transmission of 300-baud data between two data terminals up to 1 mile on a coaxial cable. Even better performance can be achieved with more powerful line drivers than the 741 op amps to allow use of lower-valued summing resistors.



2. **Selecting the station configuration—type A or B—**becomes necessary in a network of terminals.

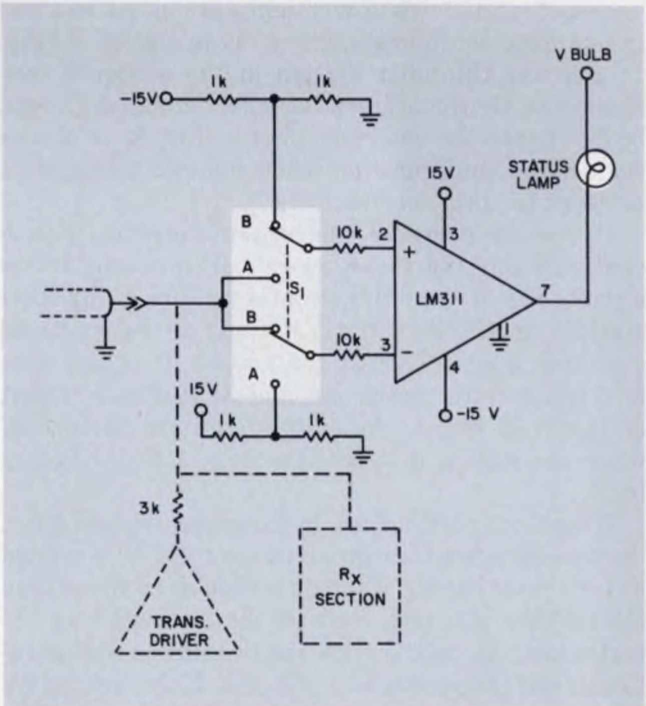
T_B	T_A	Cable	R_A
0	0	0 V	0
1	1	0	1
0	1	−5	0
1	0	+5	1

The table for the receiver at B is similar:

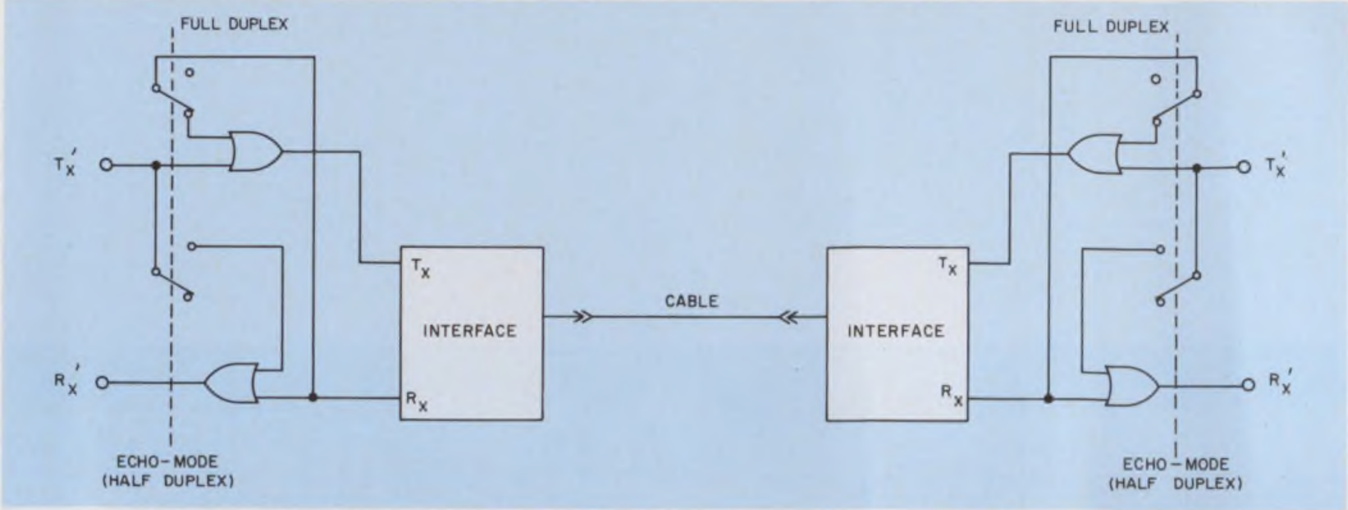
T_A	T_B	Cable	R_B
0	0	0 V	0
1	1	0	1
0	1	+5	0
1	0	−5	1

Note that at station A, the T_A/cable-volts combinations for ZERO and ONE outputs at R_A are 1/−5 V and 0/+5 V, respectively; at station B, the T_B/cable-volts combinations are different, 1/+5 V and 0/−5 V. The circuit differences in Fig. 1 between stations A and B that accommodate this signal difference are determined by whichever of the two input voltage comparators of the receiver section, C_{1X} or C_{2X}, connects to the output-OR gate, G_{1X}.

Comparator C_{1X} provides a ONE output when the transmission-line voltage is greater than +1 V, and C_2 provides ONE when the voltage is less than −1 V. Therefore, in station A, G_{1A} connects to the output



3. **A station-configuration status indicator** is convenient to have when the interface system is used with several data terminals in a network.



4. **For half-duplex operation**—one direction at a time—the system can be used to retransmit, or echo, data back so that the transmitted data arriving back at the receiver can be used to check accuracy.

of C_{1A}, and in station B, G_{1B} goes to the output of C_{2B}.

Another difference between the two stations, of course, is in the connection to the 741 line-driver inputs. At station A, the signal to be transmitted enters the inverting input to obtain a 0 to −10-V output range; at station B, the signal input goes to the driver's noninverting input terminal to obtain a 0 to +10-V output range.

Selecting a station configuration

When several data terminals are time-shared with a computer, all the data-terminal stations can be wired in one logic configuration, say, as in station A (Fig. 1), and the computer station in the station-B configuration. Or, a configuration-selection capability can be built into the interface circuit (Fig. 2) to choose the desired configuration when communicating on a network of data terminals.

To operate properly, one station must be in an A configuration and the other in a B. A simple status circuit (Fig. 3) can tell the configurations of the other stations on the line. If all stations in the quiescent condition keep a ONE on the line, as is usually done in teletypewriter networks, and S_1 in Fig. 3 is part of the S_1 in Fig. 1, the status light will go on only when one station is in configuration A and the other in B.

When both stations are in the same configuration, the line voltage will be greater than the ±7.5 V needed to turn the lamp off. Flipping switch S_1 at one station should then put zero volts on the line and turn the status lamp on, because now the two station configurations provide opposite line voltages. If the lamp stays off in both positions of S_1 then at least one of the terminals is in a disconnect state or lacks a ONE at its transmit input.

When only one-direction-at-a-time communication is needed (half-duplex), you can take advantage of the interface system's two-way capability with an operational mode that sends a received message back to the transmitter as it's being received—a so-called "echo" mode—to check the accuracy of the system.

Several operational modes are possible

Consider the arrangement of the two data terminals in Fig. 4. Both terminals have a keyboard and printer. If A sends a message to B, and B retransmits, or echoes, the message back to A, then A can check the message as it is being sent, with only microseconds delay. The message prints out at both stations; if correct at A, most likely the message has been received correctly at B.

The echo mode is particularly useful in computer time-sharing systems. The computer can determine whether to echo back received material or send new material, depending on the priorities of the moment.

Note that in the echo mode, the cable appears always to be at zero volts, except for narrow spikes caused by the system delays.

Another useful mode of operation scrambles messages to protect them from clandestine monitoring. For example, if station A is sending data to B, B can send meaningless bit patterns to A during this transmission. Thus, the cable carries a composite signal that is difficult to decode without the key. The receiver doing the scrambling, of course, has the key: It is merely the jamming signal that is going to the input of its transmitter driver.

The jamming signal can be simply a square wave at some frequency near the bit rate of the correct data or, better, a random bit pattern. For best results, no synchronous relationship should exist between the data and jamming signals.■■

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Examine the power switch in Fig. 1. If the input is taken to ground either through a switch or through the output of a TTL gate, base current flows through R_1 to turn on the pnp transistor. If the input is allowed to float or be pulled high by a TTL output, resistor R_2 turns the transistor off.

When the pnp transistor turns on, the V_{CC} terminal of the ROM rises rapidly to a voltage just below that of the V_{CC} supply. The difference is determined by the V_{CE} (SAT) of the pnp transistor. When the transistor is turned off, the V_{CC} for the ROM decays to a low value (Fig. 2). Turn-on time is how long it takes for the input signal to propagate through the switch and raise V_{CC} to the 4-V level, at which most ROMs and PROMs are fully functional—even though not all the device specs may be met.

Now it's time to propagate

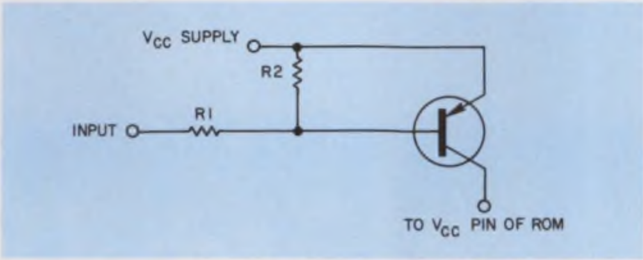
Once the device's V_{CC} has reached 4 V, time is required for all inputs to propagate through the device and establish the correct output state. This is true regardless of whether the inputs are stable before V_{CC} is switched on, or whether V_{CC} and the inputs are switched at the same time.

The required propagation time is approximately t_{AA}, the address-access time given in the data sheets. Typically, ROMs and PROMs reach the correct state within 20 ns of the specified t_{AA}. So the "worst-case enable time" of a power-switched device is given as follows:

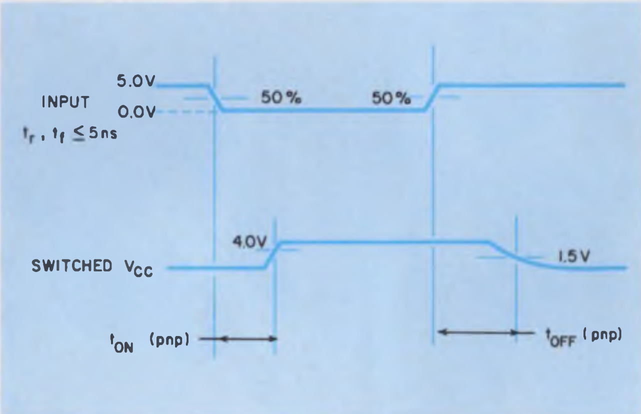
$$t_{enable} = t_{on(pnp)} + t_{AA} + 20 \text{ ns.} \quad (1)$$

Notice that the turn-off time for the power switch in Fig. 2 is specified at 1.5 V, where most TTL PROMs are "off," and their outputs floating. If V_{CC} is dropped instantly to 1.5 V, the outputs will be "off" and floating within 10 ns. The worst-case disable time is thus given

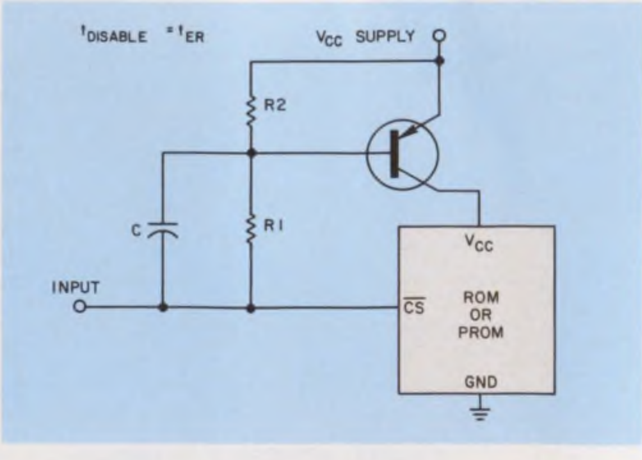
Jerry Gray, Design Manager, Monolithic Memories Inc., 1165 E. Arques Ave., Sunnyvale, CA 94086.



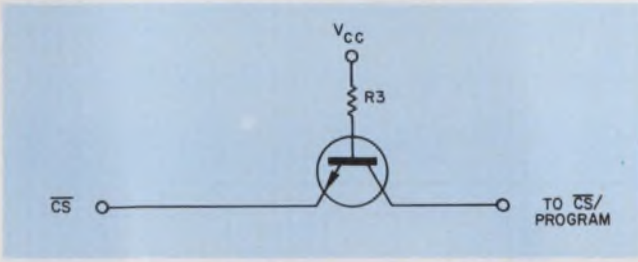
1. **ROMs and PROMs are power-switched** with a simple pnp transistor circuit in the V_{CC} line.



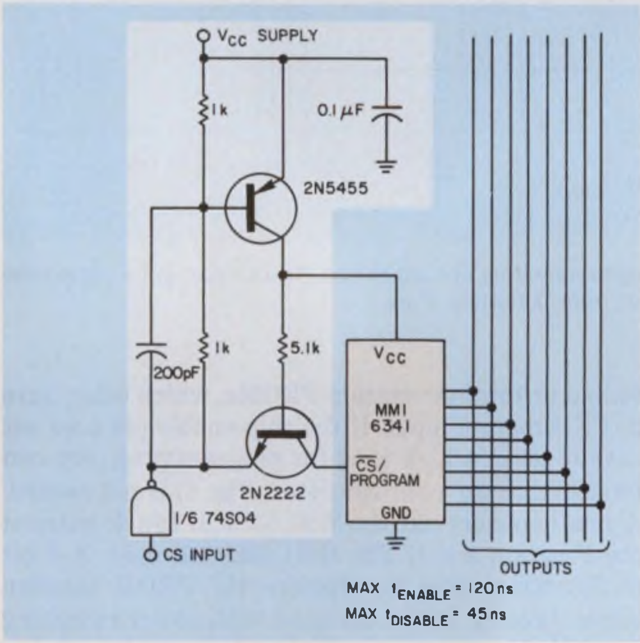
2. **The output waveform of a pnp switch** lags the input wave by t_{on} at the start, and by t_{off} at the end of the switching period.



3. **Switching performance is improved** with a speed-up capacitor, and in addition by feeding the switching input to the ROM's $\overline{CS}$ pin.



4. **PROMs require an npn transistor** at the $\overline{CS}$/Program input to avoid excessive loading of the input wave.



5. **The complete schematic for a PROM switch** is developed for the 6341 PROM from Monolithic Memories.

Table 1. Suitable pnp switching transistors

No. of ROMs/PROMs	Some suitable pnp transistors
1	2N5455, 2N3467, 2N4402
2	2N3467, 2N3244
4	2N3467, 2N5023
8	2N3467

by the following equation:

$$t_{disable} = t_{off(pnp)} + 10 \text{ ns.} \qquad (2)$$

The actual disable time can be quite long because $t_{off(pnp)}$ consists of two components: the turn-off time of the pnp transistor, and the decay time for V_{CC}. Because pnp transistors with good current-handling ability often have lousy turn-off times, you must be very careful to chose the right transistor for a pnp power switch. Several recommended transistors are listed in Table 1.

The decay time for V_{CC} depends on the current, I_{CC}, of the ROM or PROM. As V_{CC} approaches 1.5 V, I_{CC} drops very rapidly, and all or part of the current may turn on the output of the ROM. Accordingly, the $t_{off(pnp)}$ specified for the power switch may be quite high.

You can improve the performance of a pnp power switch in several ways. But two of the most effective are the following:

1. Use a speed-up capacitor in parallel with R_1 of the basic power switch in Fig. 1. This capacitor provides overdrive for turning the transistor on and off. The value should be such that the time constant, R_1C, is approximately equal to the fastest cycle time at which the power switch will be used. This technique, however, does not improve the decay time of V_{CC}.

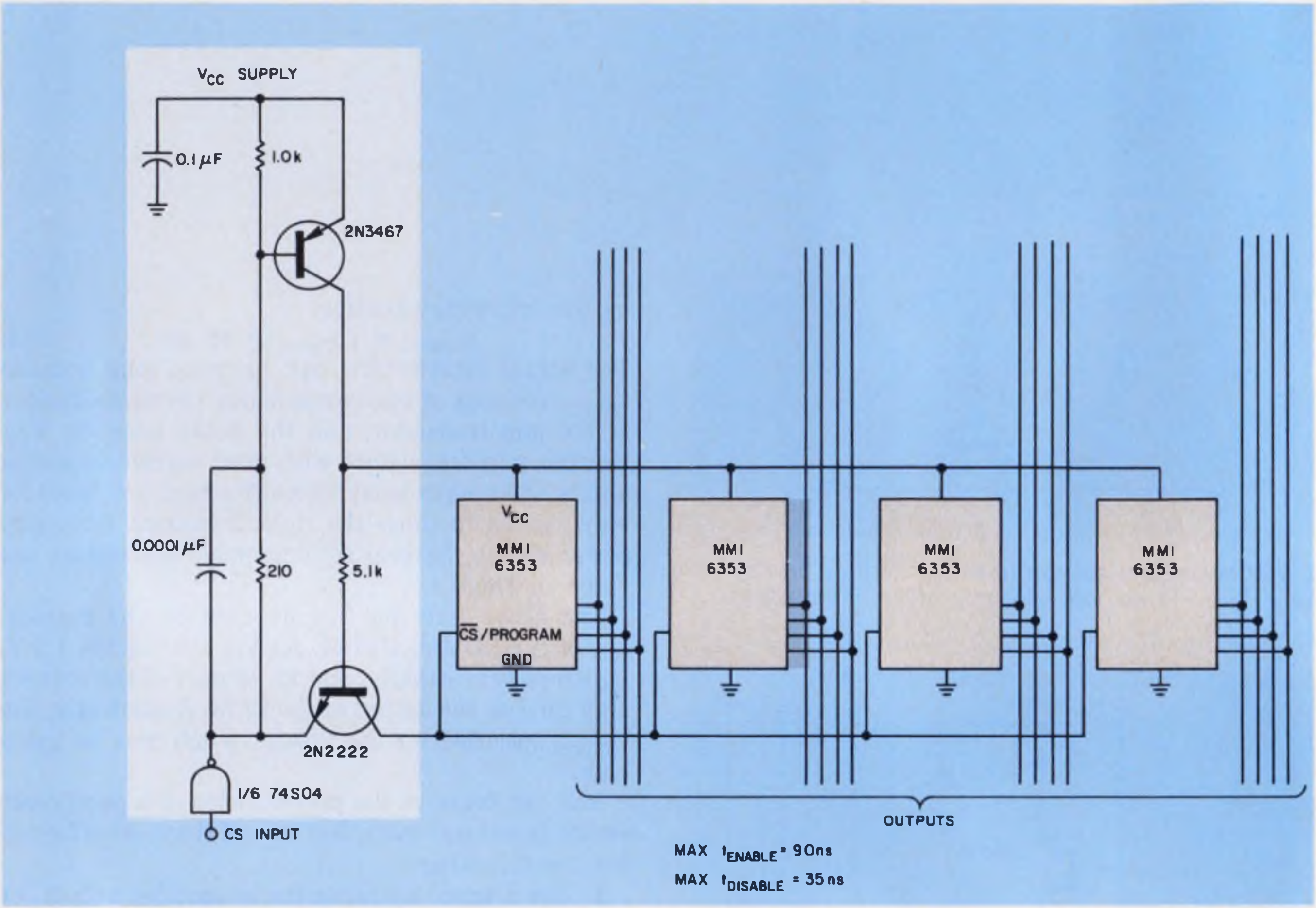
2. Tie the input of the power switch to a $\overline{CS}$ (chip enable) input of the ROM or PROM being switched. You thereby force the outputs into the OFF state as soon as the input to the power switch goes high. This means that while V_{CC} is decaying to 1.5 V, the outputs are held off, because the $\overline{CS}$ input is high. The internal $\overline{CS}$ buffer becomes ineffective when the outputs are turned off by V_{CC}.

With this second technique, the disable time is no longer represented by Eq. 2, but rather given by the t_{ER} time specified on the ROM or PROM data sheet:

$$t_{disable} = t_{ER}. \qquad (3)$$

PROMs have special needs

What sets PROMs apart from ROMs is the fact that a $\overline{CS}$ input is also used as a programming input. The $\overline{CS}$/Program input is designed in such a way that voltages higher than V_{CC} provide the internal currents necessary to program the device. Even at 5 V, this current can be very high. Consequently, when V_{CC} is



6. **This example for power-switching a PROM array** uses four MMI 6353 PROMs, for which the values of resistors and capacitors are optimized. You should get a cycle time of approximately 1 μs.

reduced by the power switch, the normal input-current spec does not apply. Instead, the $\overline{CS}$/Program input and all signals tied in parallel with it are loaded down; while you expect a logic "1," it may be a "0."

This peculiarity can cause you headaches if you choose the $\overline{CS}$/Program input in the improved switching scheme of Fig. 3. The loading of the $\overline{CS}$/Program input is normally high enough to keep the input at a low level, and the pnp transistor remains on. Sometimes the whole system oscillates.

Fortunately, the following solution is simple, and works regardless of whether the $\overline{CS}$/Program input is tied to a signal lead, or to the input of the power switch (Fig. 4): An npn transistor is used as a one-way switch to ensure that no current flows from the driver to the $\overline{CS}$/Program pin. The small delay through the npn transistor can be ignored.

Here comes the new generation

The solution shown in Fig. 4 effectively changes the $\overline{CS}$/Program input into a $\overline{CS}$-only input. But you don't necessarily have to apply this solution in the case of second or third-generation PROMs, which often have no $\overline{CS}$/Program input. If the chip-enable pin does not have to go to a high level for programming, you can be sure that the npn transistor (Fig. 4) is not needed. A small memory like the MMI 5330/31 can do without the Program input. The MMI 5380/81, a 1-k × 8 bit configuration does not require the PROM solution either, because it was designed with power switching in mind: Zeners prevent the input circuit from being loaded down. If you want to power-switch PROMs, you really must know their design.

Even if your PROM turns out to be of an earlier variety, the outlined remedies work well. In Fig. 5, only one PROM is being switched with the concept described, while in Fig. 6, four PROMs are being switched. In both cases, the components give good operation in a system with a cycle time of 1 μs.

The worst-case enable time in both cases is the t_{AA} from the data sheet, plus 30 ns. The worst-case disable time is t_{ER} from the data sheet. While the 2N2222 is used in Figs. 5 and 6, other transistors with fast turn-off time—like the 2N3444, 2N4275, and 2N5134—work just as well. ■■

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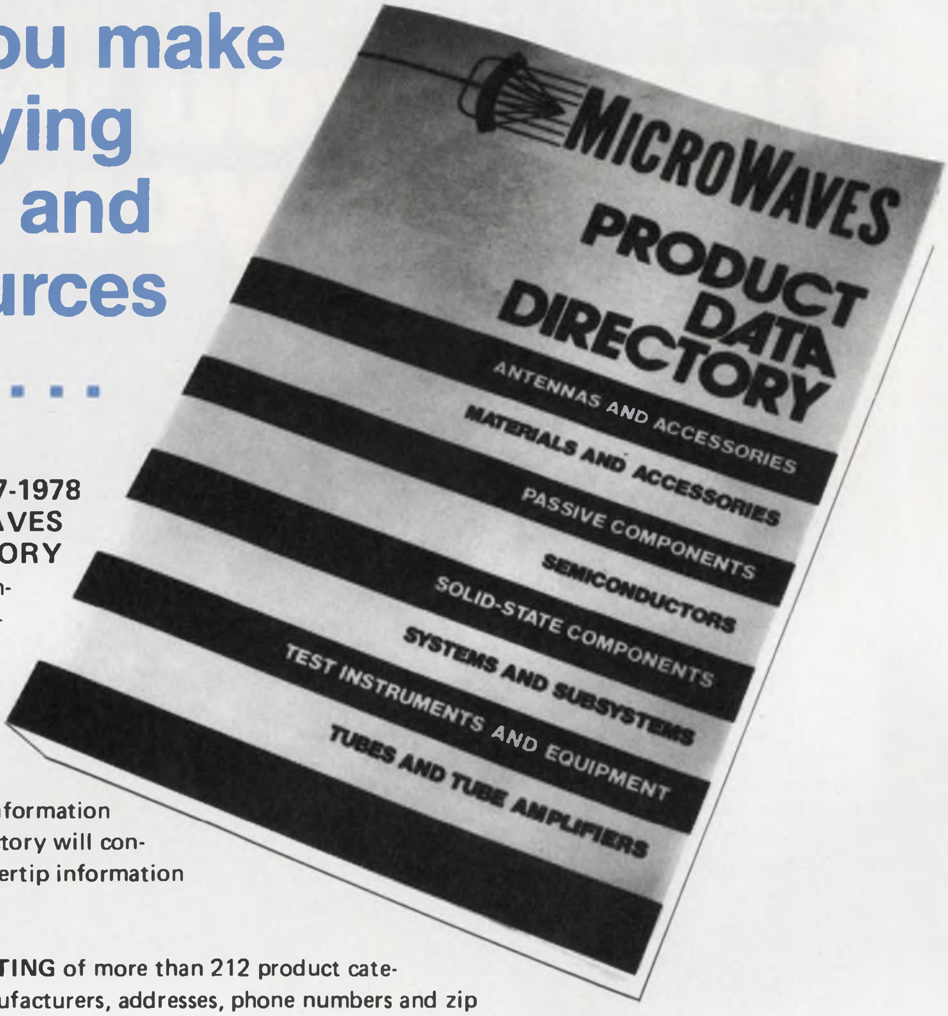

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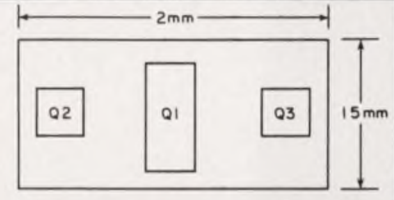
IC fluid-flow sensor gauges fluid rate and direction

Based on the principle that a heated body is cooled by a passing fluid flow at a rate that depends on the fluid velocity, an integrated-circuit fluid-flow sensor has been fabricated that can measure both the direction and the rate of fluid flow. Three transistors in the chip structure sense the direction of the flow (Fig. 1). Transistor Q_1, located in the center of the chip, acts as a heat source. Transistors Q_2 and Q_3, at opposite ends of the chip, act as temperature-sensing transistors. If fluid is flowing from left to right and parallel to the surface, Q_2 will measure a lower temperature than Q_3, because the fluid is heated by Q_1 before reaching Q_3. The temperature difference between Q_2 and Q_3 is proportional to the square root of the fluid velocity. The sign of the difference output indicates the direction of flow.



SENSOR-CHIP CONFIGURATION

For the fluid sensor to operate properly as a transducer, a fourth transistor, Q_4, is mounted in the fluid and thermally isolated from the chip. Its base-emitter voltage indicates the fluid temperature.

Current efforts by the device's developers at the Delft Technical University in the Netherlands are aimed at combining two differential transistor pairs at right angles to each other to produce a true velocity-vector output.

Implanting sulphur ions produces super GaAs FET

GaAs field-effect transistors without a mesa structure have been successfully fabricated by selectively implanting sulphur ions into a GaAs substrate doped with chromium. Not only does this process pave the way for reduced production costs, but as a result, transistors have been produced at the Electrical Communications Laboratories in Tokyo whose oscillation frequency is a very high 30 GHz.

Thin n-type layers of high uniformity, which are necessary to the production of GaAs FETs, are produced by covering a CR-doped (100) semi-insulating GaAs substrate with a 500-Å layer of sputtered SiO_2 and selectively implanting the sulphur ions.

The sulphur ions are implanted with the aid of a 0.9-μm thick mask of aluminum, which is made with photolithographic techniques.

The aluminum mask protects the underlying substrate because the 200 keV sulphur ions penetrate only about 0.2 μm of the aluminum layer.

Following the implantation, the wafer is annealed at 800 C for 3.5 hours.

The annealing process activates the implanted sulphur ions and removes the damage to the lattice caused by the ion bombardment. After annealing, the wafer is etched.

Source and drain contacts are constructed by evaporating gold-germanium and nickel and alloying for 30 s at 460 C in a hydrogen atmosphere.

The gate uses a Schottky-barrier structure, formed by evaporating aluminum—a simple process because the devices don't have a mesa structure. The gate is 1.4 μm long and 400 μm wide.

Miniprograms to be run on any microcomputer

Now programs developed on a minicomputer can run on any microcomputer board for which a "cross-translator" has been written. A universal microprocessor-development system called MicroAde develops programs that can be run on microcomputer boards linked to the minicomputer by a single cable. Based on the PDP-11, MicroAde has been developed by CAP MicroSoft, Reading, England.

Like cross-assemblers, cross-translators are hosted on the development computer and produce object code for the target microcomputer. Although a cross-translator must be written for each microcomputer, all translators share the same facilities, such as loaders, linkers and program management.

As a result, a given program can be run on all the supported microcomputers without rewriting any part of the program. And since the framework of the new cross-translator already exists, new microprocessors can be supported quickly.

Cross-translators invented by CAP's chief software designer, Esmond Hart, for the 8080 and 6800 microprocessors reside on floppy discs. Other cross translators are being developed for the 9900, the F8 and the 2650.

MicroAde has a unique high-level language capability known as Micro-Cobol, which may cause microprocessors to be used in data processing. As yet, microprocessors aren't used in such applications because usually these applications are software-intensive.

An interactive debugging system that provides a complex test-sequence facility, I/O simulation and randomly generated interrupts is included in MicroAde as well as conventional debug facilities.

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Alarm circuit guards a guarding-camera system

A system such as a surveillance camera needs an independent alarm system to ensure that the power cord is properly plugged in, and vibration and cover-open sensors to detect unauthorized entry into or movement of the device. The alarm circuit is composed of three major sections (see figure).

One section, the noise maker, consists of two CMOS oscillators wired so that the one controls the frequency of the other. The oscillator formed by G_5 and G_6 operates at about 1 Hz and changes the resistance in the second oscillator, G_7 and G_8, with a 4016 analog switch. The second oscillator swings about 2 kHz and sounds like an English siren—repeated high-to-low notes.

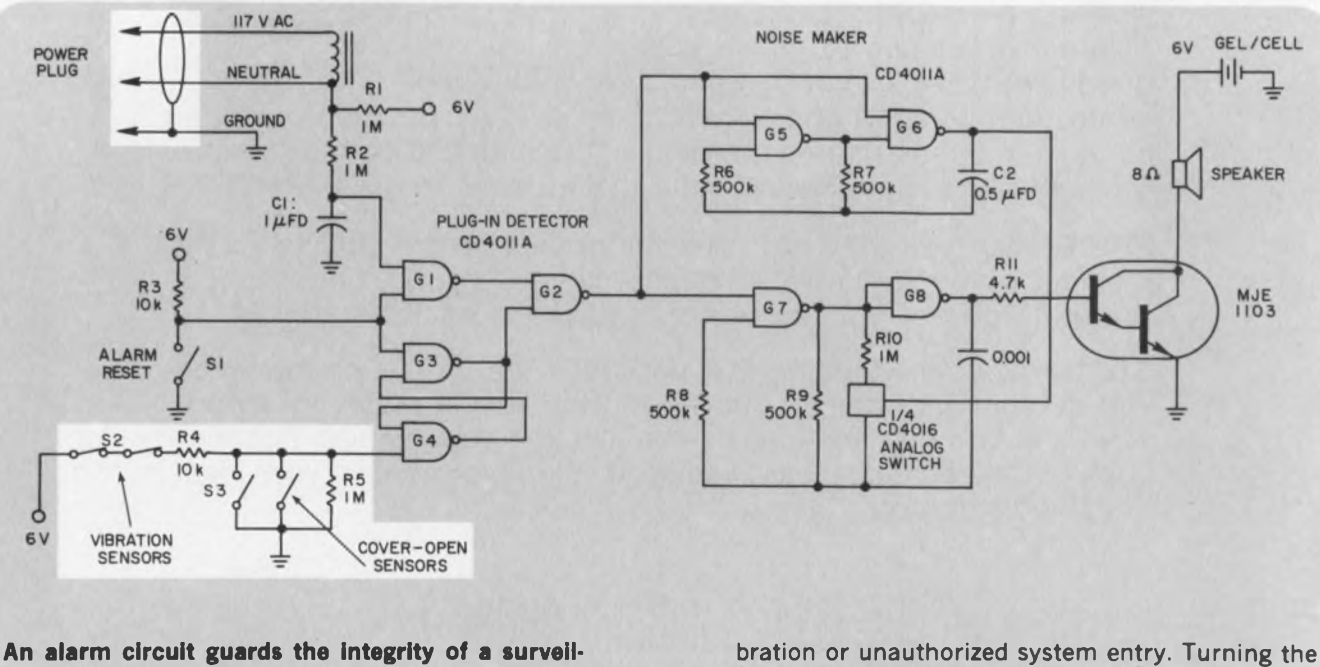
Another section detects whether or not the 117-V-ac plug is properly inserted into the outlet. When properly inserted, there is continuity between the neutral and ground conductors. If someone tries to disable the alarm by removing the plug, capacitor C_1 charges through R_1 and R_2. After 1 to 3 s, the potential across C_1 exceeds the threshold of the CMOS gate, G_1, and the alarm sounds. The alarm doesn't latch; reinserting the plug resets the alarm. And if the line power is shut down—say, over a weekend, the circuit doesn't respond: The neutral and the ground remain connected.

The third part of the circuit is the alarm logic. Gates G_3 and G_4 form an R-S latch. When one of the S_2 switches opens or one of the S_3 switches closes, the latch sets and activates the alarm. The bypass key, S_1, forces the alarm off when closed and resets the R-S latch.

A 1.7-Ah Gel/Cell can provide an alarm for at least 2 h. This battery is trickle-charged from the camera's power supply, which ensures that the alarm is continuously powered and ready for operation. The entire circuit draws only microamps in stand-by operations.

John Harrison, Technical Consultant, Northeast Electronics, Airport Rd., Concord, NH 03301.

CIRCLE NO. 311



An alarm circuit guards the integrity of a surveillance system by detecting power-plug removal, vibration or unauthorized system entry. Turning the power off doesn't trigger the alarm.

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CIRCLE NUMBER 64 FOR INFORMATION
CIRCLE NUMBER 65 FOR FREE DEMONSTRATION

Wide-frequency-range clock source needs few discrete components

Need a wide-range clock source operable from 100 Hz to 100 kHz? When operated as a simple clock source, the circuit in Fig. 1 easily covers this range, features an inherently square-wave output and uses a minimum of discrete parts with an AD537 v/f converter in a DIP. And the frequency-determining components, $R_t C_t$, can have small values because of a multiplying factor of 10 in the circuit's frequency equation—of particular importance at low frequencies.

The frequency expression, which has an initial maximum calibration error of 7%, is

$$f_0 = \frac{1}{10\ R_t\ C_t},$$

with pins 5 and 7 directly connected to each other.

A timing current, $I_t = 1/R_t$, which can be varied from 1 mA to less than 1 μA, appears as a linear-charging current in the timing capacitor, C_t. This timing current is the same for both the HIGH and LOW parts of the output waveform; therefore, the output waveform is square. For the many applications that need a square wave, this circuit has an advantage over other oscillatory sources, such as 555 astables or charge-balancing v/f converters.

As a manually tunable "lab source," R_2 divides a reference voltage from pin 7 and introduces a fractional multiplier, K, into the frequency equation. Factor K is proportional to the fractional rotation of R_2. The frequency varies directly with R_2, allowing convenient dial calibration and operation over more than three decades of frequency range.

Resistor R_3 (shown dotted) can be included in the circuit to track the calibration at the low-frequency end of the range. Capacitor C_l filters possible noise pickup at R_2's arm, especially when R_2 is at mid-range.

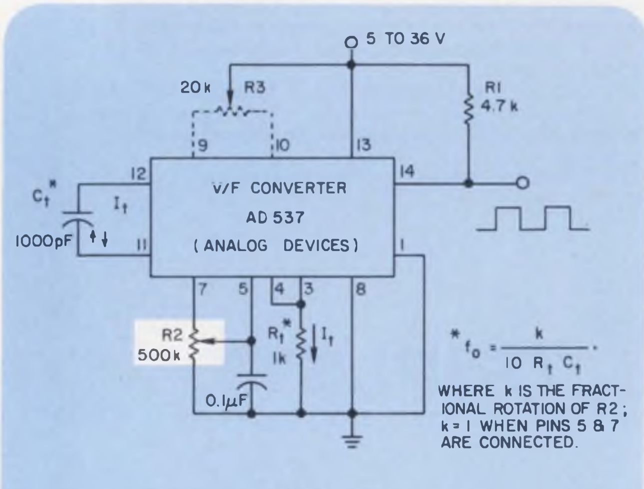
The output at pin 14 comes from an open-collector npn, so a load resistor, R_l, is required. Load-reference voltages for pin 14 can be up to 36 V, independent of the voltage level to the chip at pin 13.

Although basically a square-wave source, the circuit can be modified for asymmetric waveform operation as well (Fig. 2). The timing resistor, R_t, is replaced by a switching function with a p-channel FET, Q_1. When Q_1 is OFF, the timing resistance is $R_{t1} + R_{t2}$. If Q_1's ON resistance is much smaller than R_{t2}, the timing resistance reduces simply to R_{t1} when Q_1 turns ON.

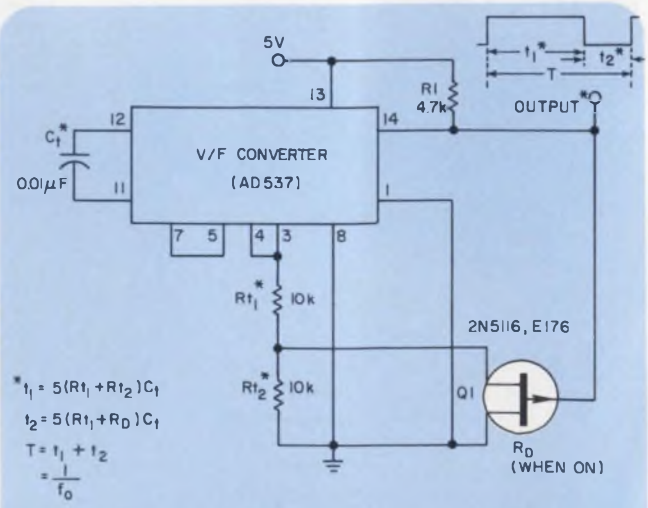
The degree of attainable asymmetry is limited only by the span range of I_t and the ON-resistance of Q_1. With R_{t1} equal to 1 kΩ and R_{t2} equal to 1 MΩ, the duty cycle is 1/1000. A 4016 analog-switch section or an open-drain CMOS buffer/converter also can be used as switches across R_{t2}.

Walter G. Jung, Pleasantville Laboratories, 1946 Pleasantville Rd., Forest Hill, MD 21050.

CIRCLE NO. 312



1. **This square-wave clock source** can be adjusted from at least 100 Hz to 100 kHz, where the frequency output is proportional to the fraction of rotation of a linear potentiometer, R_2.



2. **The basic square-wave circuit can be modified** with a switching FET, Q_1, to generate asymmetrical outputs with duty-cycle ratios as large as 1:1000.

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CIRCLE NUMBER 66

Active zener circuit provides clipping adjustable down to almost zero

Voltage limiting can be extended to well below 0.1 V by combining conventional zener diodes with an operational-amplifier stage. The circuit is simple and allows precise adjustment of clipping level, even when wide-tolerance components are used. The figure shows both conventional clipping circuits and the active-circuit concept.

The conventional arrangement clips at a level that corresponds to the sum of the forward and reverse voltages of the two series-opposing zener diodes. With this configuration, clipping levels as low as about 2.3 V can be obtained with units such as the National Semiconductor LM103 devices. Lower voltages, down to about 0.5 V, can be obtained with the forward-breakdown characteristics of multijunction reference diodes from Codi Corp., when connected in parallel opposition. But in either case, the breakdown voltage can't be conveniently trimmed to a desired value.

However, the active circuit achieves any desired clipping level down to nearly zero. An inverting op amp boosts the voltage applied to the zener from E_o to $E_o(1-\bar{A})$, where $\bar{A}$ is the gain of the amplifier circuit. The Limiting action then occurs at

$$E_o(1-\bar{A}) = V_z + V_f,$$

or

$$E_o = \frac{V_z + V_f}{1 - \bar{A}},$$

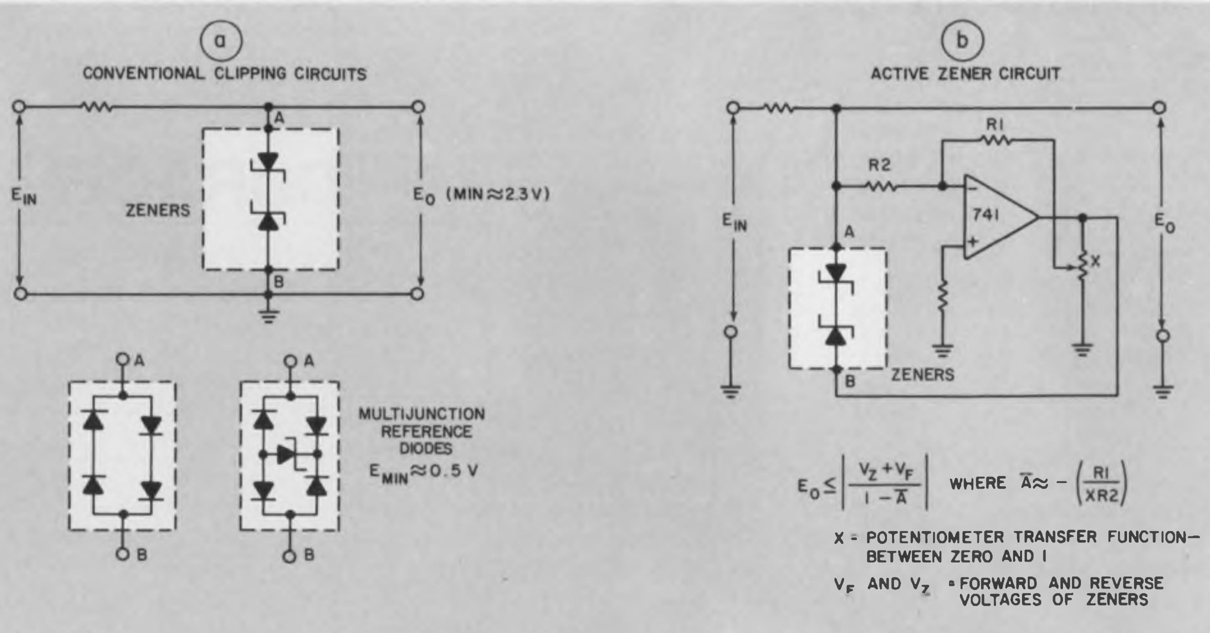
where V_f and V_z are the forward and reverse voltages of the zeners.

For example, a 4.5-V zener with a 0.5-V forward drop can be combined with a gain of −19 stage to obtain ±0.25-V clipping action.

For high frequencies, the adverse effects of zener capacitance, increased by the Miller effect, can be reduced by using a two-stage amplifier. The first stage, a noninverting adjustable-gain circuit, should have a trimmer capacitance from its output to terminal A of the voltage-limiting element. The second stage, a unity-gain inverting amplifier, will then provide the necessary drive to terminal B. The trimmer capacitance is adjusted to a value lower than the low-signal-level capacitance of the zeners, and the bandwidth of the second stage should be wide compared to the first. This arrangement ensures good shunt-capacitance compensation and an oscillation-free circuit.

Eugene R. Schlesinger, Senior Staff Engineer, Perkin Elmer Corp., Norwalk, CT 06852.

CIRCLE NO. 313



Adjustable clipping levels to very low voltages can be achieved by placing the voltage limiting elements in the feedback circuit of an op amp. Varying the setting of potentiometer X changes the level.

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CIRCLE NUMBER 67

Low-cost integrator multiplies 555 timer's delay range 100 times

With the circuit in Fig. 1, the maximum practical delay of a 555 timer can easily be increased to 100 times that of a conventional circuit. The C and R delay elements form part of an integrator, with a CA3140 op amp the active element.

In a conventional circuit, the input-bias current to pin 6 limits the resistance of R to a maximum of about 10 MΩ, so a practical maximum delay is about 1 min. An hour's delay would require impractically large capacitors.

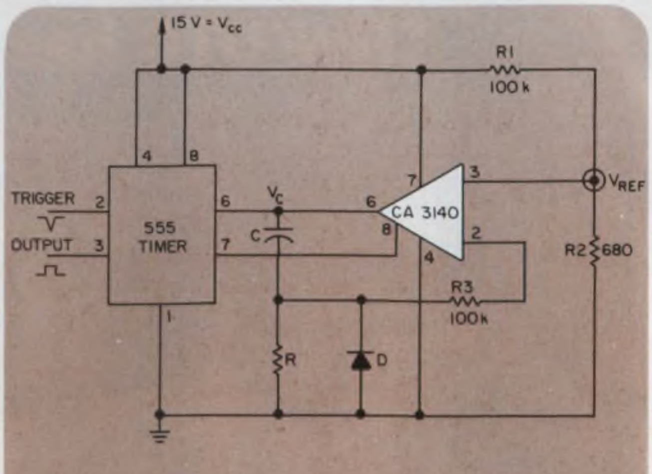
After the 555 is triggered, capacitor C charges at a rate equal to V_{ref}/RC. With V_{ref} at 0.1 V, a time equal to 100 RC is needed for C to charge to 10 V, which is 2/3 V_{cc}. At this voltage, the CA3140 output is strobed low and C discharges through diode D.

For high R values, diode D must have low leakage such as provided by the gate-channel diode of a Siliconix E202 FET. The E202's maximum leakage current is only 100 pA at 20 V; maximum forward current is 50 mA.

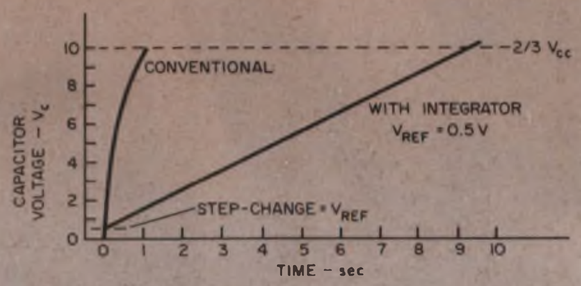
Since V_{ref} varies with C_{cc}, the timing is nearly independent of supply voltage. At V_{cc} = 5 V, however, the CA3140's output can't reach the level of 2/3 V_{cc}. But the 555's triggering point can be lowered with external resistors.

Fig. 2 shows the charging-time curves of capacitor C both without an integrator, and also with an integrator whose V_{ref} equals 0.5 V. Note that the starting point of the integrator's timing cycle contains a step change equal to V_{ref}.

William Olthoff, Euratom, Petten 1724, the Netherlands. CIRCLE NO. 314



1. **Long delay times can be derived from a 555 timer** with reasonably sized capacitors, if an integrator circuit is used.



2. **The capacitor's charging time** with an integrator circuit can be much longer than with a conventional 555-timer configuration.

IFD Winner of December 20, 1976

Donald C. Elmore, Principal Engineer, Electronic Communications, Inc., P.O. Box 12248, M/S 22, St. Petersburg, FL 33733. His idea "Diodes Act As Temperature Sensor in Remote Temperature-Measuring Circuit" has been voted the Most Valuable of Issue Award.

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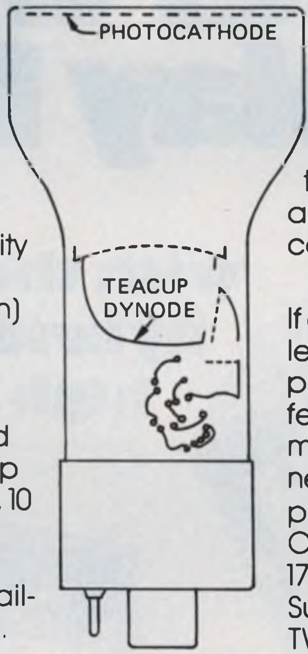
Opening new frontiers with electro optics

PMT with big new "teacup" dynode gives scintillation counters better PHR.

We expect quite a tempest over this teacup. It's a radically different RCA approach to large-diameter PMT's: The teacup is a large, cup-shaped first dynode that is an improvement over conventional venetian-blind types. It has better spatial uniformity and better off-axis uniformity. As a result, PHR (Pulse Height Resolution) is improved by 0.3% for Cs^{137} [NaI (Tl)] and 0.7% for Co^{57} [NaI (Tl)].

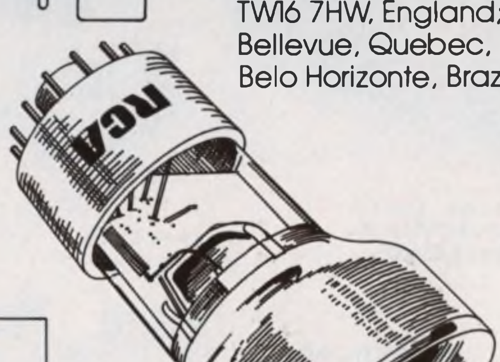
RCA 4900 is the first in a whole new family of 2" to 5" circular and hexagonal face PMT's with teacup first dynodes. It has a 3" diameter, 10 stages, and "blue" cathode responsivity of 10 μA/blue lm minimum, 10.5 μA/blue lm typical. Available with voltage divider network.



High performance in exacting applications

Besides scintillation counting, the teacup PMT can also be useful in gamma ray spectroscopy for medical applications. Several leading manufacturers of medical diagnostic equipment recently conducted their own tests on these gamma-camera type tubes, and pronounced them a giant step forward in improving camera performance.

If electro optics can solve your problem, remember: EO and RCA are practically synonymous. No one offers a broader product spectrum. Or more success in meeting special needs. Call on us for design help or product information. RCA Electro Optics, Lancaster, Pennsylvania 17604. Telephone 717-397-7661. Sunbury-on-Thames, Middlesex TW16 7HW, England; Ste.-Anne-de-Bellevue, Quebec, Canada; Belo Horizonte, Brazil; Hong Kong.



Integral voltage divider network

RCA

CIRCLE NUMBER 68

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- DDAC — Ultra-low glitch available as two DDIP packages, plus TO-3 case with 13-bit output, programmable ±2.5, ±5 or ±10V outputs with 500 mA coax drive capability. 25ns one LSB settling, internal or external reference with short circuit protected output.
- SDAC — Compact 13-bit, 24-pin DDIP with settling times to ±0.1% 500ns at ±2.5V, 1μsec. at ±5V and 1.6 μsec. at ±10V.

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with the first hybrid, low glitch (500 mV•ns), high performance (update rates to 50MHz) converters.

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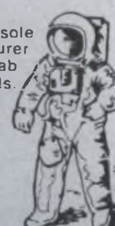

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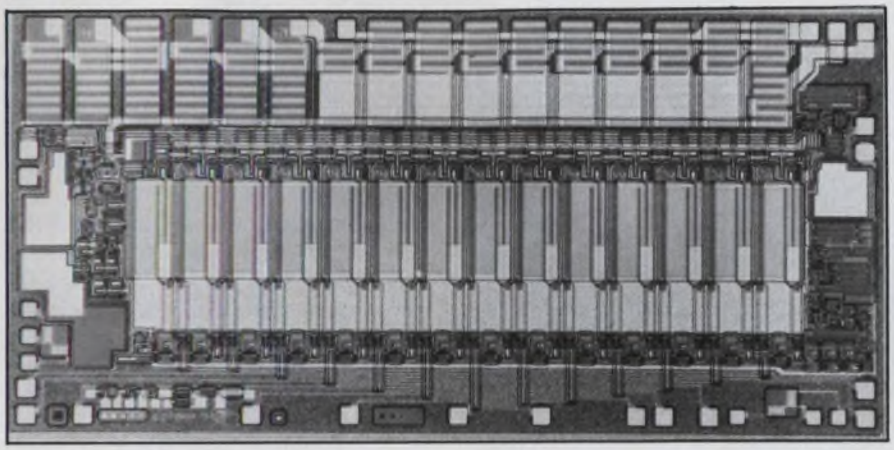
CIRCLE NUMBER 69

D/a offers tenfold speed boost over competition



Harris Semiconductor, P.O. Box 883, Melbourne, FL 32901. Ernie Thibodeaux (305) 724-7407. P&A: See text.

Offering a settling time less than a tenth that of competing 12-bit "monolithic" d/a converters, the HA-562A reaches its final value in just 100 ns, maximum. The single-chip converter, developed by Harris Semiconductor, is pin-compatible with the dual-chip AD562 made by Analog Devices, Norwood, MA. But the HA-562A also includes internal high-frequency compensation, which must be added externally to the AD562.

The Harris circuit has a maximum nonlinearity of ±1/4 LSB at 25 C and ±1/2 LSB over the full temperature range of the particular model. At 25 C, the differential-nonlinearity error is ±1/4 LSB for the HA-562A-2 version and ±1/2 LSB for the 562A-4 and 562A-5. As well as settling to within ±1/2 LSB in 100 ns, the converter takes only another 50 ns to settle with ±1/10 LSB.

Untrimmed gain error at 25 C is 0.3% of full scale, while offset error is kept to less than 0.5 μA. Both gain and offset errors can be trimmed to zero at 25 C with external pots. However for all models, gain will drift by ±2 ppm/°C and offset by 0.5 ppm/°C (unipolar mode) and ±3.5 ppm/°C (bipolar mode). Differential nonlinearity drifts by ±2 ppm/°C.

Since it doesn't have an internal reference the converter can operate in a two-quadrant multiplying mode. Feedthrough for a 2-kHz reference source fed into the 7.2-to-8.8-kΩ input is typically ±1/2 LSB. The converter current output has a ±0.75-V compliance and presents a 900-to-1100-Ω resistance. When used with an external op amp, the converter can deliver 0 to 5, 0 to 10, ±2.5, ±5 or ±10 V.

Just like the AD562, the Harris circuit accepts TTL or CMOS-input levels, but delivers an output current of 0 to 5 mA for unipolar operation and ±2.5 mA for bipolar operation—double that of the AD562. An external reference greater than +3 V or less than −3 V must be used in addition to the supplies of up to ±20 V.

Active circuitry on the Harris d/a converter requires only 15% of the chip area. The rest of the 103-× 209-mil chip is used to hold large R-2R ladder resistors; the large size of the resistors permits precise laser trimming.

Drawing approximately +15 and −20 mA from its supplies, the HA-562 dissipates 400 mW, maximum, in its 24-pin ceramic DIP. The operating temperature ranges are −55 to 125 C for the 562A-2; −25 to +85 C for the 562A-4; and 0 to 70 C for the 562A-5.

Faster than the AD562 but slower than the HA-562A is the DAC-12, a 12-bit d/a converter developed by Precision Monolithics, Santa Clara, CA. It settles in 300 to 500 ns and it is trimmed with a zener-zap technique instead of laser trimming of the resistor network. Exact prices for the converter have not yet been determined but are expected to start in the $20 to $30 range in 100-up quantities. Prices for the Analog AD562 range from $39 for the 0-to-70-C model to $100 for the −55 to +125-C version, in 100-unit quantities.

Prices for the Harris converters start at $29 for the 562A-5 and increase to $43 and $108 for the -2 and -4, respectively, all for units in 100-up quantities. Delivery is from stock.

Harris Semiconductor **CIRCLE NO. 303**
Analog Devices **CIRCLE NO. 304**
Precision Monolithics **CIRCLE NO. 305**

Wideband op amp offers 320-MHz bandwidth

Plessey Semiconductors, 1674 McGaw Ave., Irvine, CA 92714. Dennis Chant (714) 540-9945. P&A: See text.

The SL1550 wideband amplifier has a bandwidth of 320 MHz and a typical noise figure of 2 dB or less at 100 MHz. A voltage-controlled agc range of 25 dB and an external gain control characteristic of ±1 dB from —55 to +125 C are also available. The amplifier has an over-all gain of 38 dB, an output of 0.5 V rms, and requires only a single supply voltage between 6 and 9 V. Available in an eight-lead TO-5 can, the SL1550 costs $25.25 in 100-unit quantities.

CIRCLE NO. 320

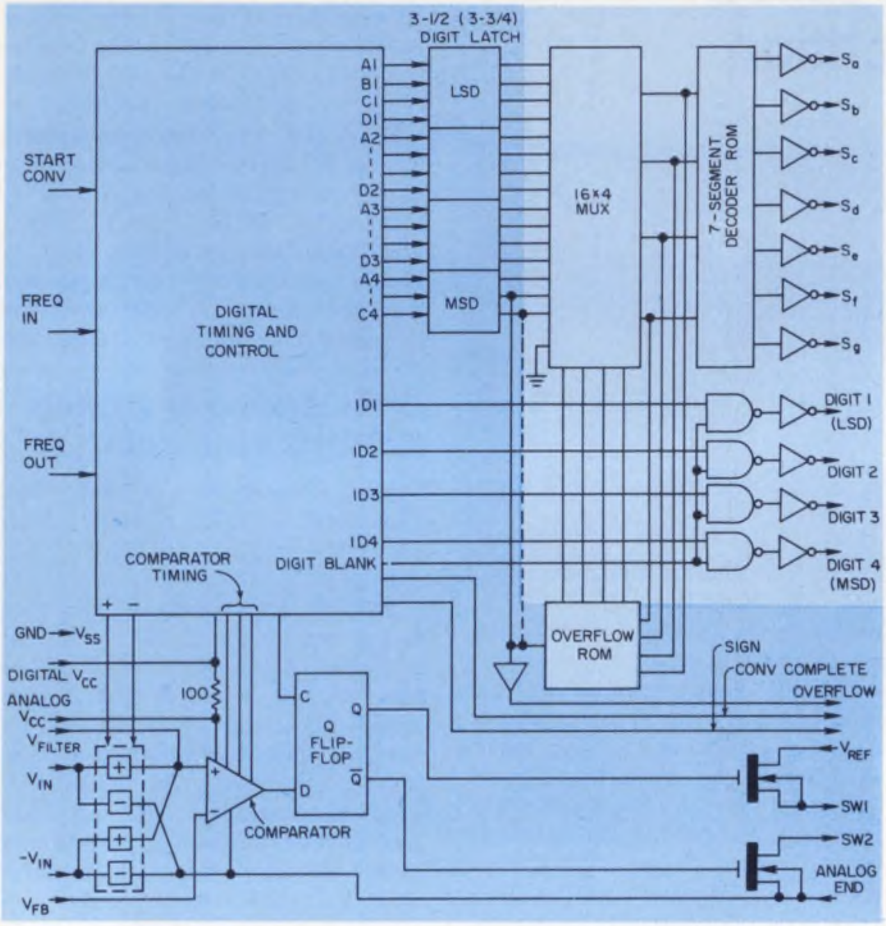
Power Darlingtons boost operating temp to 200 C

Motorola Semiconductor Products, P.O. Box 20924, Phoenix, AZ 85036. Lothar Stern (602) 244-6900. $2.75 (100-up); stock.

Designed specifically for the high-voltage, high-current and harsh environmental requirements, the MJ10012 Darlington transistor operates over a −65 to +200-C range. Breakdown voltage, BV_{CEO}, is 400 V and the continuous collector current is 10 A. The Darlington has a safe operating area of 3.5 A at 50 V and can dissipate 100 W at 100 C. Gain of the TO-3 housed transistor at an I_C of 3 A is 300.

CIRCLE NO. 321

DVM chips include 7-segment decoder and LED drivers



National Semiconductor, 2900 Semiconductor Dr., Santa Clara, CA 95051. Dennis Dauenhauer (408) 737-5000. From $9.95 (100-up); 30 days.

Requiring just an external reference, some digit drivers and a LED display, the ADD3500 DVM chip includes all other conversion and drive circuitry for a 3-1/2-digit DPM. Housed in a 28-pin DIP, the chip contains a 3-1/2-digit a/d converter, seven-segment decoder and drivers, and clock circuits. A higher-resolution version, the ADD3700, provides a 3-3/4-digit display (3.999 instead of 1.999).

The accuracy is the same for both circuits: 0.05% +0, −1 count. Up to 10 conversions per second can be performed. Maximum converter-input currents have been kept to ±1 nA.

If the converters' power supply isn't isolated, only one polarity of input voltage can be converted. If the supply *is* isolated, either polarity of the input signal can be handled. A +2-V reference, also isolated from input ground, must be used, for dual-polarity measurements. It can be derived from the chip's power supply.

Both the 3500 and 3700 have definitive outputs to indicate overflow—the displays show +OFL or −OFL. This output feature "came for free" when the decoder ROM was designed.

Pulse-duration modulation is employed to perform the a/d conversion (see "CMOS Puts New a/d Technique Ahead of Dual-slope Method," ED No. 8, April 12, 1977, p. 36) and takes advantage of the nonlinear circuit performance of CMOS.

Except for the reference voltage only a +5-V power supply is required by the DVM chips. On the other hand, competing chips such as the LD110/111 from Intersil (Cupertino, CA), the MC14433 from Motorola (Austin, TX), and the LD130 from Siliconix (Santa Clara, CA) require at least two supplies—and external decoders and drivers if LED displays are used.

Both National chips can handle switched LED currents and maintain full-rated accuracy—if special care is taken. The converters can deliver 50-mA peak currents per segment, thus peak output currents as high as 350 mA flow in the chip. This current must be timed so that it doesn't influence the conversion section of the circuit. To prevent errors from degrading accuracy to 0.1%, a fast-recovery power supply must be provided for the LEDs so that switching transients are kept short. An inexpensive three-terminal regulator readily does the job.

National Semiconductor **CIRCLE NO. 306**
Intersil **CIRCLE NO. 307**
Motorola **CIRCLE NO. 308**
Siliconix **CIRCLE NO. 309**

Analog compandors have dual-channel control

Signetics, 811 E. Arques Ave., Sunnyvale, CA 94086. Robert Lanford (408) 739-7700. 100-up prices: $6.33 (570), $5.88 (571); stock.

Dual gain-control circuits, containing a complete compressor and expandor in one linear IC, the NE570/571 provide a dynamic range of 110 dB. Either channel of the dual compandors can be used as a dynamic-range compressor or expandor. Each channel has a full-wave rectifier to detect the average value of a signal, a linearized, temperature-compensated variable gain cell, an operational amplifier, and a bias system. The compandor section includes a THD trim terminal to permit offset voltages to be trimmed out. Other features include operation from a 6-to-16-V supply, a maximum power dissipation of 400 mW, and an operating temperature range of −40 to +70 C. The NE570/571 come in 16-pin DIPs.

CIRCLE NO. 322

CIRCLE NUMBER 70 ▶

Ion-implanted diodes offer Schottky drops

Solid-State Devices, 14830 Valley View Ave., La Mirada, CA 90638. Arnold Applebaum (213) 921-9660. 100-up prices: $11.25 (6097E), $13.90 (6098E); 4 wks.

The 1N6097E and 1N6098E ion-implanted diodes handle an average half-wave rectified forward current of 50 A with a dc blocking voltage of 30 and 40 V, respectively. Both devices have a maximum forward voltage of 0.86 V. The ion-implantation technique produces a maximum reverse-recovery time of 75 ns with 50 ns typical. Both diodes have a −65 to +175-C operating range and a thermal resistance of only 0.8 C/W. There is no temperature derating up to 125 C while reverse-leakage current at rated voltage is 100 μA at 25 C and 2 mA at 125 C. Additionally, the ion-implanted units have a 700-pF capacitance compared with 7000 pF for competing Schottky devices.

CIRCLE NO. 323

Dynamic RAM family has 4 and 16-k models

Intel Corp., 3065 Bowers Ave., Santa Clara, CA 95051. Bill Regitz (408) 246-7501. 100-up prices: $9.95 to $14.95 (2104A), $47 to $62.50 (2116A); stock.

A family of interchangeable 4096 and 16,384-bit dynamic RAMs, the 2104A/2116 units, can directly replace many of the 16-pin, 4-k RAMs now used in many systems. The 2104A and 2116 series are electrically and logically compatible, allowing 4-k and 16-k RAMs to be easily combined in memory systems. The 2104As can replace the 2104 and similar 4-k RAMs. The 2116 types are improved versions of Intel's 2116 16-pin, 16-k dynamic RAM introduced in January, 1976. Access times as short as 150 ns for the 2104As and 200 for the 2116s are available. Both types are guaranteed to operate at these speeds over a power supply tolerance of ±10%, as well as over 0 to 70 C. Typical power dissipation of the 2104A is 240 mW active and 8 mW on standby. The 2116 typically dissipates 588 mW active and 14 mW on standby.

CIRCLE NO. 324

CCD memory chip holds 65 kbits in 16 pin DIP

Texas Instruments, P.O. Box 5012, Dallas, TX 75222. (214) 238-2011. $195 (unit qty); stock.

Able to hold 65,536 bits of data, the TMS3064 charge-coupled device memory is organized externally as 65,536 one-bit words. Internally the CCD chip has 16 addressable 4096-bit serial-parallel-serial loops. The two non-overlapping clocks and the chip-enable inputs can be driven by standard MOS-level drivers. All other inputs have 200 mV of dc noise immunity when interfacing with standard TTL. No pull-up resistors are required. The three-state output will drive at least two standard series 74, 74S or 74LS loads without the use of pull-up resistors. The maximum data rate is 5 Mbits/s and access time is 800 μs, minimum. The TMS3064 has a typical operating power dissipation of 300 mW at 5 MHz and a standby power dissipation of less than 30 mW. The memory comes in a 16-pin ceramic DIP package with pin rows on 400-mil centers and is designed for operation over a 0-to-70-C range.

CIRCLE NO. 325

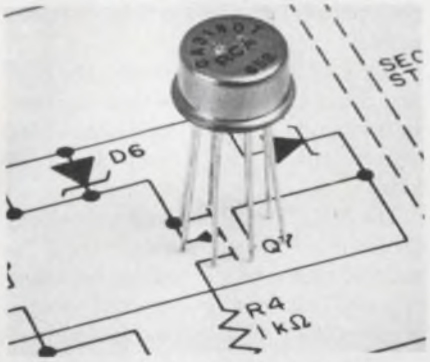
Power transistors switch fast and handle 70 A

Semicoa, 333 McCormick Ave., Costa Mesa, CA 92626. Robert Boughan (714) 979-1900. 100-up prices: from $33 (TO-3 cases); stock.

Double-diffused npn power transistors designed for switching applications offer only a 0.01-Ω resistance with a 70-A collector current. The devices have a 0.5 μs t_{on} and t_{off} and a 1-μs storage time. Their $E_{S/B}$ is guaranteed at 200 millijoules, which is claimed to be two to five times the guaranteed ratings of competitive devices. The $I_{S/B}$ is rated at 25 A and the saturation voltage is a low 0.7 V at rated collector current. Maximum f_t is 30 MHz with an I_C of 10 A; beta is typically 10 at 70 A. The family of available transistors is available with V_{CEO}'s of 80 to 150 and comes in TO-3, TO-59, TO-61, and TO-63 packages.

CIRCLE NO. 326

Compensated amps mix MOSFETs and bipolars



RCA Solid State Div., Box 3200, Somerville, NJ 08876. (201) 685-6423. From $0.80 to $9.95 (1000-up); stock.

Complete with on-chip frequency compensation, the CA3160 series of BiMOS op amps combine MOSFET inputs, CMOS outputs and bipolar devices. The CA3160, CA3160A, and CA3160B are frequency-compensated versions of the older CA3130 op amps. The input stage has an input impedance of 1.5×10^{12} Ω, typical, and an input current of 5 pA at 15 V typical. The output stage can swing the voltage to within 10 mV of either supply-voltage terminal. Other CA3160 features include a bandwidth of 15 MHz, a slew rate of 10 V/μs (unity-gain follower) and a strobing capability to reduce standby power consumption. The three versions operate over the temperature range of −55 to +125 C, and are available in 8-lead TO-5 packages with either straight or dual-in-line formed-leads.

CIRCLE NO. 327

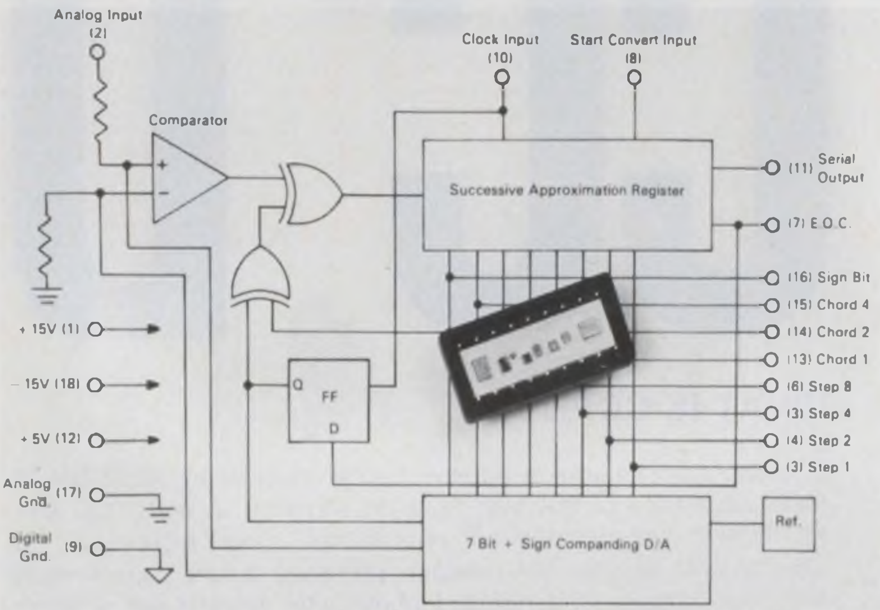
Digital multipliers offer MIL temp ranges

TRW, One Space Park, Redondo Beach, CA 90278. Bill Koral (213) 536-1500. 100-up prices for MIL versions: $115, $170, and $225 for the MPY 8, 12 and 16, respectively; stock.

The 8, 12 and 16-bit bipolar multipliers, the MPY 8, 12 and 16, are now available in military-temperature-range versions in addition to the previously announced commercial range versions. Both 12 and 16-bit multipliers come in 64-pin ceramic flat packages with built-in heat studs. They will also be available in 64-pin ceramic DIPs that have integrated heat sinks for −55 to +125 C. The MPY-8 will be supplied only in a 40-pin ceramic DIP. In addition to the full MIL-temp units, devices fully qualified to level B of MIL-38510 will be available.

CIRCLE NO. 328

Tiny companding a/d crams 72 dB of input into 8 bits



Micro Networks, 324 Clark St., Worcester, MA 01606. J. Munn (617) 852-5400. $69 (1-24 qty); stock to 2 wks.

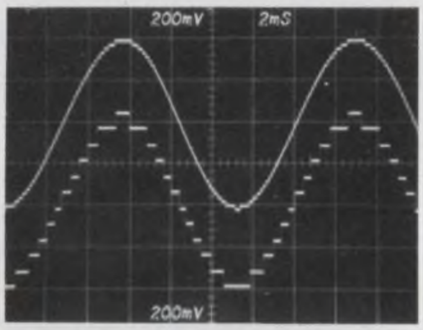
Signals with wide dynamic ranges can now be resolved with up to 12-bit accuracy using an 8-bit output a/d converter in an 18-pin DIP. The MN 5110, a companding converter, compresses analog inputs into a 7-bit-plus-sign output code, which covers a 72-dB dynamic range.

Micro Networks' thin-film hybrid a/d circuit is a companion to Precision Monolithics' COMDAC chip—an 8-bit companding d/a converter. In fact, the MN 5100 uses PMI's IC as a component.

To get an approximately logarithmic transfer function (Bell μ-235 law), the analog range is broken up into eight binarily related "chords." Each chord is divided in turn into 16 linearly related steps.

Two waveforms (see photo) show the increased resolution at low voltages of the companding a/d (top trace) with respect to a linear a/d (bottom trace).

The finest step size occurs in chord 0. Here each step represents 1.25 mV (based on ±5-V full scale). The accuracy and resolution in chord 0 is equivalent to those of a sine-plus-12-bit a/d converter.



In chord 1, the step size is doubled to 2.50 mV and is equivalent to an 11-bit-plus-sign converter. Doubling the step size proceeds for each successive chord until, in chord 7, the step size is 150 mV.

The MN5110 operates like a standard 8-bit successive-approximation a/d converter. But instead of a conventional binary-weighted d/a, the companding a/d uses a companding d/a (described in ED No. 9, April 26, 1976, p. 111). In addition, logic for initial input-polarity determination is included.

Conversion begins when the Start line is low during a low-to-high transition of the Clock. After the sign bit is determined, the three bits that select the chord are successively latched in. Then the four step-bits follow. When End of Conversion (EOC) goes low, the 8-bit parallel word is available for processing.

For continuous conversion, the EOC and Start signals can be tied together. In this mode, a typical unit does 67,000 conversions/s, with a clock rate of 600 kHz.

The MN5110's performance is nearly ideal for a voice-encoding system. The ratio of signal to quantizing distortion remains essentially constant over a greater than 40-dB dynamic range.

Signal compression or expansion has been widely used to optimize signal-to-noise ratios in information transmission. The best example is in the telecommunications industry, where a large dynamic range of voice signals is compressed into 8-bit digital words to be transmitted by pulse-code modulation. At the receiver, the words are converted and expanded back to the full analog range.

Since the converters are most accurate near the zero point, they are well-suited for servo loops—where signals must be nulled. The 8-bit units, of course, interface neatly with 8-bit μP data buses.

In many instances, the MN5110 can replace a complex system that uses a conventional converter and gain-ranging amplifiers.

CIRCLE NO. 302

Load cells stretch range down to 10 lb

Interface, Inc., 7401 E. Butherus Dr., Scottsdale, AZ 85260. (602) 948-5555. From $150 (unit qty); stock.

Two low-range models of strain-gauge load cells, the SM-10 and SM-25, add 10 and 25 lb (45N and 111N) capacities to the Super-Mini line of 50, 100, 250, 500 and 1000 lb (222N, 445N, 1112N, 2225N and 4450N) capacities. The entire series boasts tempcos for zero and sensitivity of 8 ppm/°F. Additional features include 0.03% nonlinearity, 0.02% hysteresis and 0.01% nonrepeatability. Creep is less than 0.03% after 20 min. The series' 3-mV/V output signal simplifies interfacing and a 5-ft four-conductor shielded cable is provided.

CIRCLE NO. 329

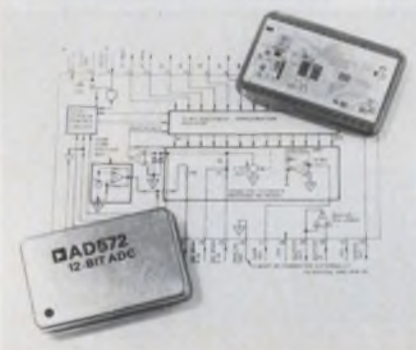
Small amp blasts out 10W of clean audio

Energy Electronic Products, 6060 Manchester Ave., Los Angeles, CA 90045. T. Nixon (213) 670-7880. $5.20 (100 qty); stock.

You get 10 W of linear output from the hybrid SI-1010G made by Sanken in Japan. The module features less than 0.5% total harmonic distortion at 10-W output. The class-B, quasi-complementary circuit uses flip chip transistors and passivated-chip power transistors with high secondary-breakdown strength. The amp operates from single or split input power.

CIRCLE NO. 331

Digitize 4096 levels over full temp range



Analog Devices, Route 1 Industrial Park, P.O. Box 280, Norwood, MA 02062. J. Mills (617) 329-4700. $250 (1 to 24); stock to 4 wk.

Because of its mere 900-mW dissipation, the 12-bit AD572S a/d converter operates from −55 to +125 C with no missing codes. The successive-approximation unit features the following maximum specs: nonlinearity of ±0.012%, conversion time of 25 μs, and tempcos of ±25-ppm/°C (gain) and ±10-ppm/°C (reference). Lower cost A and B versions operate with no missing codes over 0 to 70 C and −25 to +85 C, respectively. Processing to meet MIL-STD-883, Method 5004, Class B is available for these dual-in-line devices.

CIRCLE NO. 332

Chopperless high-gain op amp nails drift

National Semiconductor, 2900 Semiconductor Dr., Santa Clara, CA 95051. L. James (408) 737-6523. From $7.60; stock.

Featuring max noise of (0.7-μV pk-pk) and min gain of 120 dB the LH0044 op amp family is intended to replace chopper-stabilized amps. The devices boast max initial offsets of 25μV, max offset drift of 0.5-μV/°C and min CMRR of 120 dB. Models are specified from −55 to +125 C, or −25 to +85 C. The T0-5 device is pin compatible with LM108A, LH725, and LM741 op amps.

CIRCLE NO. 333

Unit gauges analog voltages

Calex Mfg., 3305 Vincent Rd., Pleasant Hill, CA 94523. R. Kreps (415) 932-3911. $68; stock to 2 wks.

You can monitor precisely low-level signals with the 546 Multifunction Voltsensor. The module has: a triple op-amp instrumentation amplifier; two comparators; logic to provide HI, Lo and GO signals; and three high-level output stages capable of sinking 100 mA or sourcing 20 mA. The device features a differential impedance of 1000 MΩ and input ranges of ±100 mV, ±1 or ±10 V that are pin selectable. The set points can be externally adjusted using potentiometers. Both the HI and LO comparators can be made to latch or to have variable hysteresis by means of pin selection. Four different mounting kits are available for the 2 × 2 × 0.6-in. module that provide potentiometers, output relays, or jumpers as required.

CIRCLE NO. 334

Sharp-cutoff filters span wide range

T T Electronics, Inc., 2214 Barry Ave., Los Angeles, CA 90064. (213) 478-8224. From $80; 3 wks.

Series-Q bandpass filters feature bandwidth ratios of 2:1 for 3-to-40-dB bandwidths. The 40-to-3-dB cut-off-frequency ratio is 1.05 for some models. You can get center frequencies (f_c) from 10 kHz to 50 MHz and any bandwidth from 5 to 20% of f_c. These hermetically sealed filters come in both chassis-mounting and PC-board cases.

CIRCLE NO. 335

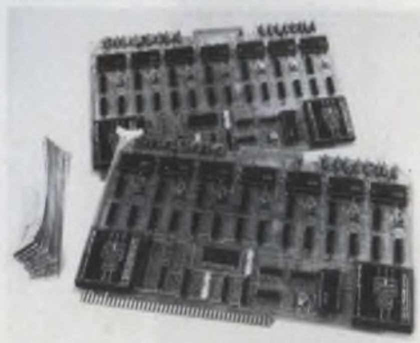
I/O boards open μC to analog signals

Burr-Brown, International Airport Industrial Park, P. O. Box 11400, Tucson, AZ 85734. G. Athey (602) 294-1431. From $120; stock.

Both the 4216 (16-channel input board) and 4102 (2-channel output board) mate with 4 or 8-bit Pro-Log μCs. The boards can be treated as memory by the CPU—each channel requires one 8-bit memory location. Each board's address block is strap selectable, so a board can be located anywhere in memory. Alternatively, the systems can be treated as I/O. An input board is a 16-channel differential-input system with full-scale input ranges between ±10 mV and ±10 V. Analog inputs are converted with 8-bit resolution. Throughput accuracy ranges from ±0.5% of full-scale reading on the ±10-V range, to ±0.7% of full-scale reading on the ±10-mV range. Conversion time is 60 μs. Output boards contain two channels, each with 8-bit resolution and a throughput accuracy of ±0.4% of full scale.

CIRCLE NO. 336

Single board gives μC 8 analog outputs



Data Translation, 23 Strathmore Rd., Natick, MA 01760. F. Molinari (617) 655-5300. See text; stock.

An 8-channel d/a converter system is mechanically, electrically and software compatible with Intel's SBC-80 μC. Two single-board models are available: the 12-bit DT1842, priced at $995 for 8 channels or $695 for 4 channels; and the 8-bit DT1843, costing $795 for 8 channels or $495 for 4 channels. On-the-board 4-to-20-mA current-loop outputs are optionally available at $30 per output. Features of these systems include ±1/2-LSB linearity and 3-μs settling time to 0.01% of full scale.

CIRCLE NO. 337

8080 core

non-volatile · high reliability

Dataram introduces the industry's widest range of byte-designed single-board core systems for 8080 and other byte-oriented applications.

And when Dataram says "byte," we mean true byte systems — with 1K to 32K bytes, 8 to 10 bits/byte, not 16 or 18 bits/word systems that simulate byte systems.

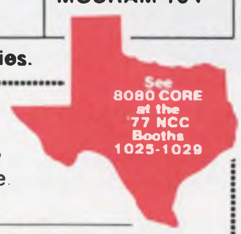
What that means to you is less power and fewer components...and that means more for less. More reliability and more performance with smaller size...and lower product costs.

8080 Core. For people who think small.

Find out more about 8080 Core today. Return this coupon at once, or call us at 609-799-0071.

SYSTEM	CAPACITY	CYCLE/ ACCESS	DIMENSIONS	VOLTAGES	TYPICAL POWER	COMPATIBILITY
DR-180	4K x 8 8K x 8	750/250 ns 750/250 ns	9.2" x 6.3" (233.4 mm x 160 mm)	+5V, +12V	30 Watts	8080 Microprocessor
DR-121	1K x 10 2K x 8 2K x 10	900/350 ns 900/350 ns 900/350 ns	11.7" x 11.5" (297 mm x 292 mm)	+5V, −12V	25 Watts	Cambridge Memories' 1K x 9 Unicore
DR-104	4K x 9 8K x 9 16K x 9 32K x 9	750/350 ns 750/350 ns 750/300 ns 800/300 ns	13.5" x 8.3" (343 mm x 211 mm)	+5V, −12V	32 Watts	National Semiconductors' MOSRAM 104

In addition to standard systems, Dataram offers impressive custom design capabilities.



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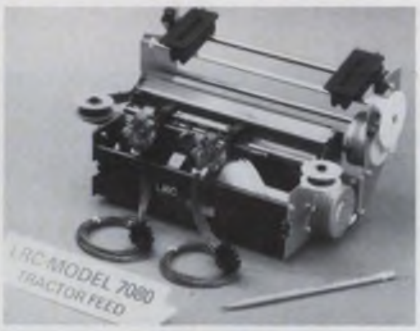
TEL: 609-799-0071 TWX: 510-685-2542

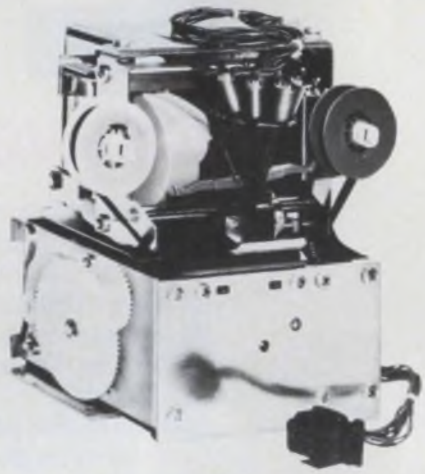
Line printers handle alphanumeric characters

C. Itoh Electronics, 280 Park Ave., New York, NY 10017. Floyd Makstein (212) 682-0420. See text; 7022T; stock; 7080, 4 months.

Able to print 22 or 80 characters per line, two printers, the 7022T and 7080, respectively, use a dot-matrix approach. Both units are impact printers and print at 1.58 and 1 line per second, respectively. The 7022T has a maximum print line of 1.86 in., a top of form sensor option and can handle form thicknesses of up to 0.015 in. It includes a print element of seven solenoids and requires external circuitry to drive the solenoids. The printer measures 6.4 × 6.85 × 4.62 in. and costs $125 in 500-unit quantities. The 7080 has two printheads, dividing a page into two 40 column halves and has a print line capability of 6.67 in. and a character height of 0.123 in. It costs just $250 (not including electronics) when purchased in 500-unit lots and measures 5.22 × 12.438 × 4.415 in.

CIRCLE NO. 338





6800 text editor offers many features

Technical System Consultants, Box 2574, West Lafayette, IN 47906. Dave Shirk (317) 742-7509. See text; stock.

Developed to support the 6800 microprocessor, the SL68-24 text editing program is claimed to be the most extensive 6800 editor available. It includes commands such as Print, Insert, Delete, Find, Replace and Verify as well as pointer movers for file Top, Bottom, as well as commands for tabs, line numbers, renumbering, overlaying, headings, zoning and for reading, writing and saving programs. The editor requires approximately 5 k of RAM. For $23.50 the company provides a complete source listing, hex dump listing, sample output and users manual. An additional $6.95 buys a cassette listing and $8 buys a paper tape.

CIRCLE NO. 339

Compact microcomputer slips into briefcase

Cybersystems, 4306 Governers Dr. West, Huntsville, AL 35805. (205) 837-2080. From $525; stock.

Ready to plug into the line and operate, the MicroCyber 1000 microcomputer is compact enough to fit in a briefcase. The 14 × 11 × 2-in. computer is based on the MOS Technology 6502 μP and includes 1024 bytes of RAM and 2048 bytes of ROM. In the ROM is the operating system for the cold-start bootstrap, TTY handlers, keyboard and display handlers, and audio-cassette handlers. The computer comes with a full hex keyboard and six-digit LED display for address and data. For further expansion, a 72-pin I/O and memory expansion bus connector is included.

CIRCLE NO. 340

Compiler program accepts assembly or PL/M codes

Intermetrics, 701 Concord Ave. Cambridge, MA 02138. Mary Allard (617) 661-1840. $1000 (mag tape).

PL/M6800, a high level programming language for the 6800 microprocessor, permits the user to intersperse assembly code between PL/M6800 statements. The compiler is accessible via the NCSS time-sharing network, or can be purchased directly from the company for in-house installation on IBM 360 or 370 computers. PL/M6800 has a one-pass compiler that produces optimized directly loadable object code. It offers a user-controlled switch that determines whether the emitted code is in the AMI or Motorola loader format. Other user controlled features include listings of source code, object code, and/or assembler code; as well as symbol table dumps. About 300 kwords of memory space are needed to hold the program.

CIRCLE NO. 341

Expansion boards flex SBC/System 80 muscles

Intel Corp., 3065 Bowers Ave., Santa Clara, CA 95051. George Adams (408) 246-7501. Single-unit prices: $775, $875, $1375, $425 and $395 for the SBC 104, 108, 116, 517 and 519, respectively.

Designated the SBC 104, 108, 116, 517 and 519, five memory expansion boards have been added to the SBC 80 single board and System 80 microcomputer systems. Each board interfaces directly with any SBC 80 or System 80 via the system bus. The SBC104/108/116 series are combination RAM, EPROM and serial and parallel I/O expansion boards containing 4, 8 and 16 kbytes of RAM, respectively. The SBC517 is a combination I/O expansion board containing 48 programmable parallel I/O lines and a full RS-232-C programmable serial channel, with addressing and connectors directly compatible with the SBC 104/108/116 series. The SBC519 provides 72 programmable I/O lines which can be expanded via direct bus interface.

CIRCLE NO. 342

Processor board uses Z80 but runs SBC 80/10 code

Mini Micro Mart, 1619 James St., Syracuse, NY 13203. Maury Goldberg (315) 422-6666. From $199.95 (kit); stock.

Software compatible with the Intel SBC 80/10 board, the RM Z80 single-board μP system, provides space for three on-board 2708 PROMs, 1 k of static RAM, two 8255's (providing nine parallel ports), and an 8251 USART for a serial interface. Both a 20-mA current loop TTY and an RS-232-C interface are also on the board. Provisions for baud rates from 110 to more than 9600 are available. Full address decoding is provided for both the on-board memory and the I/O devices. With minor modifications the RM Z80 will also run Altair, Imsai, and Processor Technology software. The board measures 7 × 10.5 in. and has gold connector fingers on a dual 43 (0.156 in. centers) format.

CIRCLE NO. 343

CIRCLE NUMBER 76

Controller handles incremental plotters

Logic Sciences, 6420 Hillcraft #317, Houston, TX 77081. William Hyche (713) 777-5744. $3500; 45 to 60 days.

A microprocessor-controlled plotter interface, the MPC-11, accepts input from either an 8-bit parallel or RS-232-C data source. Devices compatible with the MPC-11 include almost all popular incremental plotters as well as the Tektronix Model 4014 graphics CRT. Software on the MPC-11 includes the following features: Generation, rotation and scaling of a LeRoy lettering set plus special symbols, generation of circles and arcs, vector generation including dashed lines, switch selectable baud rate (75 to 9600 baud), input and output buffers and the ability to interface to modems for remote plotting at up to 9600 baud.

CIRCLE NO. 344

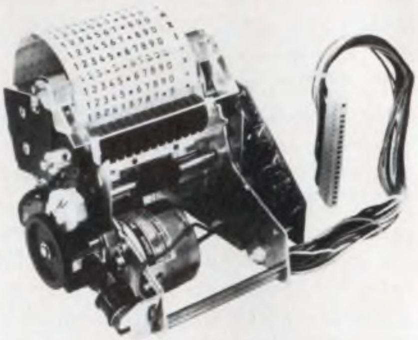
Hardcopy terminal talks or listens at 1200 baud

Digital Equipment Corp., Digital Components Group, One Iron Way, Marlborough, MA 01752. (617) 481-7400. $2270 (100-up); stock.

The LS120 DECwriter III, a keyboard terminal, can be used for interactive communication with a computer and as a unit in a data or message-communication network. It operates at 1200 baud and prints at 180 cps. Inside, a 1-k character buffer helps maximize throughput and the unit has an EIA interface, an automatic "paper out" switch, a last-character visibility and a self-test capability. The terminal is compatible with full duplex and half-duplex protocols. Optional features include a forms handling package, a communications package, an APL alternate character set, a compressed font, and a 300-baud integral acoustic coupler.

CIRCLE NO. 345

Printer does 10^6 lines between service calls



Canon USA, 10 Nevada Dr., Lake Success, NY 11040. Mike Yoshikawa (516) 488-6700. $30 (large qty.).

The CMP-1, an impact numeric printer, can print over a million clear, sharp lines without any servicing. Designed for calculators, data loggers, point-of-sale equipment and other numeric output devices the CMP-1 uses a pre-inked roller in a removable cartridge to achieve the long print capability. The ink cartridge can be changed without tools and without smudging fingers. Printer MTBF is 7.5-million lines. The printer has 13 columns (wheels) with 12 numbers or characters per wheel. Printing speed is 2.8 lines/s. Character height is 0.106 in. and width is 0.067 in. Standard office calculator paper rolls can be used (2.25 in. wide). The entire unit, including the printed-circuit board containing the driving circuit, is a self-contained package measuring 4.25 × 5 × 3.35 in. and weighing 1.5 lb. Power required is 20 V ±10% and the code input is 5-bit phase-shift parallel.

CIRCLE NO. 346

Floppy-disc system operates with M6800 μPs

Electronic Product Associates, 1157 Vega St., San Diego, CA 92110. (714) 276-8911. See text: 2 wks.

Designed to mate with a 6800 microcomputer system, the Micro-68 floppy-disc system comes complete with a single or dual-disc drive, drive electronics and controller. Each IBM compatible disc holds 256,000 bytes of data. Housed in a rugged aluminum cabinet, the system, complete with EXORciser interface for the 6800 costs $2595 for a single drive with power supplies. A dual system costs $3295. Included with either system is the floppy disc operating system and assembler and editor software.

CIRCLE NO. 347

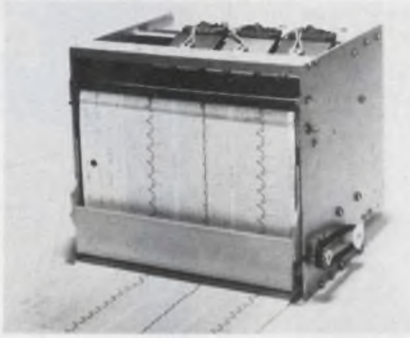
Small 3-1/2-digit DPM spans 2 to 1000 V ac

Non Linear Systems Inc., P.O. Box N, Del Mar, CA 92014. (714) 755-1134. $136; stock.

Full scale ac values of 2, 20, 200 or 1000 V—all with 0.5% accuracy—are yours with the Model PM-3.5 ac. The 3-1/2-digit unit weighs 4 oz, and occupies 0.94 × 2.5 × 4.19 in. Power consumption is less than 1.3 W at 5 V dc. The LED display has a programmable decimal point. Input impedance is 1 MΩ, except for the 900-kΩ 1000-V-ac meter. Zeroing is not necessary. An optional 5-V power supply is available for 115-V-ac line operation.

CIRCLE NO. 348

Recorder loads fast with cartridge paper



Astro-Med, Atlan-Tol Industrial Park, West Warwick, RI 02893. (401) 828-4000. $1500; 30 days.

A new 3-1/2-channel recorder incorporates cartridge chart loading. Model W302 XL provides three 50-mm-wide channels as well as a wide margin for three or more columns of alphanumeric information. Standard 8-1/2-in.-wide chart paper is preloaded into a cartridge outside the recorder, and the cartridge is simply snapped into the unit for immediate inkless thermal writing.

CIRCLE NO. 349

Materials test source spans w-i-d-e range

Exact Electronics, 455 S.E. 2nd Ave., Hillsboro, OR 97123. (503) 648-6661. $1200; 45 days.

Model 340 material-testing generator uses digital synthesis to generate sine, square, triangle, ramp, haversine, haversquare, havertriangle, and inverted waveforms over a period range of 1 ms to 99,900 h (11.4 years). Waveform period can be selected in milliseconds, seconds, minutes, or hours with three-digit resolution for each range. The digits can also be multiplied by factors of 10 and 100. For ramp mode of operation, the ramp step amplitude is resolved down to 50 μV per step at maximum signal amplitudes of 20 V pk-pk.

CIRCLE NO. 350

1800-MHz synthesizer offers AM/FM/PM

Ailtech, 815 Broadhollow Rd., Farmingdale, NY 11735. (213) 965-4911. Starting at $11,000; 16 weeks.

Model 360 direct frequency synthesizer now covers the range of 0.01 to 1800 MHz with the addition of new optional plug-in modules. Complete programmable frequency, modulation and output level plus 20-μs switching time are featured.

CIRCLE NO. 356

DMM comes with analog peaking meter

Systron-Donner Corp., Ten Systron Dr., Concord, CA 94518. (415) 676-5000. $350; stock.

Model 7003M 3-1/2-digit multimeter includes an analog meter for making nulling and peaking measurements. The 7003M offers five complete functions: dc voltage, dc current, ac voltage (true rms), ac current (true rms), and resistance. It can also include an optional internal battery pack for complete field portability. The 7003M features a resettable circuit breaker for current overload protection.

CIRCLE NO. 357

Signal generator boasts low noise

Marconi Instruments, 100 Stonehurst Court, Northvale, NJ 07647. (Longacres, St. Albans Hertfordshire AL4 0JN, United Kingdom). (201) 767-7250. About $16,000.

Model TF 2020 synthesized signal generator offers one of the best sideband noise performance available. Sideband noise is at least 130-dB/Hz down at 20-kHz offset. All functions of the 50-kHz-to-520-MHz unit can be controlled from the front panel or remotely through parallel BCD inputs. Stability is better than 1 part in 10^8 per day, and spurious signals are better than 90-dB down.

CIRCLE NO. 358

INSTRUMENTATION

30-MHz counter uses batteries or ac

B&K Precision (Dynascan Corp.), 6460 W. Cortland Ave., Chicago, IL 60635. (312) 889-9087. $120.

Not much larger than a pocket calculator, Model 1827 autoranging, portable frequency counter offers a six-digit LED display and guaranteed operation to 30 MHz with 1-Hz resolution and 0.25-ppm stability. The input circuitry is sensitive enough to display a 100-mV sine-wave signal, but is protected against an input signal of up to 200 V. The 1827 can be powered for more than 8 h by AA or rechargeable NiCd batteries. Including optional batteries, the 1827 weighs less than 1 lb. Size is only 4.4 × 9.5 × 16.8 cm.

CIRCLE NO. 359

Meter reads 3-ϕ true-rms E/I, watts

Yokogawa Corp. of America, 5 Westchester Plaza, Elmsford, NY 10523. (914) 592-6767.

Model 2505 3-phase, 4-wire digital instrument provides readings of true-rms, volts and amps as well as watts with an accuracy of ±0.25% rdg +0.05% of range. The compact unit covers voltage ranges of 100 to 600 V ac, current ranges from 2 to 20 A and power from 200 W to 12 kW (all per phase). Typical input characteristics include an input impedance on voltage ranges of from 50 kΩ to 1.5 MΩ and a power consumption on ampere range of from 0.1 VA to 2 VA. Size is 5-7/8 × 9 × 14-3/8 in. and weight is 35.3 lb.

CIRCLE NO. 360

Interface links CAMAC and GPIB

Kinetic Systems Corp., 11 Maryknoll Dr., Lockport, IL 60441. (815) 838-0005. $850; stock-6 wks.

Model 3388 GPIB Interface is a double-width module that provides the interface between a CAMAC system (IEEE Standard 583) and the General Purpose Interface Bus (also called "GPIB" or "ASCII Bus"), IEEE Standard 488. This module allows digital multimeters, counters, printers, calculators, display terminals or other devices that meet the GPIB standard to be connected to a CAMAC system. With Model 3388, up to 14 other GPIB-interfaced instruments can be connected via the standard GPIB cables.

CIRCLE NO. 361

Tough meter demands no hazard pay

Ballantine Laboratories Inc., P.O. Box 97, Boonton, NJ 07005. (201) 335-0900. $995; 30 days.

Model 9601A claims to be the first ac rms responding voltmeter and amplifier designed to conform to OSHA and UL safety requirements. The instrument operates on its own rechargeable batteries or the ac power line. The solid-state, ruggedized, explosion-proof, general-purpose instrument provides operator safety and instrument protection in making voltage measurements to 500 V in high-hazard applications. The instrument has internal electronic protection against overload and recovers within seconds after removal of an overload.

CIRCLE NO. 362

Tiny toggle switches sealed against water

Alco Electronics Products Inc., 1551 Osgood St., North Andover, MA 01845. (617) 685-4371. $1.45:TTE-13D-3T, SPDT (100 up).

Single and double-pole 3-A toggle switches of the TTE Series incorporate a new method of providing a watertight seal in the bushing and are supplied with an O-ring for sealing to the panel. Designed to be operable under 2 in. of water, the toggles are well suited for outdoor miniaturized equipment and wherever panels are subject to splashes or brief engulfment. Groups of TTE switches can be spaced on ⅜-in. centers.

CIRCLE NO. 363

Indicator lights dimmed mechanically

Dialight, 203 Harrison Pl., Brooklyn, NY 11237. (212) 497-7600. $2.57 to $2.91 (1000 up); stock.

Operator-actuated mechanical dimming to suit ambient illumination conditions is an available feature of subminiature indicator lights. Rotating a knurled portion of the lens cap operates the dimming feature, which can be either a mechanical shutter or a Polaroid filter. The shutter varies the size of an opening in the lens cap. It is available in two styles: one ranges from full opening with full intensity to complete closure; the other closes from full open to only a small opening so that indicators having a safety or other alarm function can't be completely blacked out. The optional Polaroid dimmer involves some loss of lamp intensity, even at its maximum setting, but maintains a fully illuminated lens diameter throughout its intensity range. All use T-1-3/4 lamps and offer a choice of unfrosted or back-frosted convex lenses with a variety of color options.

CIRCLE NO. 364

Voltage-divider network stable to 0.01%/6 mo

Caddock Electronics Inc., 3127 Chicago Ave., Riverside, CA 92705. (714) 683-5361. $4.50 (2500 up); stock to 2 wks.

Edge-mounted precision decade voltage drivers, type 1776, come in customer-selected resistor values in the range from 10 kΩ to 10 MΩ. Ratio stability of 0.01% per six months and ratio temperature coefficients as low as 5 ppm/°C over the temperature range from 0 to 70 C are provided. The decade voltage dividers are fully encapsulated under a solid ceramic cover. Terminals are arranged on multiples of standard 0.1-in. spacing for single-in-line connectors and sockets.

CIRCLE NO. 365

COMPONENTS

Pull solenoids available in two versions

Regdon Corp., 3713 Grand Blvd., Brookfield, IL 60513. (312) 485-5152. $1.25 (1000 up); stock to 2 wks.

Miniature pull-type solenoids are available both in box-frame and tubular versions. The Mini Twins incorporate an efficient magnetic structure for maximum efficiency in a small size. Both units are made with glass-filled nylon bobbins and other class A insulation materials. The tubular version, part number R6X6, has a diameter of 0.375 in. and a length of 0.8 in. The box-frame style, part number 3U3, is 0.36 W × 0.43 H × 0.825 L in. Both models are available with 6, 12 and 24-V-dc coils in both continuous and intermittent-duty versions.

CIRCLE NO. 366

Variable chip inductors side or top tuned

Vanguard Electronics Co., Inc., 930 W. Hyde Park, Inglewood, CA 90302. (213) 678-7161. About $2 (1000 up); 4 to 6 wks.

Variable chip inductors in side-tuned and top-tuned configurations are available in values from 0.018 through 150 μh. They are completely transfer molded with all-welded internal construction built to meet MIL-C-15305, Grade 1, Class B, and MIL-I-83446. Operating temperature range is −55 to 125 C.

CIRCLE NO. 367

Visible LEDs deliver high-intensity light

Texas Instruments, P.O. Box 5012, MS-308, Dallas, TX 75222. (214) 238-3940. $0.46: T-1, $0.49: T-1-3/4 (1000 up).

A series of high-intensity, gallium-phosphide visible light-emitting diodes (VLEDs) is available in red, amber or green. The small T-1-diameter VLEDs are designated TIL212 (amber), TIL216 (red) and TIL232 (green). The larger T-1-3/4-diameter devices are designated TIL224 (amber), TIL228 (red) and TIL234 (green). The VLEDs in molded epoxy packages are direct replacements for many other types currently being used. They feature brightness outputs of up to 25 mcd at 50 mA, low-power consumption and long life.

CIRCLE NO. 368

Thick-film resistors in low-profile SIP

Stackpole Components, P.O. Box 14466, Raleigh, NC 27610. (919) 828-6201. Average under $0.15; (low qty); 4 to 6 wks.

A line of thick-film resistor networks, the Mini-SIP, has only a 0.175-in. height above its standoff; in standard SIPs the height is 0.35 in. The ⅛-W units are offered with four, six, eight, 10 or 12 pins, and in 64 standard resistance values ranging from 33 Ω to 10 MΩ. Stackpole's omega-shaped resistance path, called the Top Hat design, is laser-trimmed to provide long paths on the same amount of real estate as the usual L-cut configurations. Also, hot spots, current crowding and high capacitance common with conventional designs are eliminated. Ratings of 200 W/in.^{2} are very realistic. With packing densities to 100 resistors per square inch on a PC board, Mini-SIPs are applicable to all logic, memory and linear ICs. Standard resistance tolerance is ±2%.

CIRCLE NO. 369

Thumbwheel switch mounts without tools

EECO, 1441 E. Chestnut Ave., Santa Ana, CA 92701. (714) 835-6000. $2 (1000 up); 6 wks.

The 1800 Series thumbwheel switch features a front-mount snap-in design eliminating the need for tools, panel-mount holes, screws, nuts or washers. The manufacturer states that the slim 0.315-in. switch module solves panel density problems by being able to mount more switches in a smaller space. Contacts are gold in a self-extinguishing nylon housing with a glass-epoxy circuit board. A wide variety of 10-position, BCD and decimal codes are available.

CIRCLE NO. 370

Solid-state relay provides time delay

Guardian Electric Manufacturing Co. of California, 4030 W. Spencer St., Torrance, CA 90503. (213) 542-8651.

A series of 7 and 10-A solid-state relays, called the SSRT, for time-delayed control of large loads is available in three time ranges, 0.1 through 50 s. The SSRT combines a time-delayed dc input stage optically coupled into a line-synchronized triac output. This feature minimizes RFI/EMI, while reducing inrush current by 60% to protect other circuit components. Ac reactive loads are switched regardless of power factor, and arcing caused by inductors is eliminated because of zero-current turnoff by the triac. The relays are housed in a nylon cover with an isolated-metal base for easy mounting and efficient heat sinking.

CIRCLE NO. 371

PWM dc/dc's outperform two-stage inverters

Bikor Corp., 1228 253 St., Harbor City, CA 90710. R. Pizer (213) 325-2820. $340 (1-25 qty); stock to 4 wks.

Pulse-width modulated (PWM) power inverters of the DOS series provide higher efficiency, lower cost and smaller size than the company's DDR single-output high-power dc/dc converters. The new units switch power in one stage as opposed to the separate power-inverter and switching-regulator stages of the previous design. Standard units deliver outputs from 5 V at 25 A to 28 V at 5 A from a choice of 12, 28, 48 or 115-V inputs. Regulation is 0.2% for line and load, while efficiency varies from 70 to 87% depending on input and output voltages. The 4-lb units measure 4 × 4.63 × 15 in. Special models are available with up to 800-W outputs.

CIRCLE NO. 372

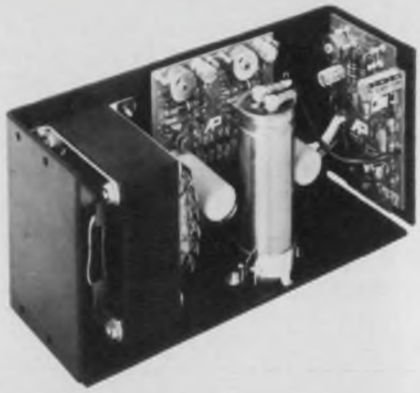
5-kVA inverter offers high efficiency

Nova Electric, 263 Hillside Ave., Nutley, NJ 07110. K. Niovitch (201) 661-3434. $2995; stock to 30 days.

First model in the Taurus series of dc-to-ac power converters is a 90%-efficient 5-kVA sine-wave inverter. Similar inverters available from other manufacturers are in the 82 to 85% efficiency range. The unit converts 48 to 54 or 105 to 150 V dc to 117 or 220 V ac at 50, 60 or 400 Hz. The device boasts voltage regulation of ±1% from no-load to full-load and frequency regulation of ±0.15% with 0.005% available as an option. Additional features include distortion of less than 5% and power-factor range of ±0.5 lead or lag. The converter is rated for continuous operation at full load. The unit also features the following protection as standard: short-circuit protection, automatic current limiting, reverse-input-polarity protection, thermal protection, undervoltage and overvoltage protection. Another standard feature is frequency-and-phase synchronization.

CIRCLE NO. 373

Open triple-outputers power micros, etc.



Adtech Power, 1621 S. Sinclair St., Anaheim, CA 92806. K. Nelson (714) 634-9211. From $75.90 (100 qty); stock.

Four models, TAPS 1, 2, 3 and 4, provide triple dc outputs for μCs, mixed-logic and other uses. You get a single 5-V output at 4 to 12 A and ±12 to ±15-V outputs at 0.5 to 3 A. Dual outputs can be ±9 to ±12 V as an option. The units feature regulation of ±0.1% for line and load with 115/230-V ±10%, 47-to-63-Hz input power; ripple of 5-mV pk-pk max; and stability of ±0.2%. These open framers deliver full power from −20 to +50 C and operate derated up to +65 C.

CIRCLE NO. 374

Switchers conform to a total-error band

Pioneer Magnetics, 1745 Berkeley St., Santa Monica, CA 90404. A. Hagiwara (213) 829-6751. From $695; 45-90 days.

Outputs of the PM 2675, 6 and 7 series of multiple-output switchers remain in a ±2% total-error band for all effects of line changes, static-and-dynamic-load changes, ripple, noise, temperature and drift. Primary output of these supplies is 250, 500 and 600 W, respectively. Each unit provides three additional outputs: two channels of 150-W or 10-A capacity and a fourth output of 75 W or 5 A. All outputs have a range of 2 to 48 V. Normally operating from either 115 or 208/220-V inputs, the supplies continue to operate for several minutes with 60% of nominal input. When the input voltage fails entirely, the outputs hold up for 30 ms. These switchers operate at full rating from 0 to 50 C and derated to 80% at 70 C. They measure 5 × 8 × 11 in.

CIRCLE NO. 375

Plug-in unit cleans your power line

Dyma Engineering, 213 Pueblo Del Sur, P.O. Box 1697, Taos, NM 87571. (505) 758-2686. $14.95; stock.

Near-capacity loading of power systems is causing increases of potentially destructive line-voltage surges and spikes. To protect your sensitive equipment from line transients, plug Dyma's ac line surge protector into a 20-A, 117-V, two-or-three-pin outlet. Then plug in your equipment. The unit, which fits into the palm of the hand, contains a suppressor coupled to a ferrite filter.

CIRCLE NO. 376

Open modules pack big wattage in small case

Abbott Transistor Laboratories, 5200 W. Jefferson Blvd., Los Angeles, CA 90016. A. Hilbert (213) 936-8185. $61 (1-24 qty); stock.

Type-NL dc power supplies provide single outputs of 5, 12, 15, 24 and 28 V at up to 84 W in C-size cases. Standard ac input is either 115 or 220 V, 47 to 440 Hz. Dual primaries are also available. All units feature tight regulation, low ripple and full-load operation up to 50-C ambient with derating to 40% at 71 C. Overvoltage protection is standard on 5-V outputs and optional on the higher voltages. Three-surface mountable cases are 7 × 4.875 × 2.75 in. The line also includes single, dual and triple-output models with power ratings from 15 to 170 W.

CIRCLE NO. 377

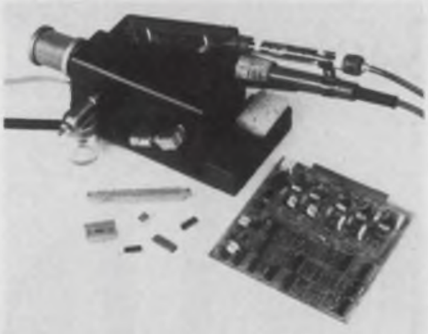
Converter powers μP plus four memory chips

Datel Systems, 1200 Turnpike St., Canton, MA 02021. E. Zuch (617) 828-8000. $89 (1-9 qty); 4 wks.

You get all the necessary outputs to power an 8080 μP plus four 2107A RAMs or four 1702A ROMs from the Model 1200, a dc/dc converter. Mounted locally on a circuit board, the module transforms 5-V-dc power into isolated triple-output voltages of +12, —5 and —9 V dc. The unit features line-and-load regulation of 0.05%, a max. rms output-ripple of 1 mV and max. recovery time of 50 μs.

CIRCLE NO. 378

Solder-gobbling module fits atop workbench



Air-Vac Engineering Co., 100 Gulf St., Milford, CT 06460. (203) 874-2541. $134.

The Model SSVM-147 vacuum desoldering module is a bench-top unit that occupies only 5 × 8 in. The self-contained holder accommodates any of Air Vac's Solder Gobblers. An air-operated vacuum pump provides 28-in.-Hg vacuum for clog-free desoldering. The lightweight (4 lb) module is available with either electrical or mechanical controls, and can be set up in 10 seconds.

CIRCLE NO. 379

μP-controlled system positions tools

Cambridge Thermionic Co., 445 Concord Ave., Cambridge, MA 02138. W. G. Nowlin (617) 491-5400.

By simply mounting the special tooling required for your application, you can convert the new Model GP-1 X-Y Positioning System to a complete numerically controlled machine that will handle such work as drilling, assembly, light machining as well as test and inspection. The unit permits either tape control or full manual operation. Block and pattern repeats, automatic step, tool override and manual jog modes are possible. The microcomputer also provides LED numeral displays showing relative X and Y positions. The X-Y table with a full 18 × 12-in. travel moves on linear ball bushings. The complete unit is mounted on a unitized and welded steel frame designed to achieve the highest rigidity to weight ratio possible.

CIRCLE NO. 380

All-plastic connector is a snap to install

AMP, Harrisburg, PA 17105. Jim Pletcher (717) 564-0100. Stock.

The "audio" connector consists of a one-piece, all-plastic receptacle housing, which can be panel-mounted without screws or other mounting hardware, and an all-plastic two-piece plug housing. To further reduce assembly time, the insulation-piercing crimp/snap-in contacts can be machine-applied without stripping the wire. The tin-plated, brass contacts can be used with wire having insulation diameters up to 0.055 in. A four-contact size is now available, with 2, 3, 5, 6, and right-angle versions to follow shortly.

CIRCLE NO. 381

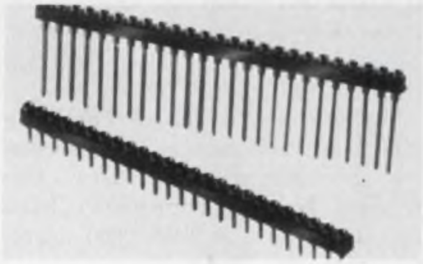
Instrument feet double as cord holder

Buckeye Stamping Co., 55 Marion Rd., Columbus, OH 43207. James Willcox (614) 445-8433.

The Cord-Wrap is designed for handy storage of power cords. It consists of a pair (or two) of 1-in.-high black-plastic pieces mounted on the back panel of an instrument, or on the bottom as feet for portable instrumentation. The power cord is wound around several of the plastic shapes and the two or three-prong plug can be "plugged" into one of them. A sample pair is available from any area Buckeye representative.

CIRCLE NO. 382

Pin-line sockets save space and money



Aries Electronics, Inc., P.O. Box 231, Frenchtown, NJ 08825. (201) 996-4096. 12¢ to $1.92; stock.

Collet-type pin strips are available in lengths from one pin to twenty-five pins, with either wire-wrapping or solder tails. The sockets can be used for low-cost, compact modular applications, and fit end-to-end or side-by-side on 0.1-in. centers.

CIRCLE NO. 383

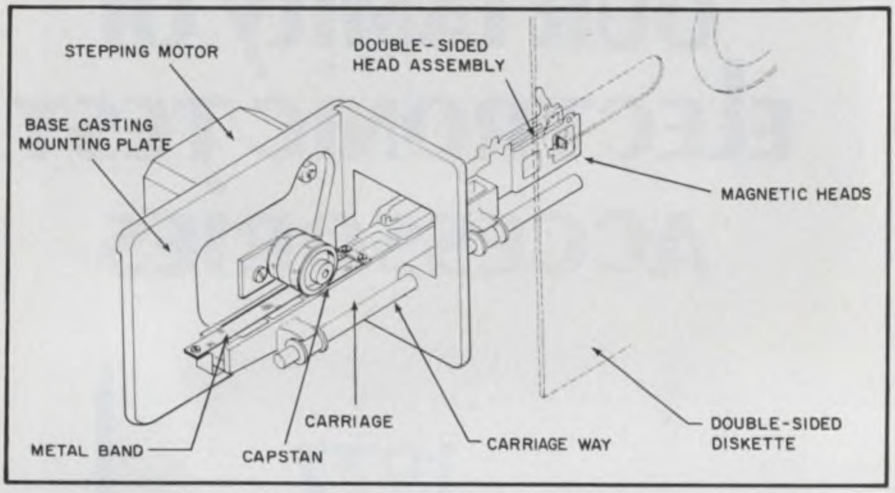
Machinable magnet is stronger than Alnico

Matsushita Electric Industrial Co., Ltd., Kadoma, Osaka 571, Japan. (06) 908-1121. See text.

Made from manganese, aluminum and carbon, a new anisatropic magnet material has been developed that combines the best of three worlds. The maximum energy product of the new magnets is 5 to 7 MGOe, exceeding that of many Alnicos; the coercivity of over 2000 Oe betters that of barium ferrites; the mechanical characteristics are superior to those of Alnicos and ferrites, permitting machining and drilling. Because only inexpensive materials are used for the new magnets, the manufacturer expects them to be competitively priced. Samples will be available in June, 1977.

CIRCLE NO. 384

Two-headed floppy accesses twice the data in half the time



Shugart Associates, 415 Oakmead Parkway, Sunnyvale, CA 94086. George Sollman (408) 733-0100. See text.

A double-sided floppy-disc drive, the SA850, records and reads data on both sides of an 8-in. Mylar diskette. Two read heads come into contact simultaneously with the diskette. Thus the drive provides twice as much on-line data storage as the single-sided Shugart SA800 drive.

Maximum access time of the SA850's 25-track movement is only 91 ms, down from 208 ms required by the SA800. Though IBM introduced two-sided floppies in mid-1976, Shugart is the first to make the technique available for OEMs. With double-density M^2FM recording, the diskette holds 1600 kbytes unformatted, or 1200 kbytes formatted. The SA850 drive also permits single-density recording (600 or 800 kbytes).

The drastic improvement in access time (which includes settling time, but not rotational latency) comes from a new head actuator with 3-ms track-to-track time, and 15-ms settling time. The actuator replaces the lead-screw/stepping-motor method of the SA800 drive with the system shown in the illustration. The head carriage is moved by a metal band driven by a stepping motor. Whereas the lead-screw/stepping-motor method has a track-to-track time of 8 ms, the new system's track-to-track time is 3 ms.

However, single-track seek time, (the sum of track-to-track and settling time) is the same as the SA800's, 18 ms, because the lead-screw actuator has a shorter settling time. Also unchanged is the head-loading time (the time to move the heads into disc contact), 35 ms, which is usually absorbed by the average seek time of 91 ms.

The use of a second head does away with the felt head-load pad that is common to single-sided drives, and must be replaced periodically. And since the SA850's head assembly uses only eight grams of head-load force, compared with 15 grams for the SA800's design, the life of each floppy should be extended from the SA800's 3.5-million loaded passes to at least 5-million passes.

The double-sided unit has many other characteristics of the SA800 and other standard floppy drives. Like the SA800, the SA850 has a data-transfer rate of 250 kbits/s, a packing density of 3400/6800 bpi, and 77 tracks per side, which are packed at 48 tracks/in.

Using a dual-index sensor to differentiate between single and two-sided floppies, the SA850 can also read and record single-sided media. It is also plug-compatible with the SA800 and can use the same media as IBM's 3740 and S/32 single-sided floppy drives, and the IBM 4964 and 3600-series two-sided drives. However, the IBM format specifies 128-byte sections, limits capacity to 250 kbytes per side, and uses only single density.

Although the SA850 has the same dimensions as the SA800 (4.62 × 8.55 × 14.25 in.), it uses 20% less power. The electronics includes read/write amplifiers and all circuits for control, write-protect, data/clock separation, and programmable diskette-door lock. Aside from its double-head capability, the SA850 is mechanically and electrically interchangeable with the SA800. At a base price of $750, the single-unit price of the SA850 is about 25% higher than the SA800. Delivery takes eight weeks.

CIRCLE NO. 310

Bright terminal takes a load off your CPU

Texas Instruments, P.O. Box 1444, Houston, TX 77001. Dan Fullerton (713) 494-5115. $6400 (1); see text.

The Series 700, Model 770 is an intelligent terminal for data processing and data communications. Distributed processing is its natural habitat. Based on TI's TMS 9900 microprocessor, the Model 770 can reduce mainframe computing and communications costs by placing data checking, validating and preprocessing at the local site. The compact desktop unit includes ROM and RAM memory, dual minicartridge magnetic tape drives, a 1920-character video display and a full ASCII keyboard with separate numeric, cursor control and programmable-function key clusters.

CIRCLE NO. 385

Low-cost unit boosts data rate

Western Telematic, 3001 Red Hill Ave., Costa Mesa, CA 92626. Steven Tatum (714) 979-0363. $399; 4-8 wks.

The Model 1200 data rate converter accepts up to 256 char/s from one I/O device at its operating rate, and passes the string on to another device with a different speed. The unit thus permits you to interact from a slow (10 or 30 char/s) terminal with the host computer over a fast (1200 baud) full-duplex modem. When the program is ready to run, you simply press a switch, bypassing the converter, and you can transfer the bulk data from on-site storage (disc, tape) to the computer, or vice versa, at the higher rate.

CIRCLE NO. 386

Equip your system with tomorrow's input device

Interface Mechanisms, 5503 232nd St. SW., Mountlake Terrace, WA 98043. (206) 774-3511. $875; 4-8 wks.

If you equip your system with a scanner, it can read "print" directly and cheaply in the form of bar codes. The μP-based light pen Model 9210 reads several codes: 39, 2 out of 5, and UPC. Message length is 32 characters (standard) or 64 (optional). The Model 9210 can operate in parallel with any on-line RS 232C-equipped terminal. Scanning speed ranges from 3 to 5 in/s.

CIRCLE NO. 387

Floppy-disc drive has 6 built-in options

CalComp, 2411 W. La Palma Ave., Anaheim, CA 92801. Russ Paquette (714) 821-2544. $625; 8 wks.

A multifunctional floppy-disc drive with a built-in six-position switch enables the user to switch-select any of six built-in operational modes. These include hard or soft sectoring, gating of "write protect" or "ready" with select, stepper motor power control, and separation of data and clock. The Model 142M performs as a single-density (243 kbytes) or double-density drive (650 kbytes)—without requiring additional control logic, and at the price of a single-density unit. The Model 142M is plug-compatible with CalComp's two other floppy disc products, the Models 140 and 142.

CIRCLE NO. 388

Inexpensive cover protects your discs

Innovative Computer Products, 18360 Oxnard St., Tarzana, CA 91356. (213) 996-4911. $5 to $7.50.

The PC-15 Protector is a heavy-duty Lexan bottom-cover that protects the vulnerable exposed underplate of 2315-type disc cartridges. Unlike the 5440-type top-loading cartridge, the 2315s are delivered without a built-in bottom cover. The Model PC15 gives support to the armature plate and cone assembly, minimizes the build-up of contaminants, and allows positive stacking during storage. The company also markets a testing device for discs.

CIRCLE NO. 389

Converted IBM Selectric is heavy-duty terminal

CPT Corp., 1001 S. 2nd St., Hopkins, MN 55343. (612) 935-0381. $1700 (25-50); stock-4 wks.

What looks like an IBM Selectric and types like an IBM Selectric, but isn't? The Rotary II I/O typewriter has an IBM 735 chassis, but many of the innards have been replaced to produce a heavy-duty I/O terminal with a speed of 15 characters/s. The electronic keyboard features four extra keys for special functions or control signals. The interface is available with ASCII characters and RS-232C emulation, including a range of options.

CIRCLE NO. 390

Line printers mated with DEC, DG minis

Rianda Electronics, 2535 Via Palma, Anaheim, CA 92801. Les Alberts (714) 995-6552. $1000 (1); 4 wks.

Line printer controllers compatible with PDP-11 and Nova computers are available for Data Products, Centronics, Printronix, Tally or equivalent printers. The package consists of one PC board that installs in the computer chassis, a 15-ft cable to the printer, a diagnostic routine (paper tape) and an instruction manual. Inquire for OEM and quantity discounts.

CIRCLE NO. 391

This μC's configuration is mostly up to you

Communication Network Systems, Box 1087, Minnetonka, MN 55343. (612) 933-3420. See text.

A microcomputer consisting of a 63-key keyboard, dual cassette interface, video display of 16 lines by 32 characters from a 128-character set, 4-k bytes of RAM, and 4-k bytes of ROM is priced under $1000 in small quantities. Assembler, Basic interpreter and scientific calculator mode comprise the software. Other configurations are available: Call CNS for a worksheet to identify your needs.

CIRCLE NO. 392

Impact printer offers versatility, low price

Syntest, 169 Millham St., Marlboro, MA 01752. Curtis Hoffman (617) 481-7827. $310 (100); stock - 8 wks.

If a 40-column matrix printer satisfies your requirements, the Model SP300 offers much for little. You get the following: a 64-character ASCII subset, with both parallel and series inputs; RS232-C or current loop option; selectable internal/external bit rate clock; print speed of 50 char/s; front and top paper exit, and more. The price includes power supply and all electronics, as well as the compact printer mechanism (9 × 6 × 10 in.).

CIRCLE NO. 393

Mini disc controller is second-source

Xcomp, 7571 Convoy Ct., San Diego, CA 92111. J. Costello (714) 560-4415. From $2800; 2-4 wks.

The Model-DC10 disc controller is both hardware and software-compatible with Interdata minicomputer systems, and can be used to replace the M46-444. The controller is installed in one standard I/O slot and operates up to four 2400 rev/min disc drives with 2200 bits/in.

CIRCLE NO. 394

Application notes

Capacitance measurements

The problems, precautions, and the principle of three-terminal capacitance measurements are contained in a 21-page applications note. Boonton Electronics, Parsippany, NJ

CIRCLE NO. 395

Computer plotting

Seven case histories documenting computerized mapping applications are presented in a six-page note. Versatec, Santa Clara, CA

CIRCLE NO. 396

SCR turn-on techniques

An application note provides a thorough explanation of SCR gate terminology, trade-offs and characteristics. Westinghouse Electric, Youngwood, PA

CIRCLE NO. 397

Laser rangefinder systems

"Laser Rangefinders—Today's Military and Industrial Systems" summarizes the use of laser systems for precision measurement of distances in commercial and military applications. The theory of operation, system constraints and comparison of Nd:YAG to GaAs laser rangefinders are explained and illustrated with graphs and diagrams. International Laser Systems, Inc., Orlando, FL

CIRCLE NO. 398

Solid-state relays

The theory, performance capabilities and applications for various classes of hybrid and all-solid-state relays are provided in a 48-page handbook. The handbook includes 28 pages of comprehensive reference material, illustrated with typical applications circuits, comparative performance graphs, and parameter diagrams, as well as a comprehensive glossary of special terms. Gordos/Grigsby-Barton Inc., Rogers, AR

CIRCLE NO. 399

Vendors report

Annual and interim reports can provide much more than financial position information. They often include the first public disclosure of new products, new techniques and new directions of our vendors and customers. Further, they often contain superb analyses of segments of industry that a company serves.

Selected companies with recent reports are listed here with their main electronic products or services. For a copy, circle the indicated number.

LRC. Matrix-related printers and printer-related subsystems.

CIRCLE NO. 427

Information International. Image analysis, text processing and information recycling.

CIRCLE NO. 428

The Plessey Co. Consumer electronics; components; microsystems; radar, avionics and communications; and telecommunications.

CIRCLE NO. 429

Lloyd's Electronics. Consumer electronics.

CIRCLE NO. 430

Ampex. Audio/video products; magnetic tape; data and memory products.

CIRCLE NO. 431

Varian. Electronic devices; instruments; information systems; industrial equipment and medical electronics.

CIRCLE NO. 432

On-Line Systems. On-line computers and software.

CIRCLE NO. 433

Coherent Radiation. Lasers; laser systems; optics; optical systems, and related accessories and components.

CIRCLE NO. 434

Hydrometals. Consumer electronics and hand tools.

CIRCLE NO. 435

New literature

Components

A booklet outlines the company's frequency-sensitive components and other sophisticated electronic devices. Motorola Component Products, Schaumburg, IL

CIRCLE NO. 409

Indicator lights

Off-the-shelf pilot and indicator lights and accessories are described in a 12-page catalog. Industrial Devices, Edgewater, NJ

CIRCLE NO. 410

Keyboard pads

Two bulletins describe the company's keyboard code outputs and legend capabilities. Grayhill, La Grange, IL

CIRCLE NO. 411

5-1/2-digit multimeter

Detailed information on the Model 5100 5-1/2-digit multimeter's capabilities and functions are contained in a brochure. Dana Laboratories, Irvine, CA

CIRCLE NO. 412

Circuit breakers

Photographs, dimensional drawings, delay curves, charts, specifications, and typical applications of magnetic circuit breakers are contained in a 12-page bulletin. Airpax Electronics, Cambridge, MD

CIRCLE NO. 413

Instruments

A condensed catalog is prefaced by a selection chart, summarizing the instruments offered by listing their various ranges—resistance, capacitance, and inductance—together with their test frequencies and basic accuracies. Electro Scientific Industries, Portland, OR

CIRCLE NO. 414

Coil winding equipment

A complete compilation of coil winding equipment is featured in a 52-page catalog. Geo. Stevens Mfg., Chicago, IL

CIRCLE NO. 415

CRT display station

The HP 2654A CRT display station and its many features are detailed in an 84-page user's manual. The manual is illustrated with photos, diagrams, tables and sample displays. Hewlett-Packard, Palo Alto, CA

CIRCLE NO. 416

CMOS ICs

A 24-page product guide describes RCA's B series of CMOS high-voltage ICs. RCA Solid-State Div., Somerville, NJ

CIRCLE NO. 417

Motors, gearmotors

A 32-page catalog groups more than 425 motors and gearmotors by frame size (output capabilities), and then within each group—according to electrical type. Bodine Electric, Chicago, IL

CIRCLE NO. 418

All-metal packages

A 125-page catalog contains photographs, engineering drawings, and specifications for the company's flatpacks, plug-ins, dual in-lines, automatic insertion dips, standard headers, and microwave modules. Isotronics, New Bedford, MA

CIRCLE NO. 419

Specialty materials

"Advanced Materials for Electronics," a 126-page catalog, features specialty materials for the electronics industry. Transene Co., Rowley, MA

CIRCLE NO. 420

Data-conversion products

Data-conversion products are highlighted in a 20-page short-form catalog. Micro Networks, Worcester, MA

CIRCLE NO. 421

Relays

Specifications, selection data, dimensional drawings and wiring diagrams on the company's relays are included in a 56-page catalog. Magnecraft Electric, Chicago, IL

CIRCLE NO. 422

MOS/LSI microcircuits

A 16-page catalog describes MOS/LSI circuits and includes a cross-reference of available second sources. SMC Microsystems, Hauppauge, NY

CIRCLE NO. 423

OEM hardware, software

A 16-page brochure with four processor product bulletins describes products for OEMs. Interdata, Oceanport, NJ

CIRCLE NO. 424

Tracking pedestals

Applications and specifications for tracking pedestals and servo-control products are described in a 44-page brochure. A glossary of tracking-system definitions, formulas and wind-loading charts for various sizes of antennas are also included. Scientific-Atlanta, Atlanta, GA

CIRCLE NO. 425

Instrument rentals

A 52-page catalog contains full specifications, monthly rental rates and model numbers on more than 800 instruments. Continental Rentals, Bedford, MA

CIRCLE NO. 426

μP Bibliography

Looking for a reference of major articles about microprocessors? Search no more. Technical Index Services has just started a publication called "A Microprocessor Bibliography" that provides over 275 articles and paper references in its first issue. The bibliography costs $5 and can be ordered directly from Technical Index Services, Dept. ED, 2635 Merrywood Rd., Charlotte, NC 28210.

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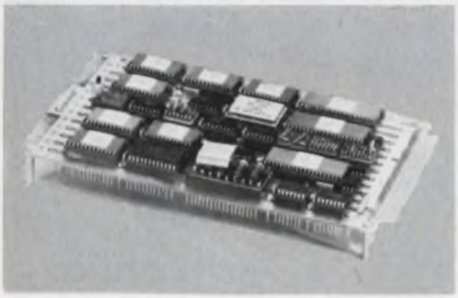
MAGNETIC PICKUPS **188**



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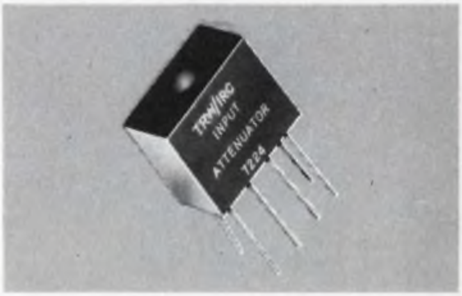

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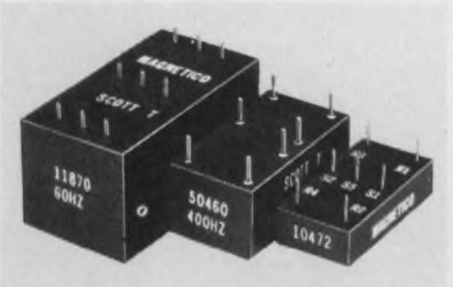

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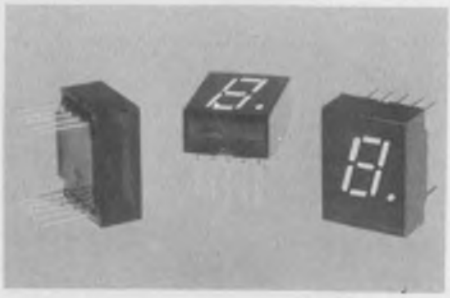

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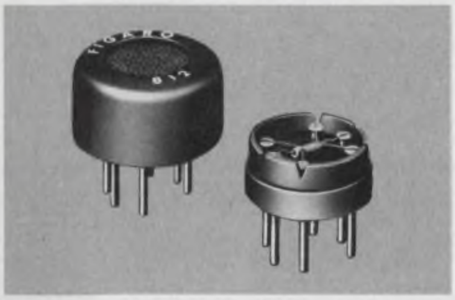

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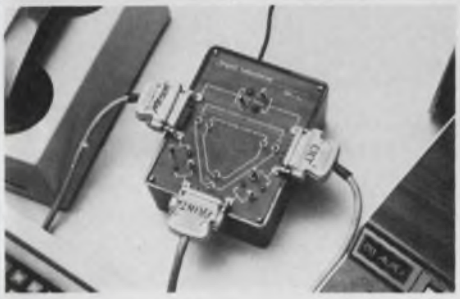

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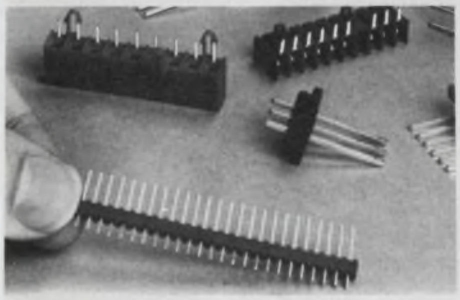

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Product index

Information Retrieval Service. New Products, Evaluation Samples (ES), Design Aids (DA), Application Notes (AN), and New Literature (NL) in this issue are listed here with page and Reader Service numbers. Reader requests will be promptly processed by computer and mailed to the manufacturer within three days.

new literature

application notes

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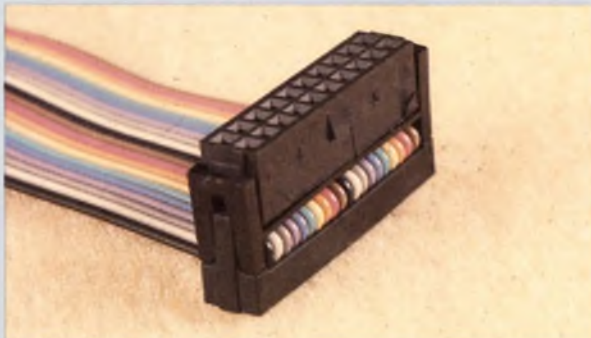

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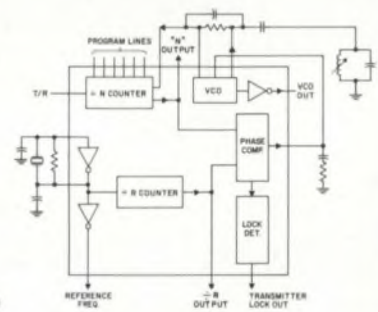
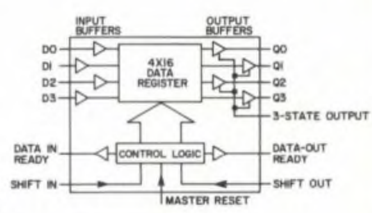
Here are three new COS/MOS ideas, good buddy.

A new 40-channel CB synthesizer and two other circuits prove: RCA COS/MOS has really got the hammer down on the rip strip of hot new applications. In these circuits and more to come, you have improved speeds and density to work with. Plus the other COS/MOS advantages. All adding up to better performance and significant cost and space savings.



1.



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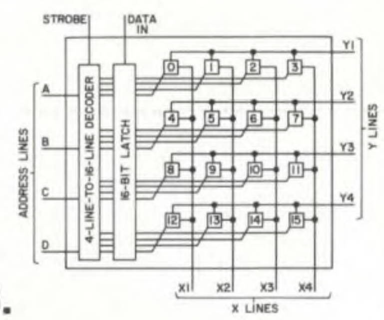

3.

1 40-Channel CB: cut costs of ownership.

Our new synthesizer IC combines receiving and transmitting oscillator functions on a single chip. Result: lower CB manufacturing cost—and more. The low power requirements and environmental ruggedness of COS/MOS help reduce power-supply and operating costs, and make it a natural for use in vehicles. Operating between 15-20 MHz with no pre-scaler, TA10336 has a transmit-receive shift, 6-bit channel code, and a 10.24 MHz reference.
Circle 241

2 FIFO Register: simplify microprocessor interfacing.

On a single chip you get 4 independent FIFO registers that can be used in parallel. CD40105B is 4 bits by 16 bits long, is expandable, and features independent asynchronous inputs/outputs (outputs are 3-state). It really shines in microprocessor applications requiring input/output peripheral buffering.
Circle 242

3 4 x 4 Crosspoint Switch: lower the cost per crosspoint.

The CD22100 is 16 switches on a single chip, replacing 16 relays (at about 1/3 the cost) or 3 standard ICs. This can mean major space savings in in-house telephone and data communications systems, for example. And of course fewer connections means higher reliability. Coming soon: a 4 x 4 x 2 crosspoint switch.
Circle 243

For more information on these COS/MOS integrated circuits, contact your local RCA Solid State distributor.

Or write: RCA Solid State. Box 3200, Somerville, NJ 08876; Sunbury-on-Thames, Middlesex TW16 7HW, England; Ste.-Anne-de-Bellevue, Quebec, Canada; Fuji Bldg., Tokyo, Japan.

RCA COS/MOS experience is working for you.

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