VOL. 25 NO. 5

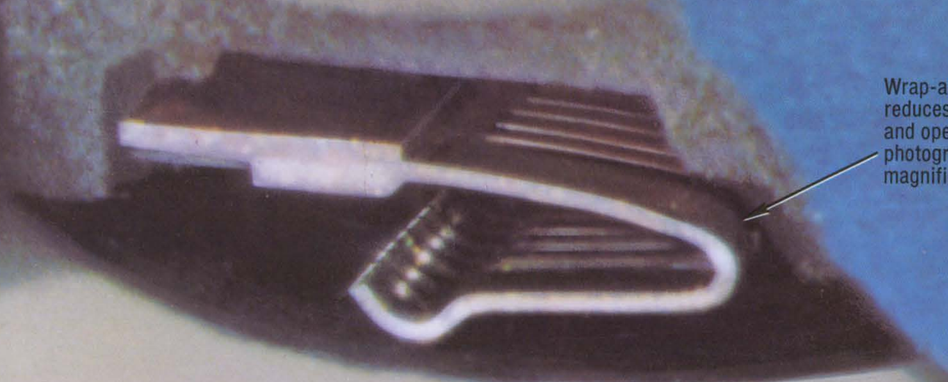
Electronic Design®

FOR ENGINEERS AND ENGINEERING MANAGERS

MARCH 1, 1977

Today's scientific calculators: They've got more functions and more of the hand-held ones are programmable. Some hand-helds even come with memories that retain data when they're turned off. Others include solar-array battery chargers and hard-copy printouts. Battery life is still a problem. For details, see p. 20.

Unique wrap-around wiper offers superior setting stability . . .



Wrap-around, multi-finger wiper reduces contact resistance variation and open circuit problems. Micro-photograph shows trimmer wiper magnified 28X.

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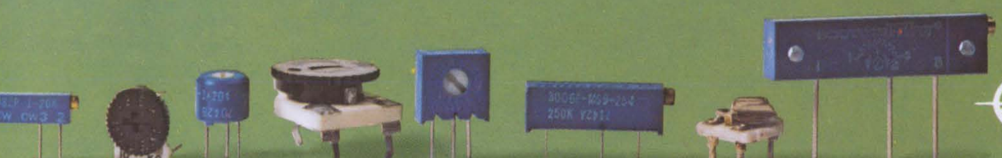

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CIRCLE NUMBER 262

Electronic Design®

VOL. 25 NO. 5

FOR ENGINEERS AND ENGINEERING MANAGERS

MARCH 1, 1977

NEWS

TECHNOLOGY

PRODUCTS

DEPARTMENTS

Cover: Photo by Keith Peterson, courtesy Hewlett-Packard, Corvallis, OR

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Editorial Offices
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Rochelle Park, NJ 07662
(201) 843-0550
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Cable: Haydenpubs Rochellepark

Editor-in-Chief George Rostky

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Peter N. Budzilovich, John Kessler
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Editorial Field Offices

East

Jim McDermott, Eastern Editor
P.O. Box 272
Easthampton, MA 01027
(413) 527-3632

West

Dick Hackmeister, Western Editor
8939 S. Sepulveda Blvd., Suite 510
Los Angeles, CA 90045
(213) 641-6544
TWX: 1-910-328-7240

Dave Barnes
844 Duncardine Way
Sunnyvale, CA 94087
(408) 736-6667

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Across the Desk

Sad circuit

Though my forte is analog, I have invented a new breakthrough in digital memory circuits. In fact, I have already made this invention available to a contralto friend, who used it the other night during her performance of Mahler's heart-rending "Kindertotenlieder."

The new circuit, based on an ultra-thin process (about 10^{-8} cm) is a Read-Only Memory for people who worry a lot. It's called Angst-ROM.

Bob Pease
National Semiconductor
Santa Clara, CA 95051

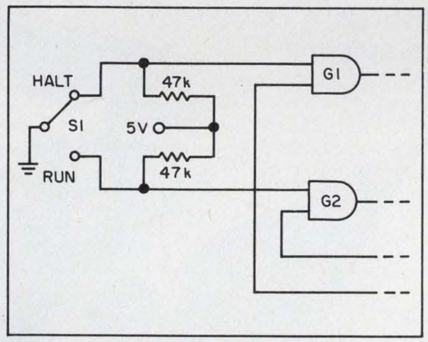
Error causes permanent pull-up

In "Control Logic for μPs Enables Single-Cycle-Operation" (ED No. 21, Oct. 11, 1976, p. 76), the circuit in Fig. 1 has a possible error, which I feel would cause the circuit not to operate as stated in the article.

It is stated: "A gated latch, consisting of gates G_1 through G_5, stops the processor by pulling RDY low at the proper time after switch S_1 has been moved from run to halt." If one studies the circuit hookup of S_1, as shown in this article, he will realize that there is a possible wiring error. Gates G_1 and G_2 are permanently pulled up to 5 V no matter what position S_1 is in. The logical input level at G_1 and G_2 could not be changed by the position of S_1.

Dominic Memoli
Design Engineer
Vocational Training Center
and Workshop
230 Hanse Ave.
Freeport, LI, NY 11520

Ed. Note: Sharp-eyed reader Dominic Memoli is correct. The S_1 switch should be connected as shown here. Both our art department and their checker have been given demerits and promise to sin no more.



Match the capability with the right circuit

An "Idea for Design" article by John Okolowicz, entitled "Delay Circuits Keep Headlights On when Needed; Turn Them Off if You Forget" (ED No. 18, Sept. 1, 1976, p. 114), states: "If the light switch is turned off first, no delay results." This is a desirable capability of such a circuit; but the circuits shown do not provide this capability.

A simple modification of Mr. Okolowicz's circuit (see Fig.) will permit all capabilities described in the original text to be provided.

Normally, a spare contact is not available on an automobile's igni-

(continued on page 14)

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, N.J. 07662. Try to keep letters under 200 words. Letters must be signed. Names will be withheld on request.

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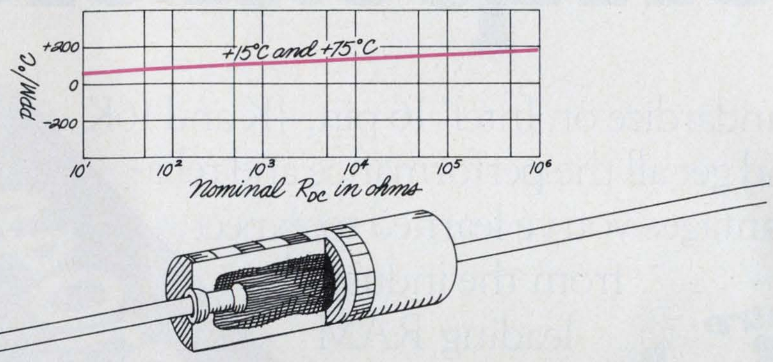

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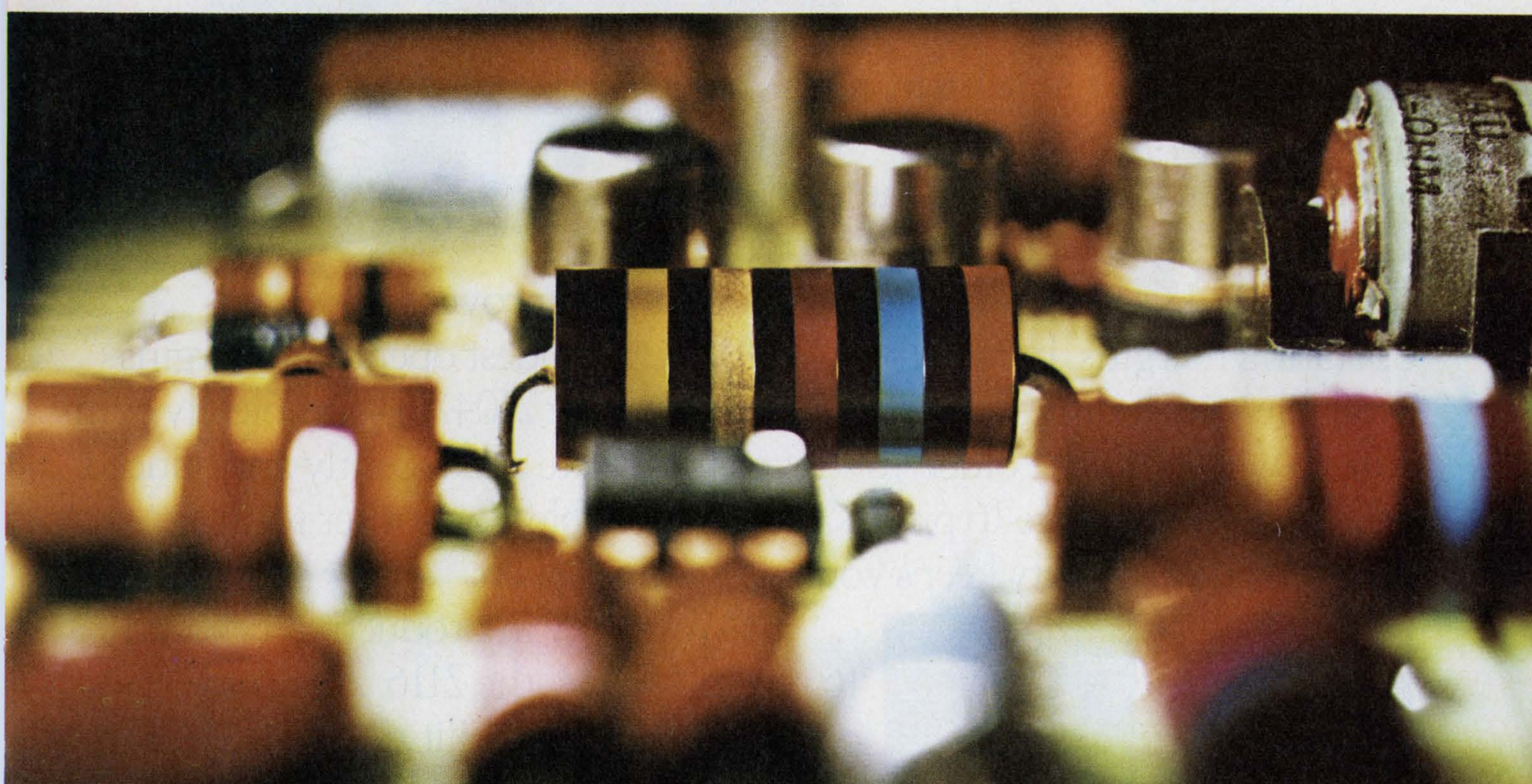

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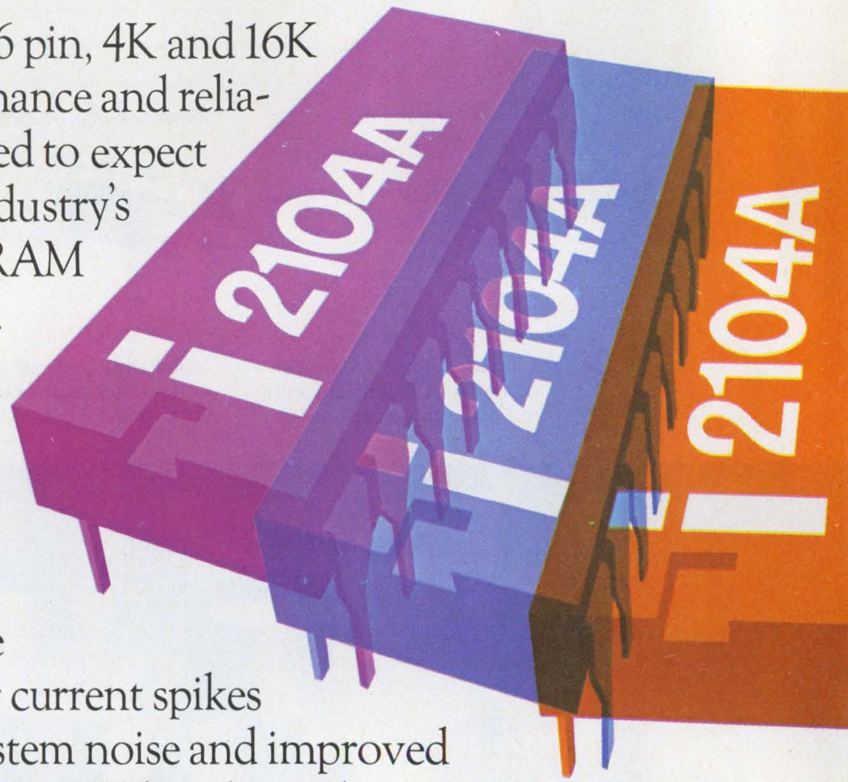
CIRCLE NUMBER 9

EC113

Intel delivers compatible 4K



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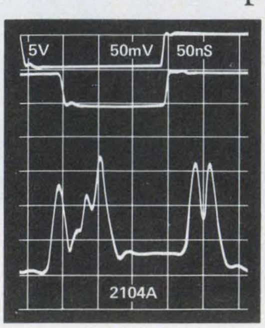

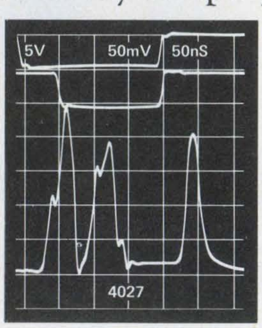

We're now in production on our 16 pin 16K RAM, the 2116. Again we've planned for compatibility. The 2116, 16K is completely interchangeable with our 4K 2104A. The 2116 provides four times the density per package at half the power per bit. Like the 2104A, it provides a ± 10% margin on power supplies. And because the 2116 includes an output latch identical to all 16 pin 4K RAMs,

the first and 16K RAMs.

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2104A-2	4K	200	320	32
2104A-3	4K	250	375	30
2104A-4	4K	300	425	30
2116-2	16K	200	350	69
2116-3	16K	250	375	68
2116-4	16K	300	425	65

For Data Sheets and our 16-page Application Note, use the reader service card or write Intel Corporation, 3065 Bowers Avenue, Santa Clara, California 95051.

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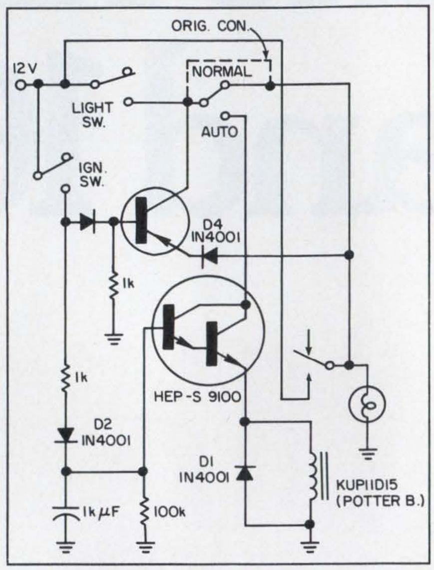
CIRCLE NUMBER 11

ACROSS THE DESK

(continued from page 7)



tion switch, so D_2 is added to the circuit to prevent discharge of C_1 through other accessory circuits. D_3 isolates Q_1 from the 1000-μF capacitor; D_4 in the Q_1 emitter circuit permits Q_1 to be turned off by the +12-V source with D_3 in the base circuit.

William R. Sloan
PE, Indiana

4935 Ivy Brook Dr.
Fort Wayne, IN 46815

Misplaced Caption Dept.

The damn circuit breaker always seems to go just when I get to an interesting part of a book.

Sorry. That's Georges de la Tour's "The Education of the Virgin," which hangs in the Frick Collection in New York City.

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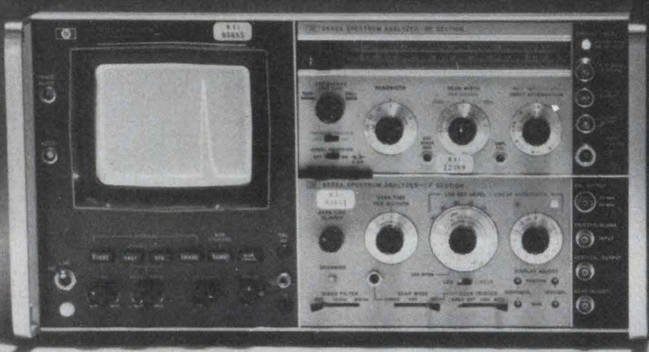

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CIRCLE NUMBER 14

MARCH 1, 1977

Digital wristwatch contains a scientific calculator

The first wristwatch to incorporate a scientific calculator minimizes current drain with CMOS and a liquid-crystal display. Competitive products from Pulsar, Unisonic and Uranus have LED displays and can perform only simple mathematical operations.

Announced by National Semiconductor's Consumer Product Division, Sunnyvale, CA, and the Windert Watch Co., Los Angeles, the watch features an eight-digit, fully scientific calculator that displays the six most significant digits without any buttons being pressed. The remaining two can be shown by pressing a button. In addition, the calculator has a memory in which eight digits can be stored.

Not only can the watch process natural and common logarithms and their antilogs as well, but it can also compute the angular and inverse functions of sine, cosine and tangent.

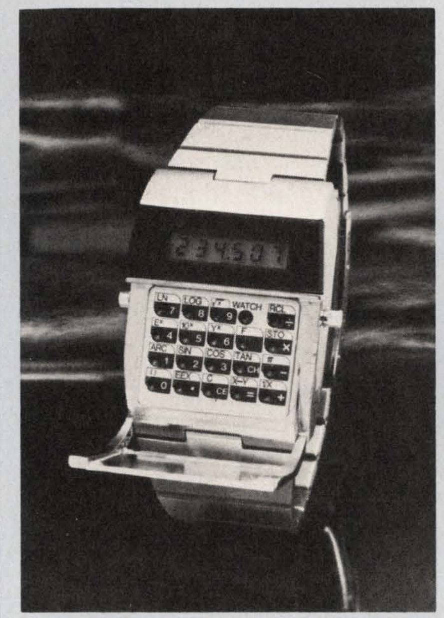
The calculator is preprogrammed to perform square-root reciprocal and π functions as well to change signs.

Although the wrist machine normally operates in the floating-point mode, any number from 10^{-99} to 10^{99} may be entered via a scientific-notation key. In this case the display presents a one, two or three-digit mantissa with two digits for the scientific notation.

The calculator keyboard is activated by a pointed object like a stylus or a ball-point pen.

Of the 20 keys on the keyboard, the calculator operations use 19. Eighteen of these calculator keys are dual-function while one is a "function" key for accessing a second function on the individual keys.

Operating any of the calculator keys instantly puts the watch into the calculator mode. It remains in this mode until a "watch" key is



depressed. The device then returns to the timekeeping mode.

In this mode the watch can display hours, minutes, seconds, the month, the day of the week and the date. The latter three functions are controlled by a built-in automatic calendar.

To reduce power consumed during calculations, the chip is designed to sacrifice some computation speed. Consequently, some calculations can take as long as 13 s before an answer is displayed. While the calculator is processing the figures, an indicator blinks.

The watch uses only two batteries, not six as in competing units. Two backlights make the display readable at night. Suggested selling price is $350.

Do-it-yourself with MOS and bipolar IC

A monolithic array of unconnected transistors, resistors, and capacitors developed at Stanford University's Integrated Circuits Laboratory incorporates bipolar and MOS devices on a single substrate. By masking one customizing aluminum interconnect pattern onto the die, the array can be transformed quickly into virtually any simple digital or linear circuit.

Called the Kitchip, the device was described at the International Solid State Circuits Conference in Philadelphia last month. Stanford isn't selling the device on the open market. "But if someone were willing to tool up, it could be a commercial product," says Stephen R. Combs, a graduate student at the California school and Kitchip project leader.

"The Kitchip brings high-performance, low-cost ICs to a previously unaddressed class of applications, namely small-scale, low-volume circuits," says James D. Meindl, a Stanford professor and Combs' advisor. "The ready availability of an advanced integrated circuit that combines linear, quasi-linear, digital, and analog multiplex functions on a single chip should have significant impact," he says—especially when combined with quick turnaround from design to production.

According to Meindl, 22 circuits have been fabricated on an early version of the Kitchip in the past year. But that version has a major limitation: It is all bipolar. Yet it still made possible a number of products that could not be built with commercially available ICs, says Meindl. Important biomedical applications include a complete, four-channel, implantable ultrasonic blood velocity meter; an implantable pressure, biopotential and temperature telemetry system; and a micropower command receiver. But at the same time, he adds, "more complex future systems will require both MOS and bipolar circuitry."

Until now, mixed MOS and bipolar processing on a single chip has been used in such commercial products as RCA's 3140 bipolar-FET op amp, but not in uncommitted transistor arrays. Only bipolar devices are available in mask-customized arrays, such as the ones supplied by Interdesign, Exar, and Stewart-Warner.

The devices available on the Kitchip include n and p-type transistors that are bimodal—that is, they can be wired on the final mask to function as MOSFET or bipolar devices. In addition, there are VMOS switches for signal multiplexing, low and high-value resistors, and a junction FET. Each die contains over 200 bimodal, 12 committed-pnp, 8 JFET, and 4 high-current n-type transistors. The devices are laid out on a 160-mil-square chip so that a number of common analog circuit blocks such as balanced mutiplexers, active-load differential pairs and current mirrors can be formed easily.

Since the operational mode of any of the bimodal transistors is determined only by the metal interconnection pattern, such combinations as low-power CMOS or complementary bipolar logic with high-performance MOS or bipolar linear circuits can be manufactured on the same chip.

A 7-1/2-digit DVM —another first

The first 7-1/2-digit (14,000,000-count) voltmeter available in the U.S. is being marketed by Guildline Instruments Inc. of Larchmont, NY. Guildine calls the $3995 instrument the Model 9577. Schlumberger's Solartron Electronic Group Ltd. of Hampshire, England, which makes the unit, has been marketing it in Europe since last year as the Model 7075 Maestro. Solartron ships it to Guildline, which tweaks in its calibration pots and handles its sales and service in the U.S.

Until now, the highest-resolution DVM available in the U.S. was the 6-1/2-digit Model 6900 by Dana Laboratories Inc. of Irvine, CA, and marketed by Dana and Keithley Instruments Inc. of Cleveland. The Guildline/Solartron's higher resolution is useful in making transfer measurements (comparing one voltage with another). But a rated accuracy of 3 parts-per-million of reading plus 15 μV on the 10-V range, for example, translates into a possible error of $\pm$52 counts. That uncertainty makes the last digit meaningless in absolute measurements.

The 9577 measures dc voltages, true-rms values of ac voltages, resistances, ratios of dc/dc and dc/ac voltages and temperature (with an external resistance thermometer). Maximum resolution is 1 μV or 1 mΩ.

PCB dielectric replaced by a safer fluid

A new PCB-free dielectric fluid, Dielektrol, developed by General Electric in Hudson Falls, NY, is now used to impregnate capacitors. The fluid (phthalate ester) virtually eliminates environmental risk, while matching and even exceeding the performance of PCB. Moreover, it fits existing material and manufacturing processes and doesn't add substantially to cost.

The fluid is nontoxic, biodegradable and neither persists, nor accumulates in the environment or in the tissue of living organisms. And it presents no hazards when incinerated or placed in approved landfills.

Environmental testing on mammals, fish, birds and micro-organisms uncovered no apparent damage. Massive doses of Dielektrol fluid were consumed, inhaled or contacted by skin or eye tissue, but revealed no harmful effects. Chronic toxicity tests—assessing the effects of smaller doses over longer periods of time—are in process.

The fluid provides electrical properties similar to PCB throughout the normal temperature ranges, and has a low dissipation factor even after extensive life tests.

However, the fluid is combustible. Dielektrol I (used in smaller-sized capacitors) has a flash point at approximately 165 C, and Dielektrol II (used in power capacitors) at over 250 C. Like all other PCB replacements developed to date, Dielektrol is classified IIIB-combustible.

Nearly all capacitor designs that use Dielektrol I feature General Electric's patented internal pressure-sensitive interrupter. Dielektrol II tends to self-extinguish, because of its higher flash point. Also, power capacitors using Dielektrol II must be properly fused.

Recorded messages to be stored in bubble memory

A recorded-message machine that stores its message in a magnetic bubble memory is being tested in a Detroit switching office of the Michigan Bell Telephone Company. Called the 13A announcement system, the Bell Labs machine records and announces standard, repetitive 12 or 24-s "call assist" messages for up to 500 telephone lines—all at the same time.

The 13A has a number of advantages over its predecessors, which record on a magnetic drum, according to a Bell Labs spokesman. While messages on a magnetic-drum unit eventually degrade and must be re-recorded message quality in the bubble memory remains good. And where the earlier system can handle but one message, the 13A records and announces up to eight.

The improved message recorder stores each message on a separate PC board, which holds two magnetic bubble packages. Each package, about half the size of a cigarette pack, contains four bubble chips. The chip can store up to 68,121 bits of information.

Before speech is stored in the magnetic bubbles, it is electronically encoded into digital information. The storage capacity of each package is 12 s of digitized speech. A special electronic decoder reconstructs the voice signals when needed.

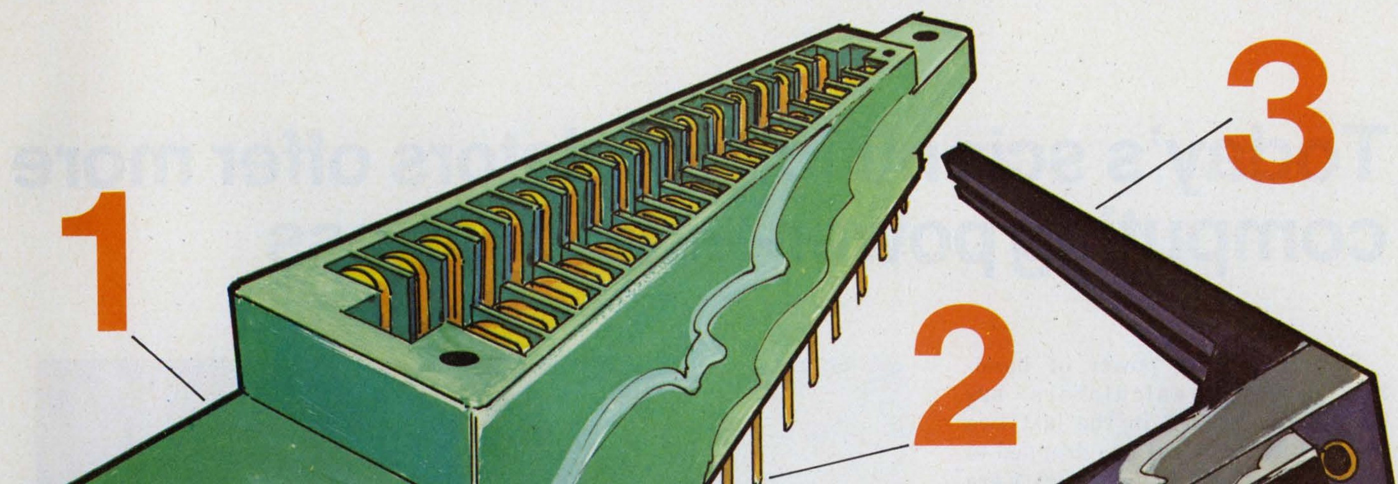
Antenna receives sub signals at 100-m depth

A superconducting receiving antenna for submarines that has been tested to 100-m depth overcomes the receiving limitations of current long-range submarine-communications systems. These systems operate in the 3 to 30 kHz vlf band. At those frequencies, radio waves do not penetrate very deeply into the sea.

Three superconducting quantum-interference devices (SQUIDs) make up the antenna, which was developed and tested by scientists at the Naval Research Laboratory, Washington, DC. These highly sensitive, magnetic-field sensors can receive signals in the 30 to 300 Hz elf band, which penetrate much more deeply into the sea than the higher-frequency signal.

Elf signals from the Navy's Clam Lake, Wisconsin high-power transmitter were successfully received by the SQUID antenna at a surface field site, as well as 100 m below the ocean surface.

bare facts



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CIRCLE NUMBER 15

News

Today's scientific calculators offer more computing power—and cost less

The computing power of hand-held scientific calculators has doubled or trebled in the last two years. But their cost has dropped to one-third or less of what they were priced at that time. The reason? Rapid progress in diverse technological areas contributing to calculator design features.

- More computing and peripheral circuitry has been packed onto individual LSI chips, giving calculators more computational power and data storage capabilities.
- Microampere CMOS RAMs and nonvolatile electrically alterable MNOS RAMs have been developed that permit program data to be stored for long terms using microwatts of power or indefinitely without power.
- Power requirements have been lowered with more efficient circuitry and displays and by incorporating dissipative off-chip components into the chips.
- Small, low-power printers have been developed that are suitable for hand-held machines.
- More rugged rechargeable nickel-cadmium (NiCd) batteries have been developed that overcome early-failure problems caused by excessive recharging, inadvertent polarity reversal and cell shorting.
- The reliability of liquid-crystal displays (LCDs) has been improved, so once again they are turning up in a growing number of new calculators. Their low current drain—plus the use of CMOS—permits watch-type button cells to be used that power the units for months at a time.
- Solar-cell costs have been lowered and their efficiency raised enough for them to be incorporated into calculators with LCDs and CMOS circuitry to keep the batteries charged.

Jim McDermott
Eastern Editor

New algorithms, improved arithmetic and added operating functions are increasing the computing power of new generations of calculators. In this TI SR-56, computational capability is enhanced through the incorporation of a 100-step program that is executed by simple key entry.

The net effect of these and other advances has been to establish a number of significant industry trends.

First of all, the prices of scientific calculators continue to drop from the most costly to the cheapest units. But because of the higher chip densities and improved algorithms and calculator architectures, computing power has been rising constantly.

For example, on the high end, Hewlett-Packard's newest magnetic-card programmable unit, the HP-67, costs $450—$345 less than HP's first model, the 65, which came out just two years ago. But the 67 (or the 97, its printer equivalent) has over three times the memory, power and program capacity of the 65, points out Glenn Theodore, product line manager at HP's Corvallis, OR, plant.

"The 67 has 224 steps, versus only 100 for the 65. But the 67's program capacity is well over 300," Theodore adds. The reason is that all calculator functions occupy but one step of a program memory on the 67 and 97, even though entering those functions requires multi-

This time it's Model 248. A new 4½-digit miniature DMM offering True RMS measurement and 10μ volt sensitivity for only $345.

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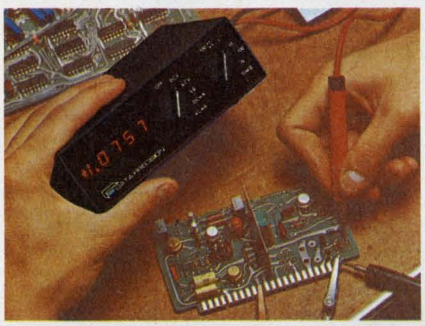

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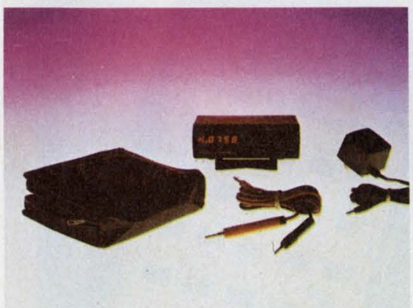

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ple keystrokes.

This feature is called "all-merge" codes. For example, if a function requires a shift key plus another key, the operation occupies only one program step. This capability is particularly important for storage and recall operations from data registers, Theodore notes, which are the most frequently used functions in programming. In the HP-65, only a limited number of functions can be merged.

The 67's program capacity is further enhanced by such programming functions as indirect addressing. The address of a label or a data register can be stored in the indirect or I register.

The program instruction can call for STORE Indirect or GO TO indirect, in which case the machine will store the address into or retrieve it from the I register. Thus, the user can decrement, for instance, in a loop in which you might want to store successive pieces of data in successive data registers.

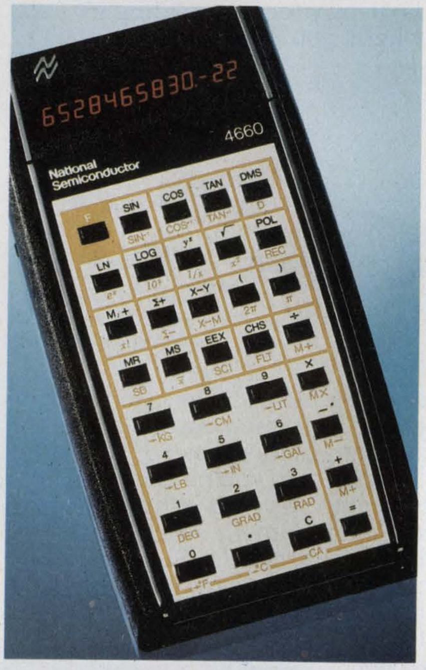
HP's reader-prompter

The third significant advance in the HP-67 is the "smart" card reader. This magnetic reader can record not only programs but also data for reentry into the calculator. It also prompts the user for proper operation—that is, the card has two sides and each side may contain either data or program information, but not both at once.

If the card must be passed first through side 1 and then through side 2 to load the program memory, the card can be entered without worrying about which side is being read. It will load whatever is on the card into the proper location.

Advantages of the merged-key code have been incorporated by Mostek into a new key-programmable 12-digit calculator design that combines the company's MK 50075 ALU chip with its MK 50107, 50108, 50109 and 50110 ROMs. The combination provides a 100-step program memory, but the merged-key code packs considerably more than 100 keystrokes into it, says Mike Andrakin, Mostek software specialist. The shift, inverse, hyperbolic and program keys occupy no storage, but rather are merged with the keystroke that follows. Texas Instruments' magnetic-card, programmable SR-52 ($249.95) has 224 program memory locations like the HP-67, but it doesn't have all-merged code. Even so, loading the program memory doesn't affect 20 other memory registers, the program flags, the program counter or the display format.

By remembering which half of the program memory was read last, it is possible to load a program without affecting the internal processing registers or the displayed number. In other words, if a program exceeds the 224 steps, it can be partitioned into segments that separately fit into the program memory. The program is then executed by sequentially reading and running the load segments.



Metric-to-English measure conversions are a special feature of this National Semiconductor 4660 unit. It is totally programmed.

A complete 224-step program can be loaded from a small magnetic card into this TI SR-52 in two seconds.

The SR-52 stores 224 program instructions with two passes of its magnetic card. Side A is read into program memory locations 000 to 111, while side B is entered into locations 112 to 223.

Texas Instruments has been able to improve the algebraic manipulation of its latest series of machines by means of, in the company's words, an enhanced algebraic operating system (AOS), which is compatible with Fortran.

The earlier TI calculators used an algebraic notation with a hierarchy that put multiplication and division on a higher level than addition and subtraction.

But the new AOS puts powers of numbers on a higher level than multiply and divide, notes Rod Wilmont, TI's product manager for professional calculators. "With the AOS you can do the following: $1 + 2 \times 3^4$. The calculator will store all of the operations and numbers and enter the power of four," says Wilmont.

The limitation of the earlier TI algebra was due, in part, to the lack of sufficient storage registers, Wilmont adds. For example, the SR-50 had only one register in which to store a single number. But the improved circuit density of the SR-52 chips makes room for 10 internal processing registers to hold operands for calculations in progress.

Most powerful machines today

The HP-67 and the TI SR-52 are the only magnetic-card programmable calculators available.

With their magnetic cards, the HP-67 and TI's SR-52 are the most powerful hand-held calculators today. But soon they will be challenged by a calculator from National Semiconductor that will use solid-state program cartridges instead of cards. These cartridges will contain 4096-step ROMs. Each ROM will provide a library of engineering, or math or statistical programs.

Slated to be available this spring for about $400, the 7100 will have not only 4096 steps available in the program cartridge but also 240 steps of mainframe program storage in pseudo-nonvolatile CMOS RAMs. According to Bob Johnson,

product manager for professional calculators, 256 program addresses will be available for accessing programs in the solid-state cartridges through the 240 steps built into the calculator. The 7100 has 480 user-writable program steps, all of which use fully merged instructions.

In addition, 37 working registers that are all addressable and four levels of subroutines are built into the 7100. Thus, subroutines can call subroutines, which gives it additional power, says Johnson.

One of the prime functions of a magnetic card is to record calculator programs and store them away. In the 7100, however, a plug-in cartridge like the one for the 4000-step ROM replaces the magnetic card, and a 240-step MNOS electrically alterable ROM replaces a program memory. This ROM stores the 240 steps from the mainframe memory. Of if desired, the blank EAROM can be plugged in to make 480 steps available to the mainframe. The 240 mainframe program steps are stored in CMOS RAMs, and as long as the battery is charged to any degree, the program will remain intact. The same condition holds true for the 32 data-storage registers.

A trend to nonvolatile storage

The 7100's incorporation of either pseudo-volatile or nonvolatile memories to store programs when the calculator is off is an example of a growing trend. Another example is an HP calculator with a pseudo-volatile memory, the 25C. It is key programmable with reverse Polish notation and uses 49 program steps. Also, the 25C has a CMOS memory that retains 49 program instructions, plus all the data in eight addressable registers and the Last-X register.

When switched off, the calculator's programs and data are held by power from the rechargeable cells. If the batteries are removed, a capacitor furnishes temporary power.

Rockwell Microelectronic Device Division in Anaheim, CA, is currently developing a single-chip key-programmable scientific calculator that will have provisions for interfacing with a program-holding CMOS RAM. Called the A7000, the chip is expected to be available on

Three times the memory, power and program capacity of the HP-65 is designed into the new $450 HP-67.

a sample basis by May.

A somewhat different approach is taken by Casio in its PRO-101 programmable unit, which has 256 program steps that can be divided up for a maximum of 15 programs. Designed for numerical rather than scientific calculations, the PRO-101 has a CMOS memory for program storage that is powered by three separate silver oxide button batteries. Should the main batteries—four AA primary or rechargeable cells—go dead, or optional ac power be turned off, the oxide batteries can retain data up to 12 months, according to Casio—provided no new programs are entered.

True nonvolatile storage has been demonstrated by General Instrument in a prototype calculator that interfaces GI EAROMs with one of the company's programmable calculator chip sets.

For the designer who doesn't need, or can't afford, the luxury

A thermal printer aids programming and debugging in the HP-97 card-programmable machine.

of a magnetic-card programmable calculator, the key-programmable type machines offer the next best solution.

Key-programmables without a semipermanent storage feature like that of the 25C—TI's SR-56 and the HP-25—are being challenged by a new generation of powerful lower-cost machines. The SR-56 costs about $100 and the HP-25 $175. But APF Electronics' Mark 90, which has 70 preprogrammed functions, costs $69.95 and has 72 program steps with conditional and unconditional branching, looping and full editing. The editing operation includes stepping forward, backward, inserting, deleting, and No Operation. Single-step execution is also provided.

For added flexibility, the Mark 90 has 10 separate user-accessible data memories, which can be addressed individually or simultaneously.

For the user willing to write his own programs, a machine like the Mark 90 can be very cost-effective. But if a variety of complex engineering programs are required, the software already available from TI or HP may be worth the added calculator investment.

Two-year price plunge

Over the past two years, prices for a wide variety of these lower-cost nonprogrammable calculators have even taken a tumble. But the computing power has risen. Two years ago, for example, the cheapest scientific unit with a few simple trig functions sold for about $50. Today, a comparable machine sells for about $20 and has 20 to 25 preprogrammed functions, including hyperbolics, factorials, roots and exponentials.

The higher-priced machines of today's nonprogrammable lines can be useful to the user who doesn't need the power of a programmable. One example is the $69.95 Kingspoint 6010 (see photo), which is preprogrammed with more than 50 scientific and statistical functions. It has a 12-digit display—10 mantissas and 2 exponents—and operates in either floating-point or scientific notation. A seven-operating-register system permits problem entry in true algebraic mode notation and enables solutions without the use of memory. Ten

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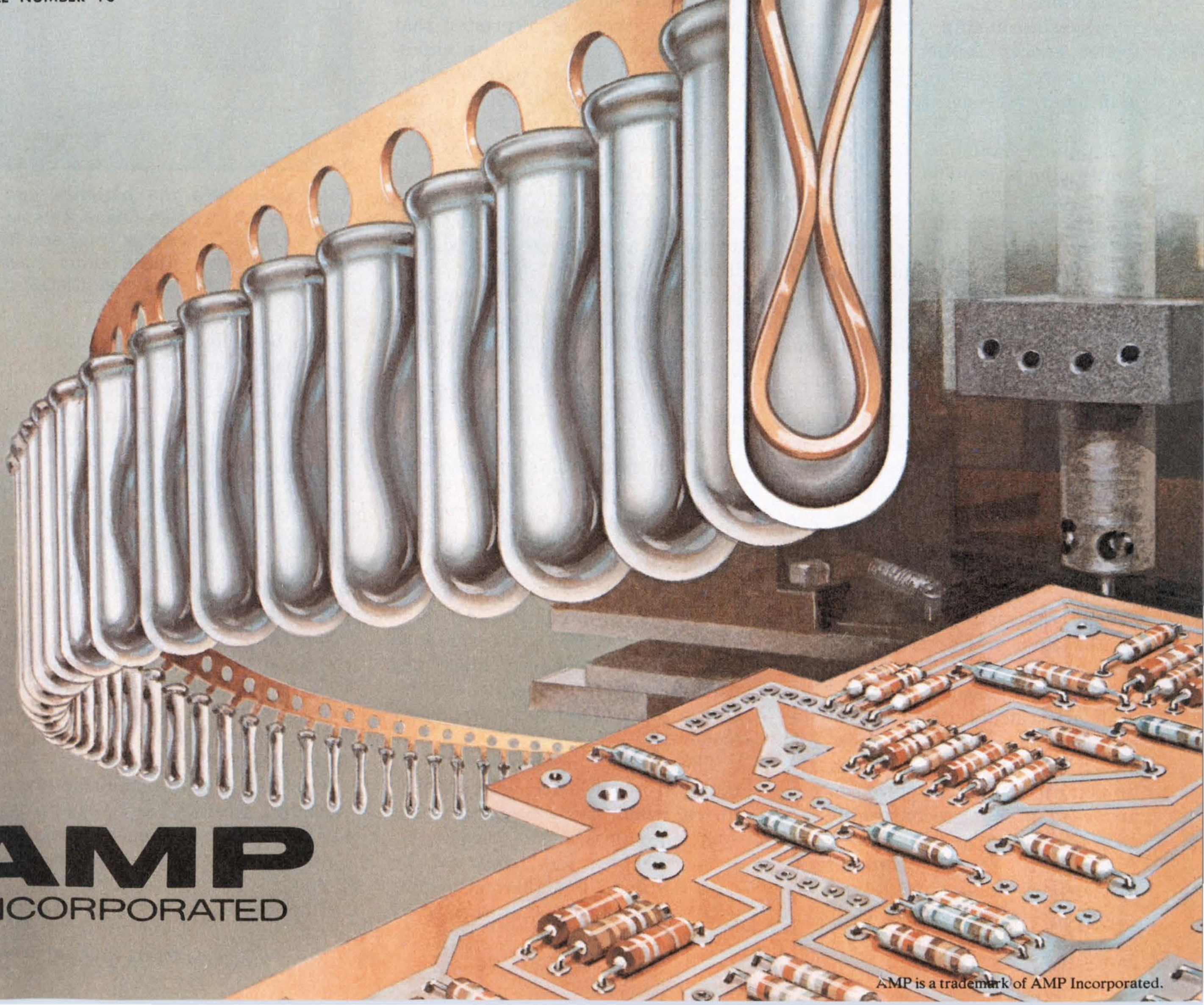

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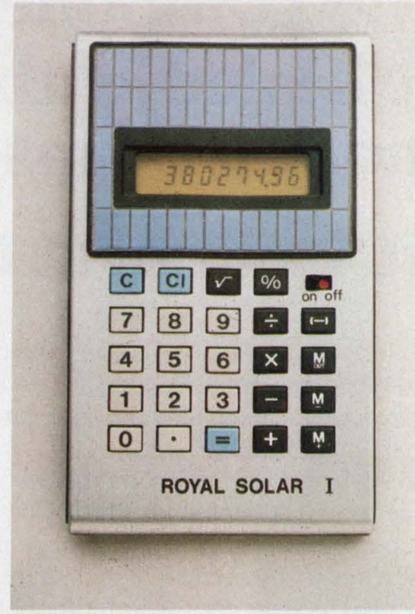
Printers are appearing in hand-held calculators. The electro-sensitive paper in the Sharp EL-8151 responds to voltage impulses from the printer matrix elements. It operates from the unit's NiCd rechargeable batteries.



Solar cells keep the batteries continuously charged in these calculators by Royal Typewriter (top) and by Sharp (bottom). These units have liquid-crystal displays and CMOS.

special scratch-pad memories permit up to 10 intermediate calculation results or up to 10 constants to be stored.

A special on-chip, processor-controlled energy saving system allocates power according to the minimum energy needed for each phase of operation.

Another example is National Semiconductor's 4660 (see photo), which costs $59.95 and is an algebraic-notation version of National's RPN-notated 4640. It is a scientific machine with 45 preprogrammed functions, including summations, factorials, polar-to-rectangular conversions and metric/English conversion functions.

The power needed to operate calculators has been substantially reduced within the last two years by two design improvements. First, dissipative discrete display-drive elements such as transistors and resistors have been eliminated by placing their functions on the chips in more efficient configurations. Second, the computational circuitry on the chips has been designed to require less energy.

For these reasons, many of the scientific calculators in the low-to-medium-price-fields—but not TI's and HP's—are now sold with AA dry batteries and the option to buy an ac adaptor or rechargeable AA cells and a charger.

However, the higher-priced, higher-performance machines are supplied with rechargeables and a charger. In some cases, the charger is built into the calculator.

A desirable feature that up to now has been absent from hand-held calculators is a printer that uses a paper tape roll with standard office-machine, parallel-printout format. This development has been held up by the lack of a low-cost, lightweight print mechanism that requires low power to operate.

But now two types of printers with suitable characteristics are available and being incorporated into new products. One of these printers uses a roll of electro-sensitive paper while the other has a thermal print mechanism using heat-sensitive paper.

The electro-sensitive printer has appeared in three of Sharp Electronics Corp.'s standard eight-digit, four-function business calculators. Two models—the $79.95 EL-8051 and the $99.95 EL-8151 (see photo)—use a 12-digit printer and 13-digit printer, respectively. Extra digits are for data entry.

A third machine, the EL-1163 ($119.95) is a 10-digit model with a summation memory. All Sharp machines can be operated in either a print-and-display or display mode.

The printers operate directly off the built-in NiCd rechargeable batteries, which can give up to about 4000 lines in the print mode.

Thermal printers are used by both HP and TI. A thermal printer —the same same that in the HP-97—will be included in a new HP-10 seven-function business calculator with algebraic notation. The HP-10, which will be about the same size as the HP-65, is scheduled for delivery about May 1.

The HP-97 card-programmable unit uses a thermal printer that can operate solely on batteries for three to five hours. It prints up to 21 characters wide using a 5 × 7 dot matrix.

Thermal printers are also used in TI's $295 PC-100 peripheral unit in which an SR-52 or SR-56 can be locked. The printer uses a 2.5-in. thermal tape that prints up to 20 characters per line.

Calculator chip manufacturers, including Rockwell and General Instrument, have developed calculator-chip sets with a printer-drive option.

Liquid crystal displays (LCDs)

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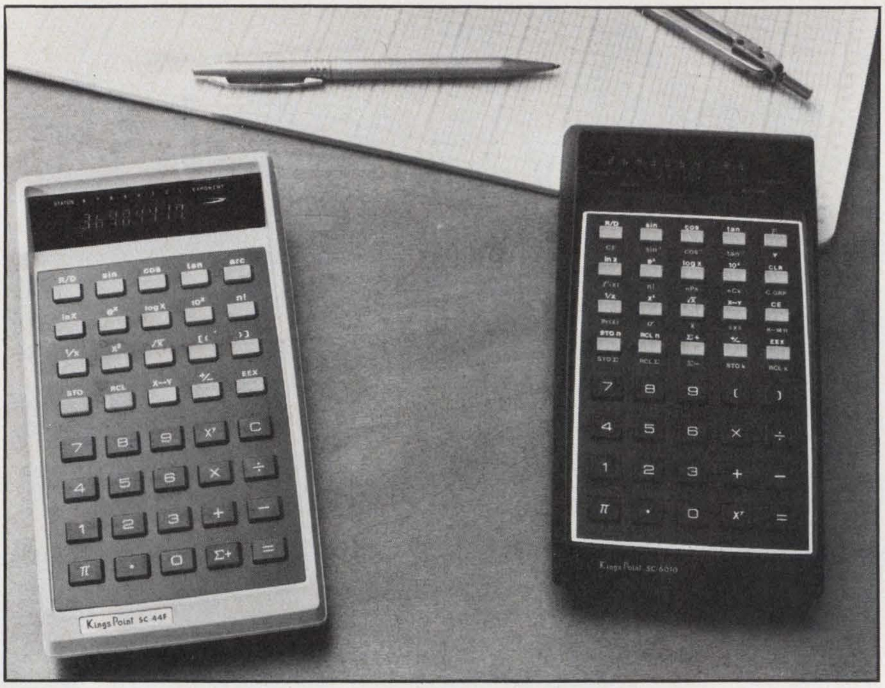
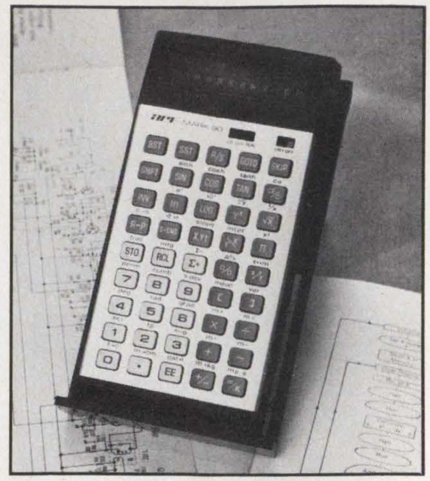


Extensive scientific and statistical functions are programmed into the Kingspoint SC-6010 (right). The SC-44F (left) has scientific and factorial functions and a plasma display.



More than 70 key-accessible preprogrammed functions and a 72-step program memory with editing functions are designed into this low-cost APF Electronics Mark 20 machine.

with enhanced reliability are now appearing in consumer CMOS calculators produced by such Japanese firms as Sharp, Teal, Casio and Sanyo. In these designs, standard AA primary or rechargeable cells, which have been industry standards, are eliminated. The combined current drain of the CMOS computing circuitry and LCD display is low enough to permit them to be powered by two or three button cells of the type used in watches. Battery life is at least six months. The use of button-cell batteries permits the design of attractive, slim cases.

If the reliability of these new displays can be demonstrated in practice, says Chung Tung, R&D engineering manager at Hewlett-Packard's Corvallis Division, OR, they should eventually be adopted by the scientific calculator industry for preprogrammed and key-programmable units that don't have magnetic-card readers. Such calculators can use throw-away batteries.

Because the calculators with LCD displays draw little current, it is feasible to use rechargeable button cells and keep them charged up with the energy from a solar-cell array.

Two consumer LCD/CMOS calculators, Sharp's Sun Man and Royal Typewriter's Royal Solar I (see photo) are the first to appear in this country with silicon solar cells integrated into the calculator package.

The Sun Man ($99.95) is an eight-digit, six-function calculator with a rechargeable three-cell 3.6-V battery that "will never have to be replaced," says the manufacturer. The display requires 70 mW. Capable of operating for 50 hours without charging, the calculator requires two hours' exposure to window light for a full recharge.

The Royal Solar I ($99.95) has an eight-digit display with indicators for "memory in use," minus sign and "overflow." It has an independent memory register and uses two rechargeable NiCd button cells in series for a full-charge voltage of 2.4 V. ■■

Want more information?

Readers interested in learning more about the individual calculators mentioned in this article or of similar machines may contact the manufacturers and suppliers listed below. Types of calculators are indicated by the letters following the listing: K—key programmable; M—magnetic-card programmable; N—nonprogrammable.

APF Electronics, Inc., 444 Madison Ave., New York, NY 10022. (212) 758-7550. K, N **Circle No. 411**

Calcumatic-Leisurecraft Products, Ltd., 909 Third Ave., New York, NY 10022. (212) 686-0096. N **Circle No. 412**

Canon, Inc., 10 Nevada Dr., Lake Success, NY 11040. (516) 488-6700. N **Circle No. 413**

Casio, Inc., 15 Gardner Rd., Fairfield, NJ 07006. (201) 575-7400. K, N **Circle No. 414**

Colex International, 1229 W. Washington Blvd., Chicago, IL 60607. (312) 733-1200. N **Circle No. 415**

Commodore Business Machines, 901 California Ave., Palo Alto, CA 94306. (415) 326-4000. K, N **Circle No. 416**

Hewlett-Packard, 1000 N.E. Circle Blvd., Corvallis, OR 97330. (503) 757-2000. K, M, N **Circle No. 417**

Ibico, Inc., 50 Lively Blvd., Elk Grove, IL 60007. (312) 640-7333. N **Circle No. 418**

Kingspoint Corp., 104 Harbor Dr., Jersey City, NJ 07305. (201) 432-7707. N **Circle No. 419**

National Semiconductor, 1177 Kern Ave., Sunnyvale, CA 94086. (408) 732-5000. **Circle No. 420**

Netronics R&D Ltd., 333 Litchfield Rd., New Milford, CT 06776. (203) 354-9375. K (Kit) **Circle No. 421**

Panasonic, 1 Panasonic Way, Secaucus, NJ 07094. (201) 348-7170. N **Circle No. 422**

Royal Typewriter Co., 150 New Park Ave., Hartford, CT 06106. (203) 523-4811. N **Circle No. 423**

Sanyo Electric, 1200 W. Artesia Blvd., Compton, CA 90220. (213) 537-5830. N **Circle No. 424**

Sharp Electronics Corp., 10 Keystone Pl., Paramus, NJ 07652. (201) 265-5600. N **Circle No. 425**

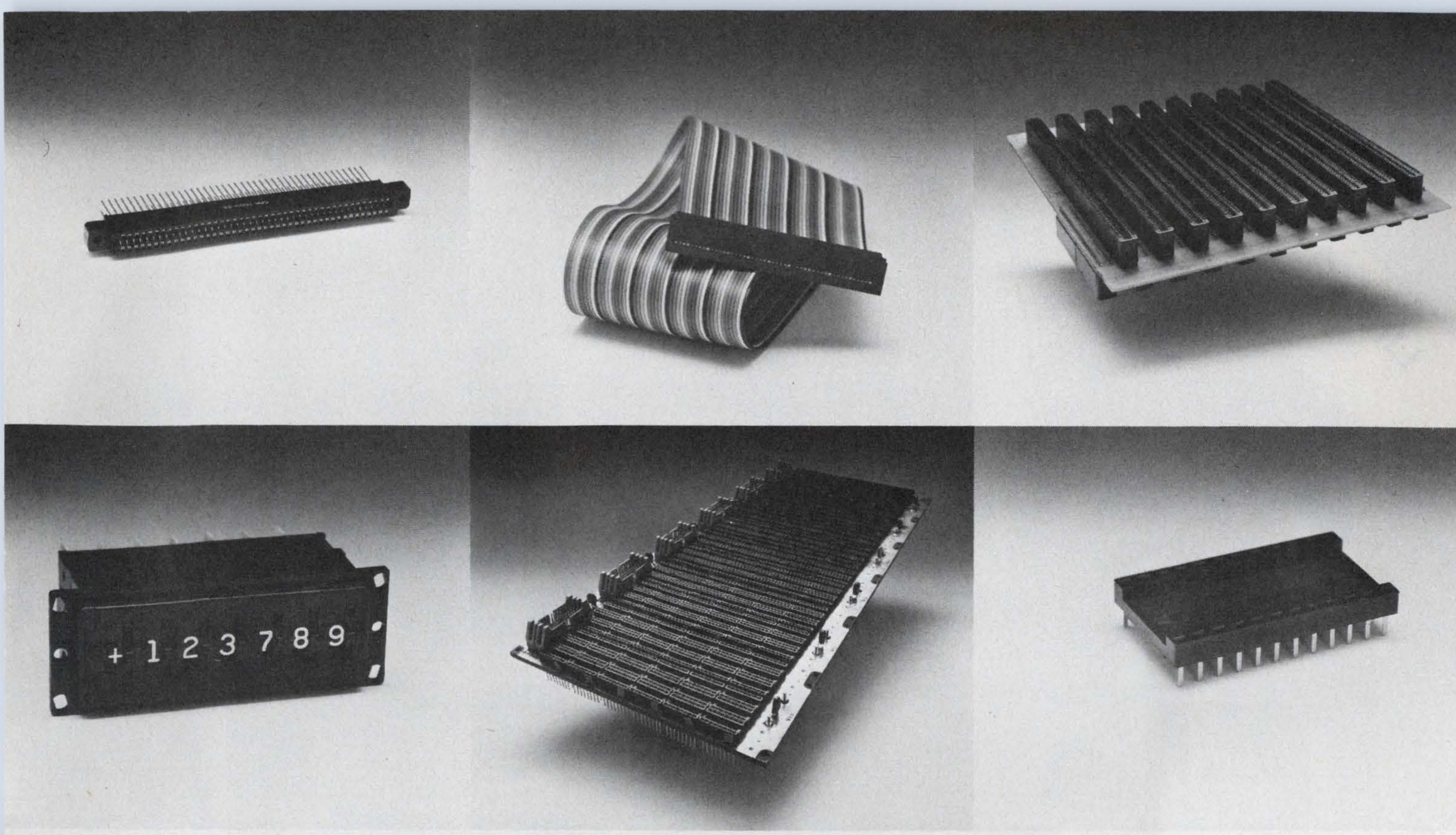
Sinclair Radionics, Inc., 115 E. 57th St., New York, NY 10022. (212) 688-6623. N **Circle No. 426**

Teal Industries. P.O. Box 5505, Carson, CA 90749. (213) 532-9631. N **Circle No. 427**

Texas Instruments, P.O. Box 5012, MS 84, Dallas, TX 75222. (214) 238-3741. K, M, N **Circle No. 428**

Unisonic Products, Inc., 115 Broadway, New York, NY 10006. (212) 255-5499. N **Circle No. 429**

Unitrex of America, Inc., 689 Fifth Ave., New York, NY 10001. (212) 688-3400. N **Circle No. 430**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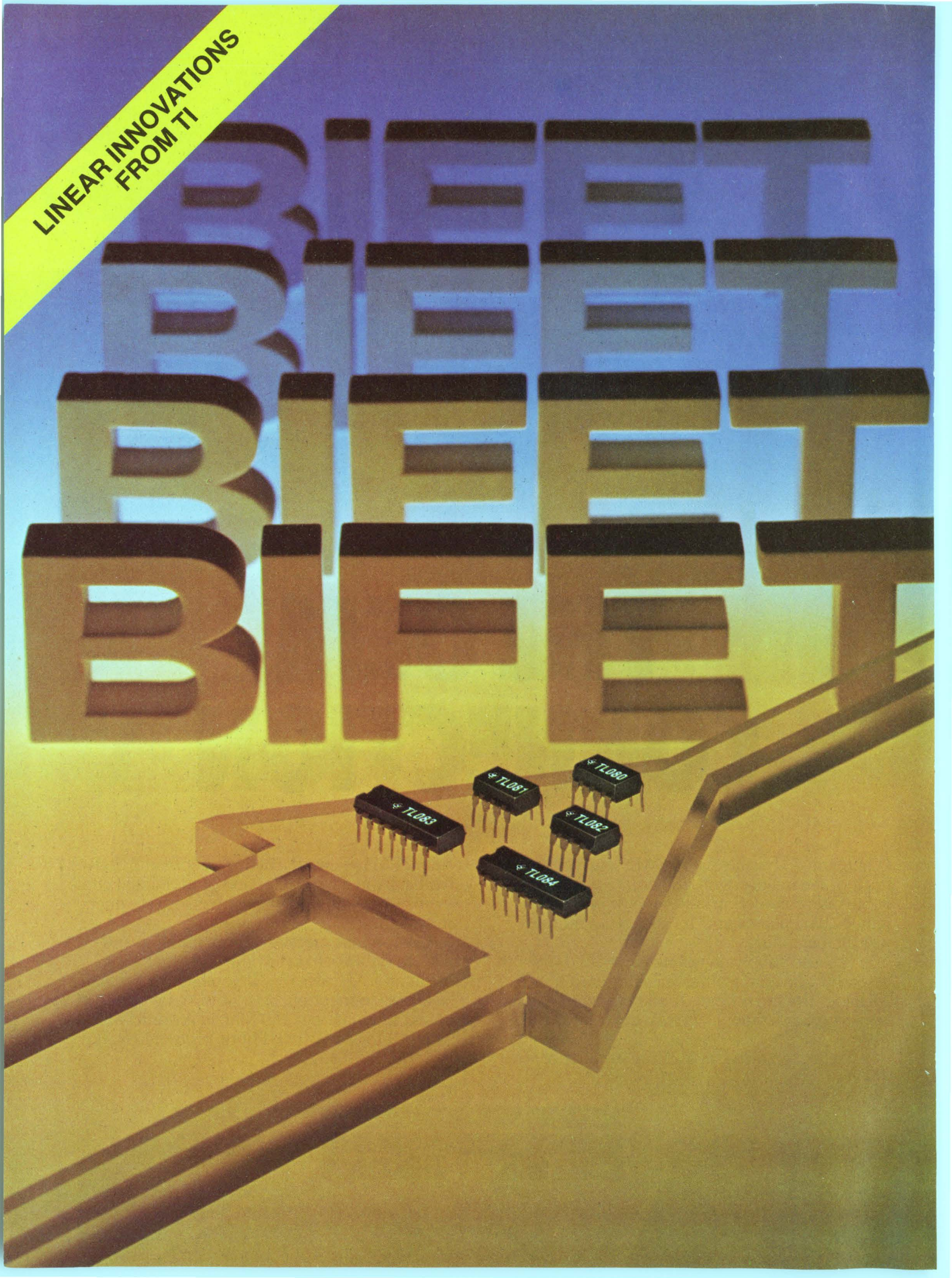
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These same parameters apply for each member of the family; the entire series has identical AC and DC specs. For the greatest versatility and broadest user selectivity ever offered in operational amplifiers.

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TL081	1	Yes	Yes	μA741; LF13741; CA3140; LF355
TL082	2	Yes	No	LM358; MC1458; RC4558
TL083	2	Yes	Yes	μA747
TL084	4	Yes	No	LM324

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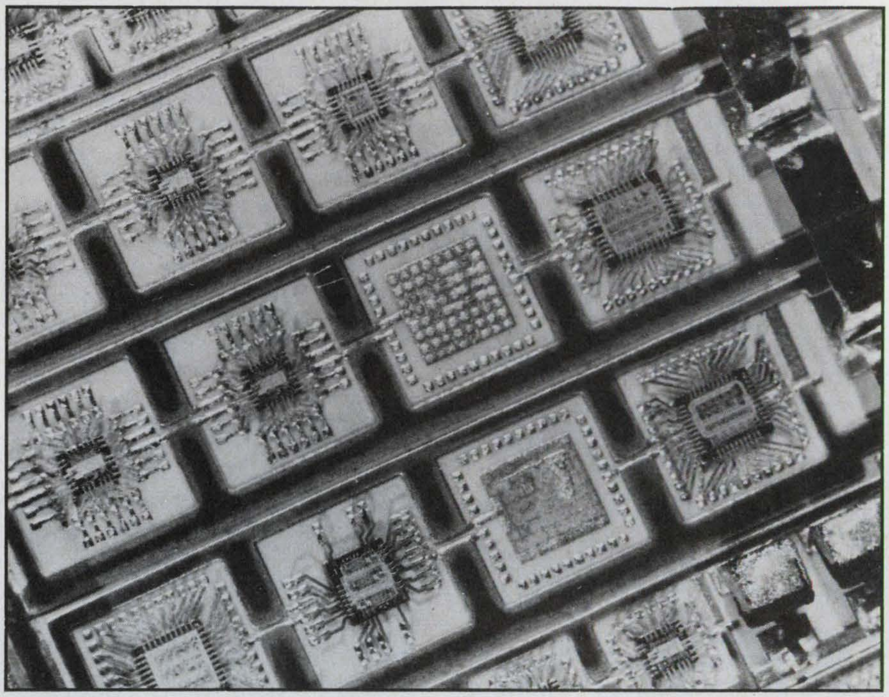
CIRCLE NUMBER 21

Current-mode logic is packed densely to raise speed and cut power drain

Current-mode logic is as fast as emitter-coupled logic and, because it doesn't have ECL's emitter-follower output drivers, dissipates less power. But without drivers, CML can't drive long lines. This problem has been solved in Honeywell's latest large-scale computer, the Model 66/85, which features a small circuit-board assembly that keeps lead lengths between integated circuits down to an average of less than half an inch.

With gate-propagation delays of about 1.5 ns, CML is also five times faster than standard TTL, yet consumes about half the power, roughly 12 mW per chip, says Jerry Rauser, manager of the bipolar and MOS circuit development group at Honeywell's Solid State Electronics Center in Minneapolis. So to take "maximum advantage" of these properties, adds Lee E. Sheehan, vice-president and general manager of Honeywell's U.S. Information Systems Group, a special micropackage was created by the company's large-scale system designers in Phoenix to house up to 110 chips in one assembly.



Current-mode logic circuits are fast and dissipate little power, but don't have the capacity to drive long lines. Honeywell's 66/85, however, overcomes this problem with high-density packaging and multilayer wiring on a ceramic substrate. Each assembly holds up to 110 CML chips.

Laying it on

The circuits are mounted on a ceramic-substrate "board" carrying silk-screened gold-paste conductive paths and dielectric insulating layers. There are four wiring layers—one in the x direction and one in the y direction for signals, a power bus, and a ground bus that also serves as a heat sink and a mounting surface for the ICs.

The result, according to Sheehan, is a thick-film, ceramic substrate circuit assembly, only 80 mm (about 3 in.) square and 2 mm thick, but with almost the same amount of circuitry contained on a conventional 12-in. square printed-circuit board using TTL. The assembly is cooled by water pumped at less than 5 psi through a heat exchanger that mounts against the ceramic side of the board.

The CML circuits are similar to ECL circuits except for the output configuration. And since manufacturing processes for CML, ECL and other bipolar logic families are also similar, the cost of manufacturing the CMLs is comparable, says Rauser. For now, Honeywell is making all of its own CML chips, but "we do intend to source CML circuits from outside vendors," according to Sheehan, adding that Texas Instruments and Nippon Electric are two possible sources.

Honeywell's first application for this logic family, the 66/85 computer, is designed for general-purpose information processing. In a typical configuration, the $6-million machine will have 1-million words of MOS memory, a system console, two card readers and one card punch, two high-speed line printers, a dual-control, dual-channel magnetic tape subsystem with twelve 1600-bit/s tape units, 3.2-billion bytes of mass storage through two disc subsystems, and two front-end network processors. The systems will be available for installation this fall.

The 66/85 is designed to handle host-processor functions in distributed systems, as well as general-purpose applications. In a distributed system, which is characterized by multiple computers in relatively independent locations, the host processor provides supporting services and guidance to the other processors. Also, Honeywell's line of distributed-system-oriented products has recently been expanded by the introduction of three medium-to-large-scale processors as well as the 66/85, a front-end processor, and a series of terminals. ■■

Washington Report

Defense sets new program review

Military programs now will have to undergo a formal review by top Pentagon officials even before study contracts can be awarded, according to a new Defense Department directive.

Called "Milestone Zero" by the Pentagon, this point of review is expected to be applied this year to several programs involving the electronics industry. These include a new Air Force reconnaissance aircraft known as the RFX, the Navy's Wide Aperture Array Sonar System for nuclear submarines, and a new radar satellite.

The move, which was demanded by Congress and resisted by the Pentagon, is required for all federal agencies under Circular A-109 issued last year by the White House Office of Management and Budget. That circular is intended to formalize procurement processes throughout the federal government and end the current practice of permitting contractors to help write the specifications for new programs based on their own government-funded studies.

The Defense Systems Acquisition Review Council will continue to review programs at three other decision points: advanced development, full-scale engineering development and production. In the past, no review was required until initial studies were completed and the Pentagon was ready to begin advanced development.

Air Force takes laser weapons lead

The Air Force is emerging as the front runner in the Defense Department's ultra-secret high-energy laser weapons program under the new defense budget, which severely cuts back Army and Navy funding for that effort. Although a 10% cut in the program—from $166 million to $150 million—has been ordered by Defense, the Air Force share remains steady at just under $80-million.

Moreover, the Air Force has been authorized to begin what the Pentagon calls a focused technology effort aimed at a decision in the early 1980s on whether to begin work on prototype laser weapons. Possible uses: aircraft and spacecraft defense, and anti-ballistic-missile applications.

Soviet moves spur U.S. space defense studies

Following four confirmed attempts last year by the Soviet Union to intercept and destroy its own satellites, the Air Force has funded industry to study ways to protect U.S. satellites from enemy attacks. Testifying before Congress that the Soviet moves jeopardize "the heretofore accepted sanctuary of space," Gen. George Brown, chairman of the Joint Chiefs of Staff, warned that the U.S. would have to improve the detection and maneuverability capabilities of its own spacecraft.

Among the firms already funded, according to the Air Force, are Space Applications, Inc., La Jolla, CA, which performed a $60,000 study to evaluate charge-coupled device (CCD) arrays for a terminal optical warning sensor; Westinghouse Electric, which completed a $750,000 study of an impact sensor to detect non-nuclear, pellet-type warhead attacks against spacecraft; and Rockwell International and TRW, which completed parallel $50,000 studies to identify maneuvering systems for communications satellites.

Communications satellites are considered particularly vulnerable because of their stationary positions 22,300 miles above earth. Rockwell also conducted a $50,000 study to investigate the Navstar global positioning satellite's maneuverability.

Congress takes up defense budget cuts

A preliminary Congressional markup of the defense budget by March 15 is expected to include the reductions proposed by the Carter administration to the original budget submitted last month (see "Washington Report," ED No. 4, Feb. 15, 1977, p. 57).

The cuts, which are expected to total more than $2-billion, will defer spending on many major programs, but not terminate them. The B-1 bomber and M-X missile will be stretched out at least a year, and the previous administration's plan for accelerating fighter aircraft procurement will be put off until the following fiscal year at the earliest.

GE starts work on expanded military comsat

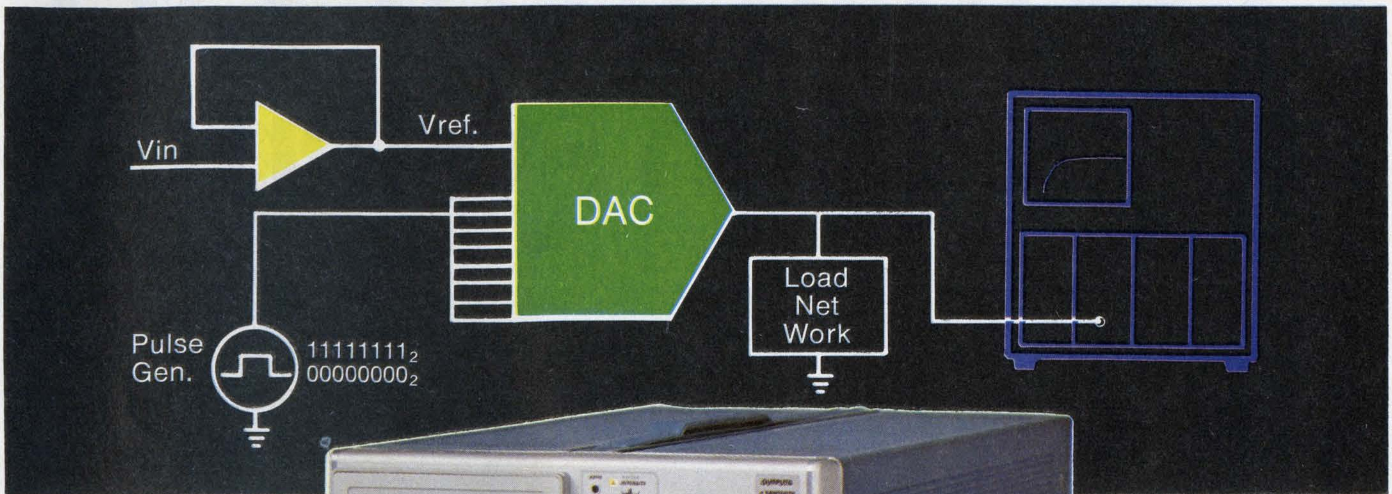
The first three of a planned 12 Defense Satellite Communications System (DSCS) III spacecraft will be developed by General Electric for the Air Force's greatly expanded network of military communications satellites. The new satellites will have twice the operational lifetime of the Air Force's DSCS II satellites—10 years—and six communications channels instead of four.

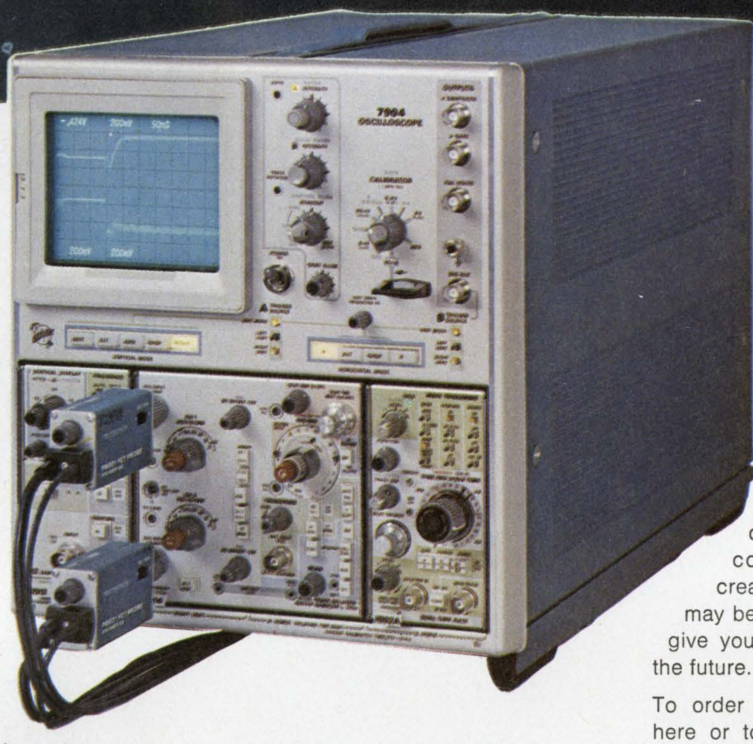
The DSCS III satellites will weigh nearly a ton in orbit and operate at X-band with electronically scanned multibeam antennas. The first launch is scheduled for 1979. The first two launches will use conventional Titan II-C launch vehicles, but future DSCS III satellites will be put into orbit by NASA's Space Shuttle.

The 12 satellites are expected to cost $250-million, and the total DSCS III program, including ground stations, will exceed $1-billion, the Air Force estimates.

Capital Capsules: **The U.S. Postal Service must move quickly to electronic-message systems** or face continuing service deterioration and be forced to depend on subsidies, according to the National Academy of Sciences' National Research Council. Electronic systems could replace nearly half of all first-class mail, the council estimates. . . . **A study of gallium arsenide solar cells** will be launched by North Carolina A&T State University, Greensboro, NC, under a program sponsored by NASA and Rockwell International Corp. The study will be performed by the university's new Solid State Electronics Laboratory. . . . **System Development Corp. is analyzing acoustical data from the ocean depths** as part of the Navy's Fixed/Mobile Experiment for antisubmarine warfare, funded by the Defense Advanced Research Projects Agency.

For Your D/A Converter Analysis,





Use this dual-trace scope to make easy, accurate D/A converter settling time and amplitude measurements . . . and to analyze and verify the performance characteristics of other high-speed components.

Configured in a 7904 mainframe, the 7S14 Sampling plug-in lets you examine settling time anomalies as narrow as 500 ps, to vertical sensitivities down to 2 mV/div. The internal delaying time base lets you select the whole waveform, or any portion, for observation.

The 7D12/M2 Strobing Voltmeter and 7B92A Dual Time Base plug-ins help you easily measure the overall amplitude of the device output, and the P6201 Active Probe conveniently captures the DAC's output with minimum circuit loading.

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No significant distortions will be introduced into your settling time measurement because the 7S14 Sampler minimizes the scope's vertical amplifier recovery time effect. The high-impedance probe minimizes loading the circuit under test.

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You can measure overall output amplitude to within 0.25% with the strobing voltmeter and dual time base plug-ins included in the plug-in scope system. And it couldn't be easier: the intensified zone generated by the time base points out which part of the waveform you're measuring and the amplitude is read out digitally on the crt.

Extend Your System's Sampling Performance

This sampler allows you to display time windows as narrow as 500 ps at sweep speeds to 100 ps/div. Choose from 4 other sampling plug-ins and 10 sampling heads for time window measurements ranging from 25 ps to 1 ns. All these sampling plug-ins, including the 7S14, will operate in any 7000 Series Mainframe. All will significantly minimize the recovery time limitations you might encounter with amplifiers in a real-time scope. And some sampling plug-ins include TDR capability.

pick this plug-in scope

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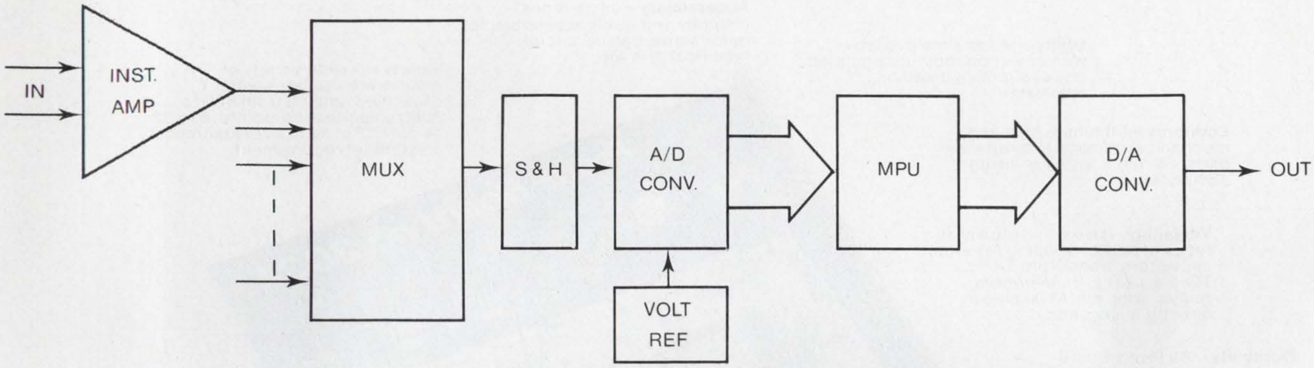

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National Semiconductor Linear Products

16-bit bipolar microcomputer family is 10 times faster than MOS-based systems

Designed to be six to ten times faster than available MOS microcomputers, a 16-bit bipolar μC under development by Parts Purchasing Corp. will be more than just another chip set. Included with the circuits, which are expected to be available in 1978, will be a floppy-disc operating system, an assembler, a linking loader, an editor, a 125-program library and a high-level system compiler that can reside in 8 kwords of ROM.

The μC chip set, organized to make use of a register-oriented architecture, will have a pipeline memory unit to attain the high speed. Major applications for the μC are expected to be communications processors and controllers, where bit and byte-manipulation capabilities are necessary.

Developed at a reported cost of more than $3 million by Transitron of Wakefield, MA, then cancelled as it neared the manufacturing stage in mid-1976, the Model 1601 μC is now being readied for production in 1978 by Parts Purchasing, a Fort Lee, NJ, firm that bought out Transitron's Microcomputer Division late last year.

The hardware includes eight general-purpose and three special-purpose registers, the program counter, stack pointer, and processor-status register. While an instruction is being executed, pipelined main memory fetches the next instruction. The vectored priority-interrupt system handles outside interrupts as well as the interfaces for floppy discs, card readers, 600-line-per-minute printers; and up to three TTYs.

Multiple addressing modes reportedly increase the basic instruction set of 96 commands to a

(continued on page 42)

Cosmac evaluation kit contains all hardware

With a CDP1802 Cosmac microprocessor and all other parts necessary to build a minimum microcomputer, the CDP18S020 evaluation kit requires just a power supply and terminal. Control logic and built-in displays provide facilities required for program debugging.

A RAM memory consisting of 256 bytes is included, as well as space for 30 additional memory ICs (for a total of 4 kbytes). The ROM memory consists of 512 bytes holding a utility program that performs commonly required functions: memory inspection and modification, start of program execution at a given location and terminal interfacing.

Controls on the evaluation board include a run program button to start program execution at memory location 0000, and a run utility button to start the utility program. A reset button initializes the CPU and board logic, and a continuous step control permits single-stepping through one machine cycle each time the run program button is depressed.

A 6 × 4 in. area of the board is free for I/O devices the user wants to add. ICs of various pin counts can be inserted into prepared positions and jumpered to an uncommitted 44-pin connector built on the board. The manual supplied with the CDP18S020 Evaluation Kit provides assembly instructions, operating procedures and data. In addition, the manual contains a set of memory, control, I/O and software-application notes that will be updated periodically.

The CDP18S020 evaluation kit costs $249 and is available from stock.

RCA Solid State Div., Rte. 202, Somerville, NJ 08876. (201) 685-6423.

CIRCLE NO. 502

(continued from page 41)
repertoire of 550 effective instructions by means of unindexed, pre-indexed, and post-indexed addressing in combination with absolute, relative, and based addressing up to 32 kwords.

Many of the μC's instructions execute in 200 ns. A register-to-register add takes 400 ns; a 16-bit multiply, 7 μs; and a 16-bit divide, 12 μs.

Branch instructions can read or test any bit in main memory without tedious masking operations. Any individual bit can also be set or reset directly without masking. Three types of multiply and divide instructions give either a signed 15-bit result, an unsigned 16-bit result, or a signed 31-bit double precision result.

All the software except the compiler was done and tested by Transitron, according to Marty Gordon, who headed the original project there. Parts Purchasing commissioned Computer Linguistics of Colony, NY, to build the CL/1 compiler to allow high-level writing of systems software by OEM.

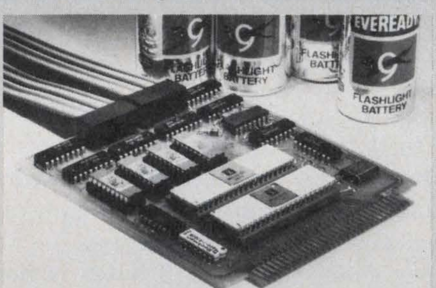
"CL/1 is a high-level language that combines data structuring as in COBOL and PL/1 with a procedural language much like BASIC," says Steve Herrick, President of Computer Linguistics. "It is less forgiving than most interactive BASICs, but delivers much tighter code. And it does allow bit and byte manipulation."

"The μC will first be available on an 8 × 9 in.-card," says Paul Tava, a consultant to Rudolph D. Pola. "This will contain the CPU's six chips (four-bit RALUs, a control ROM, and the micro control unit), 1 k 16-bit words of RAM, timing, decode, bus drivers, and a control-panel interface. The 8 k of compiler ROM can be rolled in and out of the μC's 32 k of addressable area, as needed, and is sold as an option on another card."

Only three other 16-bit bipolar "microcomputers" have been even quietly announced. The SBP9900 single chip and the 74S481, multiple-chip set, both from Texas Instruments, Dallas, TX, use memory locations in place of "hardware" working registers, and the 9440 from Fairchild, Mountain View, CA, is a single-chip I²L unit. Reportedly, the 9440 will emulate the Nova minicomputer instruction set.

Parts Purchasing Corp. CIRCLE NO. 503
Fairchild CIRCLE NO. 504
Texas Instruments CIRCLE NO. 505

CMOS microcomputer card handles 12-bit data words



Designed for use in battery-powered equipment, the LP-12 CMOS microcomputer provides almost full minicomputer power. The 12-bit CMOS computer uses the 6100 μP and is instruction-set compatible with Digital Equipment Corporation's PDP-8E.

Housed on a 4 × 5 -in. PC board are the μP, 256 words of RAM, a socket for the 1 k × 12 ROM (IM6312), a 12-bit latched input port, a 12-bit latched output port and a programmable interval timer. The operating current drain of the LP-12 is less than 20 mA at 5 V, typically.

Memory and I/O expansion cards are available for applications requiring additional capacity. All cards in the family are the same size as the processor board and have the same 64-pin edge connectors. Complete development support, including control panel, system monitor, ROM simulator and TTY interface, is available.

The LP-12 costs $195 when purchased in 100-piece quantities and is available from stock. *Cybertek, Inc., 222 150th Ave., Madeira Beach, FL 33708. (813) 392-3467.*

CIRCLE NO. 506

Central μP-based system controls remote station network

A μP-based system that controls in real time a number of remote stations via data-communication links has been introduced by Northwest Digital Systems, Bellevue, WA. The System 808 can be customized for individual data-acquisition requirements with a wide variety of function-oriented PC cards. To date, the unit has been used

(continued on page 44)

(continued from page 42)

successfully in power plants, sewage-treatment plants, pulp mills and wood-processing shops.

A remote station can be equipped with a multiplexer unit, which receives commands from a master control unit and, controlled by program subroutines, carries out required tasks. For easy updating, programs are stored in erasable PROMs. And by virtue of its μP, the remote multiplexer unit can carry out tasks under the control of its own internally stored programs.

Built around the 8080A μP, the System 808 has a memory capacity of up to 65 kbytes. Besides complete software support, the system offers surge protection, noise isolation, and various parity and redundancy checking routines for data transmission. Security codes for selective access are also provided on request from the company.

Analog I/O subsystem provides 64 channels

Designed for the National IMP-16 μP, the HMBL/06 analog system provides 32 analog-input channels as well as 32 analog-output channels. Each channel can be addressed individually.

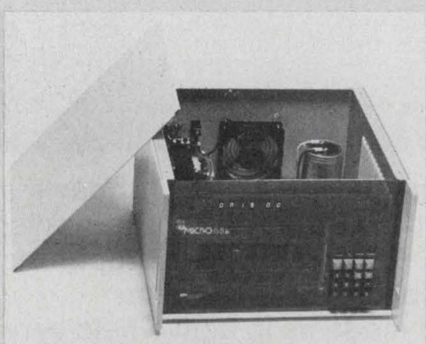
The HMBL/06 card set consists of four 8.5 × 11-in. printed-circuit cards that plug directly into a standard IMP-16P cage. The card set can be subdivided into the data-acquisition/control board and the d/a converter output boards. The HMBL/06-1 board contains the 32 multiplexed analog-input channels and the control circuits for the 32 analog-output channels. The HMBL/06-2 board has 11 d/a converters with a set of latches for each output channel. Resolution of the entire system is 12 bits.

Although the HMBL-06 card set is designed specifically for the IMP-16, it can be adapted to most microprocessors. Single-unit prices for the cards start at $1160 for the 06-1 and go to $1350 for the 06-2. Delivery takes 3 weeks.

AD Engineering, P.O. Box 153, Lilburn, GA 30247. Bernard Drew, Jr. (404) 534-9895.

CIRCLE NO. 507

Complete microcomputer makes use of EXORciser boards



A revised version of Electronic Product Associates' Micro-68, called the 68b, offers all the features of the Micro-68 and then some. Also based on the 6800 μP, the 68b is housed in an aluminum cabinet and has a 13-slot motherboard that is compatible with Motorola's EXORciser modules. The cabinet also contains a 20-A power supply.

The Micro 68b comes completely assembled with hex keyboard, six-digit LED display, 8 kbytes of RAM, a 1-kbyte monitor ROM and a CRT/TTY and audio-cassette interface. Price for everything is $1878, and delivery of the microcomputer system is from stock.

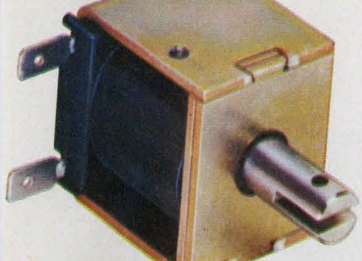
Electronic Product Associates, 1157 Vega St., San Diego, CA 92110. Patti Neumann (714) 276-8911.

CIRCLE NO. 508

Arithmetic program in chip form aids 8080 calculations

Available in an 8708 EPROM-compatible package, the FP708 arithmetic package gives 8080-based microcomputers arithmetic capability. Designed to be compatible with the Intel SBC 80/10 OEM or SDK 80 microcomputer systems, the chip plugs into one of the

(continued on page 46)



No. 28
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CIRCLE NUMBER 29

(continued from page 44)

existing 8-k PROM sockets on the board (location ϕCϕϕH).

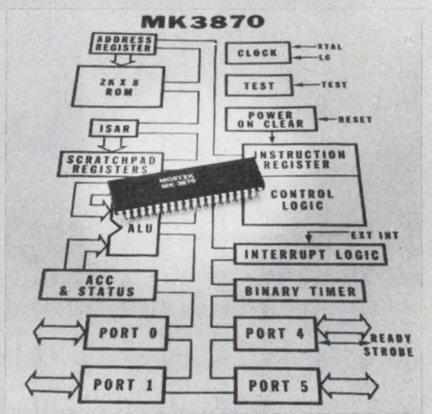
The FP708 is faster than a calculator chip, accurate up to 5 digits and requires no scratch-pad memory. It performs 16-bit binary floating-point arithmetic, such as adding, subtracting, multiplying, dividing, squaring and square-rooting. It also executes binary (16-bit)-to-BCD (five-digit), BCD-to-binary, floating-to-fixed-point, fixed-to-floating-point conversions, and utility operations.

No additional memory overhead is required to support the FP708 other than a maximum 26 bytes of stack memory. Typical execution times range from 0.4 ms for an add to 6.5 ms for a square-root operation. The single-chip FP708 is available from stock at a cost of $260. A 4-chip set, the FP702, that is compatible with the 1702A EPROM will be available soon.

Novonics, 602 Sciandro Dr., Greensburg, PA 15601. David Reese (412) 423-6633.

CIRCLE NO. 509

Single-chip F-8 microcomputer has 2-k × 8 storage on chip



With complete F-8 software and hardware compatibility and 2 k × 8 of mask-programmable ROM, the 3870 is a full microcomputer on a chip. Operating from a +5-V supply, the NMOS device can execute all F-8 instructions.

Systems built with the 3870 but eventually requiring more memory (ROM, RAM or PROM) or I/O can simply upgrade to the expandable MK3850 (F-8 CPU) without major redesigning or software development. Features included on the 3870 include 2 kbytes of mask-programmable ROM, 64 bytes of scratchpad RAM, a modulo "N" binary timer and multiple-clock modes.

The supply's ±10% tolerance allowance provides compatibility with any standard TTL-logic environment. Four modes of vectored interrupts are available, as well as a 4-MHz single-phase clock. Power dissipation is 300 mW, typical.

A complete line of developmental tools supports the 3870: the software development board (SDB-50/70), the application interface module (AIM-70) and the emulator-70 for field prototyping. Cost is less than $10 for plastic devices in quantities of 1000 units. The single-chip MK3870 will be available in 30 to 60 days in a 40-pin plastic or ceramic DIP.

Mostek, 1215 W. Crosby Rd., Carrollton, TX 75006. Don Ward (214) 242-0444.

CIRCLE NO. 510

Micro Capsules

Simplified versions of the PPS4/1 Series of μPs, housed in 28-pin DIPs, will be popping up by mid-1977 from Rockwell, Anaheim, CA. One version of the Model A75 will offer 640 bytes of ROM and 64 × 4 bits of RAM, and cost well under $10 in 1000-unit quantities. Another version, still being developed, will offer a high-speed counter on the chip. . . **An enhanced 6502 μP,** dubbed the 6552, will be available shortly from MOS Technology, Norristown, PA. The circuit is expected to handle a 6-to-7-MHz clock, yet be compatible with all 6502 systems. . . . **Joining forces with the Delco Div. of General Motors,** Motorola, Austin, TX, has landed a major contract for microprocessor products. The result will be full microprocessor systems in every GM car to control all engine braking and dashboard functions. . . . **A microprocessor two to three-times faster than the 1802 μP** from RCA, Somerville, NJ, should be coming out of the company's ovens by mid-year. The enhanced version reportedly will use silicon-on-sapphire CMOS technology to get the speed boost.

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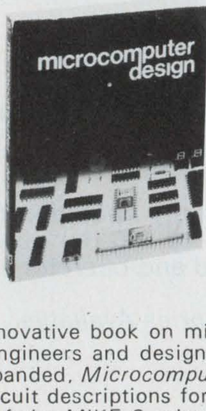

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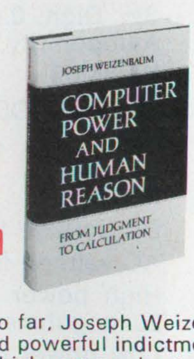

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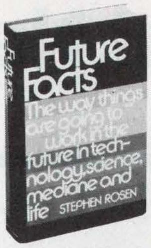

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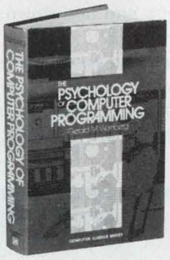

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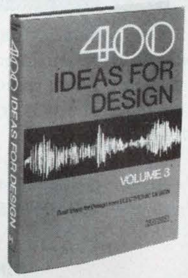

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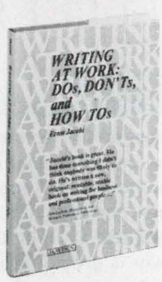

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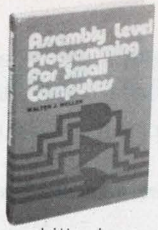

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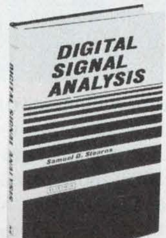

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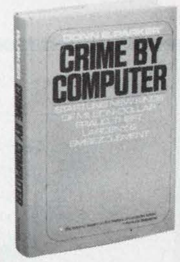

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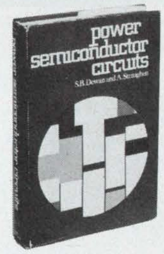

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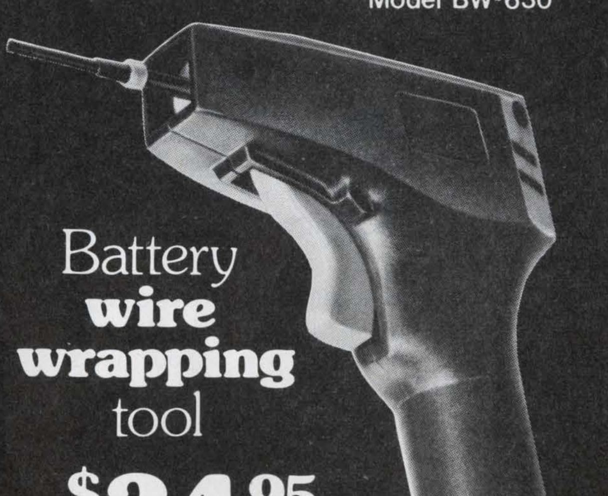

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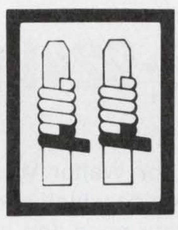

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CIRCLE NUMBER 34

Editorial

Teamwork

Charlie knew there were no more one-man shows. Business is too complex, these days, for one guy to do everything himself. Teamwork is essential.

So Charlie structured his company around teams. He had groups of engineers developing a system, instead of having one guy do the whole job.

But Charlie was a perfectionist. Nothing was ever quite good enough for him. So he challenged everything—and everybody. Instead of asking why something was done, he would assume it was done wrong. He always put his people on the defensive. And though he didn't do it deliberately, he always left his people feeling that anybody working for him must be slightly stupid.

When Charlie let a fellow know how badly he did something, he unwittingly suggested that somebody else might be doing it well. So he created a high coefficient of friction among his people. Before long, out of motives of self defense, Jack spent a good bit of time finding fault with Dave, who tried to find what Mac did wrong.

When members of a team met to discuss their projects, each man was busy protecting himself and stabbing the other fellow. It was obvious to Jack that he looked stronger if Dave looked weaker; and Dave felt more comfortable when Mac's mistakes were exposed.

Charlie, in turn, saw every exposed weakness as a revelation of Holy Truth and Progress. So he felt proud. He could see that his team concept was really working. But he was wrong.

He had indeed created teams. But he had also created an atmosphere that destroyed teamwork.

George Rostky

GEORGE ROSTKY
Editor-in-Chief

Powerful calculators for the blind

are now possible with a low-cost interface circuit. And variants are useful to the sighted as well.

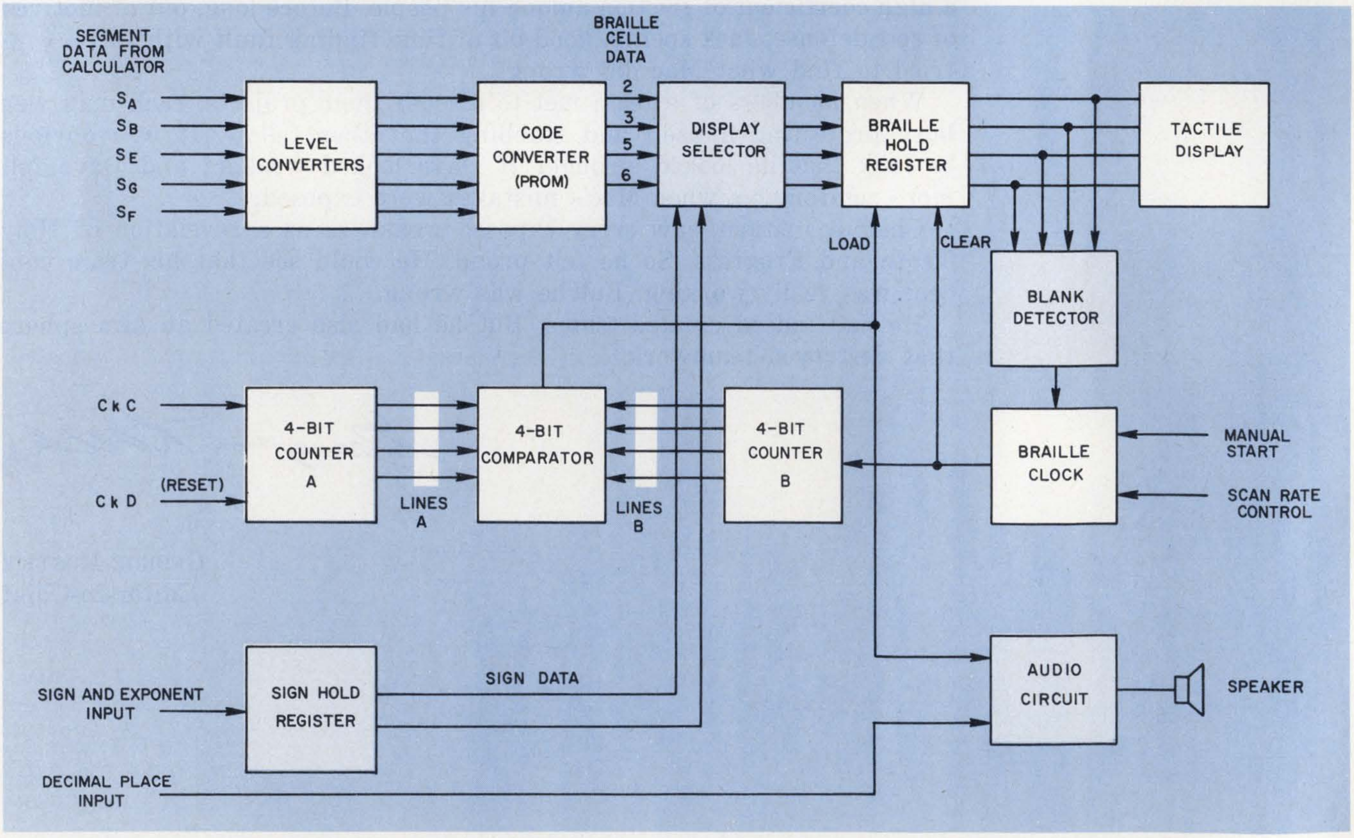
When you use your calculator, or read an instrument in your lab, do you ever wonder how blind engineers get along? Until recently "talking" calculators have made some limited computing available to the blind—but at a steep price. Now a Braille interface, adaptable to almost any calculator, can be assembled at a parts cost well below $100.

Furthermore, you can apply essentially the same circuit to everyday lab problems, such as converting digital instrument readings into numerical control outputs for motors and other mechanical actuators. With some additional buffering, you can also use the interface to display calculator or other LED displays on a video monitor, or TV screen.

Claus P. Janota, Research Assistant, Applied Research Laboratory, P.O. Box 30, State College, PA 16801.

The described Braille interface is used with a Texas Instruments SR-52 programmable calculator because of its powerful instruction set, magnetic-card programming and keyboard design. The keyboard's uniformly spaced rows and columns of keys, with tactile feedback, are well suited for operation by blind users. Moreover, a connector that permits attachment of a printer (Model PC-100) makes buffered control signals available, and thus simplifies interfacing.

The necessary segment-drive and timing signals for the interface are brought out through a small connector at the side of the calculator without impairing the instrument's normal use. The



1. **The highlighted components in the block diagram** convert 7-segment numerals to 4-point Braille. The rest of the circuit takes care of punctuation, such as minus signs and the decimal point.

display content of the SR-52 is available at the printer connector, but in such a complex form that it is easier to tap the LED drivers directly.

After clamping the calculator atop the interface circuitry, the blind user enters data, instructions and programs in the usual manner. He then initiates a Braille display sequence with a precision snap-action switch, and selects the speed at which he wants to scan the calculator's display. The output appears at a set of metal pins that are raised sequentially to represent the numeric data, including signs.

Get your scalpel ready

The surgery needed to modify the calculator is a snap, whether you want to build a Braille display or apply the interface for numerical control. You obtain the inputs from five drive lines for the calculator's seven-segment display (S_A, S_B, S_E, S_G, S_F in Fig. 1). You can leave out the bottom and lower-right segments of the display without causing any ambiguity. The five lines are first conditioned in the "level converter" which transforms the low segment-drive voltage to the 5.5 V required by the CMOS circuitry of the interface.

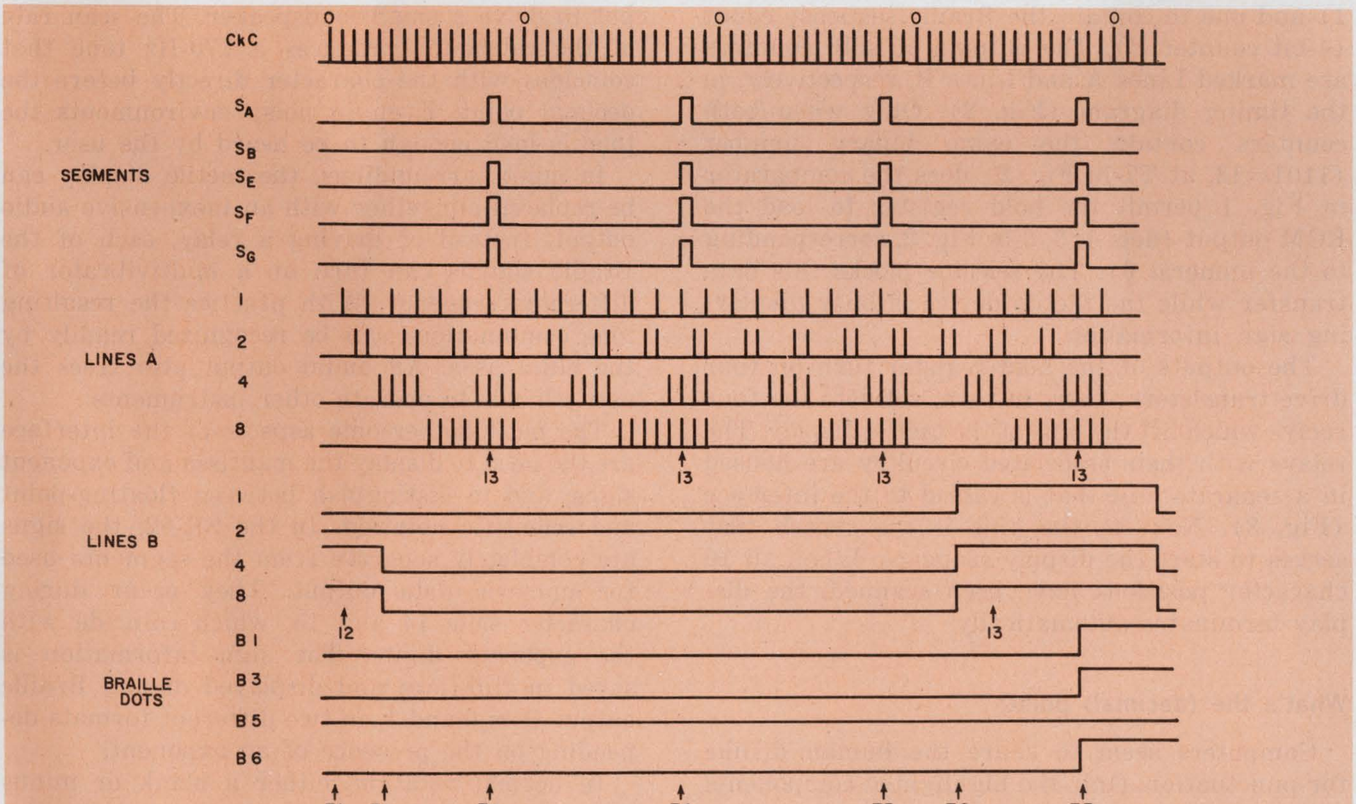
Now you can use the five drive lines as addresses to a programmable read-only memory. You obtain the proper combination of the four Braille display signals at the PROM's output. Four dots (2, 3, 5 and 6 of the complete six-dot Braille format) are sufficient to output numeric data, as well as the minus sign and some punctuation.

As the calculator scans the ten mantissa and two exponent digits, the corresponding Braille signals change accordingly. A scan cycle lasts about 1.3 ms and consists of 16 character slots. The first four aren't used to display characters. The scan travels from the most to the least-significant digit, with the exponent following the latter immediately.

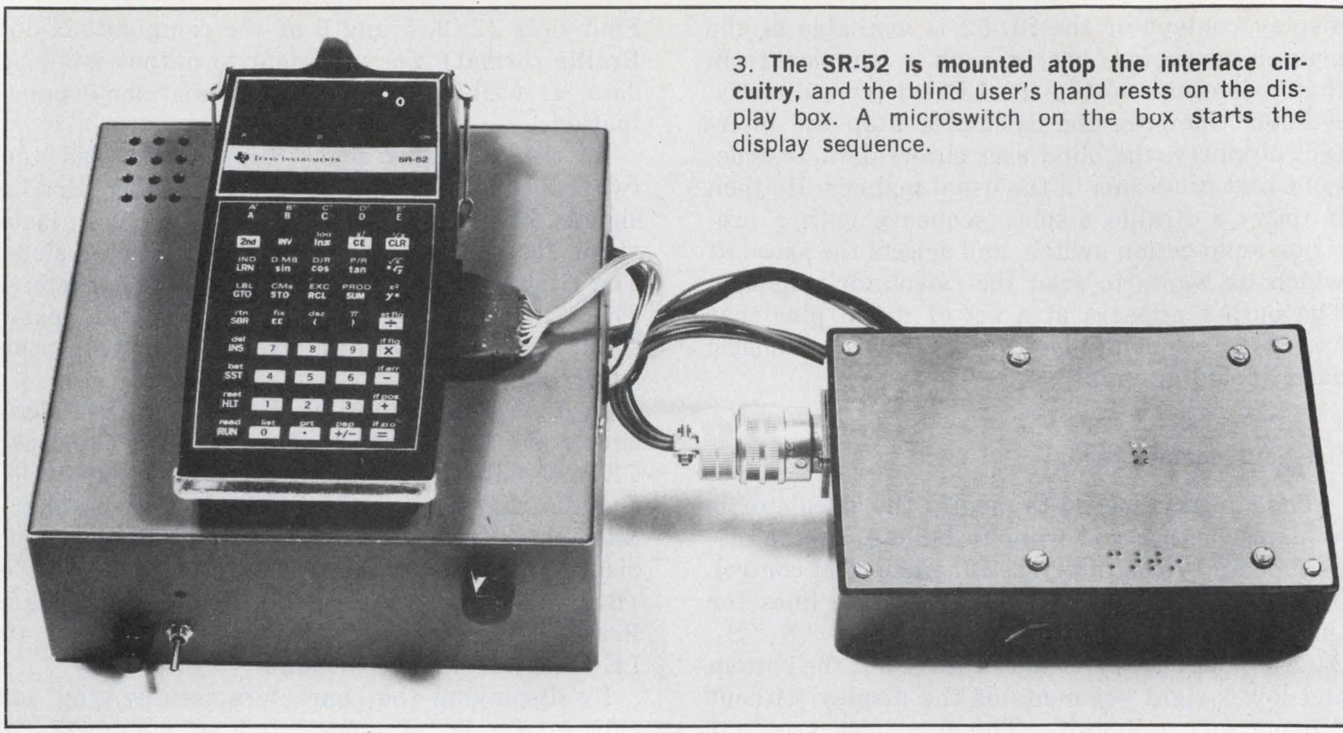
Two clock pulses are available from the calculator's printer interface: The display-cycle clock, CKD, signals the beginning of each display cycle, and the character clock, CKC, starts each character slot. Unlike the nearly simultaneous visual display of all 12 output digits, the tactile (Braille) output is displayed serially. A single Braille character can therefore replace the 12 LED digits of the calculator.

By displaying the characters serially, you not only save a lot of money, but actually make it easier for the blind user. He can keep his finger in the same position, sensing one digit after the other.

The calculator's scan rate of 1.3 ms/cycle is, of course, much too fast for Braille sensing. Experiments have shown that the blind user is most comfortable with a display rate of 0.5 to 2 s



2. **To activate the Braille relays,** the calculator count (A) and Braille count (B) must be equal (T7). Count A is also "13" at T3, T4 and T5, but count B is not until T6. The actual clock rate of B is much slower than shown.



3. **The SR-52 is mounted atop the interface circuitry,** and the blind user's hand rests on the display box. A microswitch on the box starts the display sequence.

for each character. The interface circuit must then activate the Braille display just when the right character is being strobed on the optical display.

You can solve the timing problem by using two 4-bit counters: One to keep track of the optical display character position (4-bit counter A, Fig. 1) and one to contain the Braille sequence count (4-bit counter B). The outputs of both counters are marked Lines A and Lines B, respectively, in the timing diagram (Fig. 2). Only when both counters contain the same binary number (1101=13, at T7 in Fig. 2) does the comparator in Fig. 1 permit the hold register to load the ROM output (dots 1, 3, 6 in Fig. 2, corresponding to the numeral 6). The selector blocks this data transfer while the tactile device is busy displaying sign information.

The outputs of the hold register turn on four drive transistors; they, in turn, activate the four relays which lift the pins of the tactile display. The relays with their associated circuitry are housed in a separate unit that is cabled to the interface (Fig. 3). Next to the pins is the switch that serves to start the display sequence. When all 16 character positions have been scanned, the display terminates automatically.

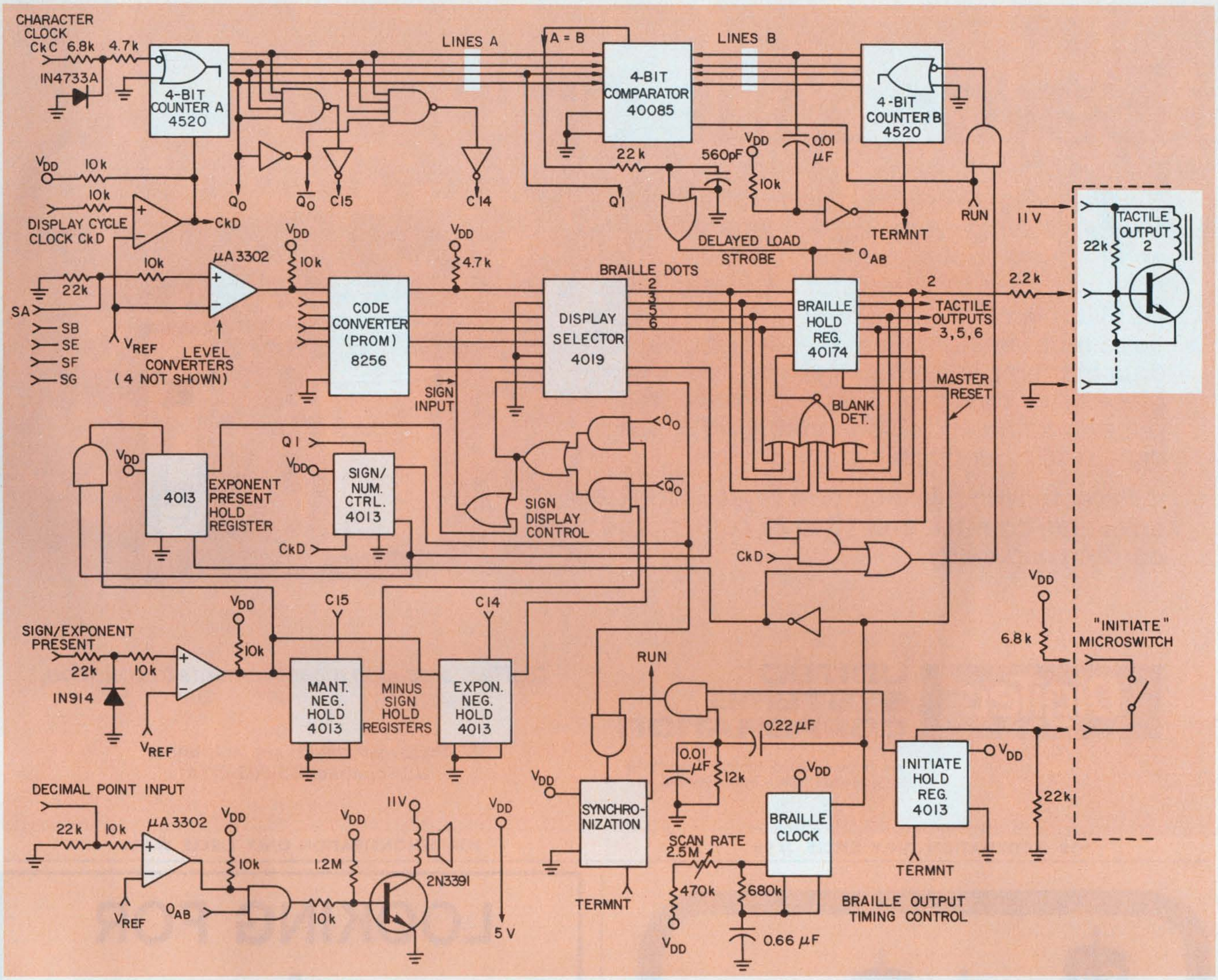
What's the (decimal) point?

Computers seem to share the human dislike for punctuation. Only the highlighted components of the block diagram (Fig. 1) and the full schematic (Fig. 4) handle numerals. All the remaining components keep track of punctuation. The decimal-point display of the SR-52 is really another segment of the associated digit, but is displayed simultaneously rather than serially. Tactile display of the decimal point would have required either another relay, or an additional display period. It is easier to AND the decimal point pulse of the calculator with the comparator output to drive a small loudspeaker. The scan rate of the calculator produces a 770-Hz tone that coincides with the character directly before the decimal point. Even in noisy environments the tone is loud enough to be heard by the user.

In quiet surroundings, the tactile display can be replaced altogether with an inexpensive audio output. Instead of driving a relay, each of the Braille signals can turn on a multivibrator of different frequency. With practice the resulting tone combinations can be recognized readily by the blind user. An audio output also frees the user's hands to operate other instruments.

The most bothersome aspects of the interface are the need to display the mantissa and exponent signs, and to distinguish between floating-point and scientific notation. In the SR-52, the signs are completely separate from the segments used for numeric data output. They occur during character slots 14 and 15, which coincide with the exponent digits. The sign information is saved in flip-flops and displayed during Braille output slots 0 and 1, in two different formats depending on the presence of an exponent.

In normal notation, either a blank or minus sign appears before the numerical output. For scientific notation, two signs are always generated, with the mantissa sign preceding the ex-



4. In the full schematic, the same circuit components are highlighted as in the block diagram of Fig. 1. Inputs from the SR-52 are located along the left edge. Only one of the four Braille relays is shown.

ponent sign. The normal Braille plus-sign was replaced with an apostrophe (dot 3 only) to save circuitry. When an apostrophe or two minus signs appear at the beginning of the readout, the user interprets the last two digits as an exponent.

At the normal display rate of one character per second, the resulting display cycle of 16 seconds can be frustrating, if the user selects only a small number of digits with the "fix" key of the SR-52. To complete a display cycle more quickly, the Braille counter advances at a much faster rate whenever a blank character occurs. This feature is also helpful during slow computations. The visual display then remains blank, and a very quick Braille display cycle results, with no pins being raised. When the blind user initiates a new display cycle a few seconds later, he can easily determine when processing is completed.

The SR-52 indicates computational errors by a blinking display. The resulting Braille display can be jittery depending on the relationship between the Braille output rate and the blinking rate. To verify the error condition, the blind user may have to initiate another display cycle, or change the output rate.

The interface circuit was implemented primarily with CMOS (series 4000) logic to reduce power supply requirements. A single voltage-regulator chip (µA78MG) can therefore power all 17 integrated circuits. Only the PROM is bipolar, with a 32 × 8 configuration to match the requirement (32 × 4 bits). The same PROM can also be programmed to allow conversion from BCD and 1-2-2-4 code to Braille, for interfacing with counters and digital voltmeters. To transfer data from a LED display to a serial link such as the RS232C, the PROM is coded with the ASCII information, and storage registers are added.

Because the Braille interface is external to the calculator, it can be used to drive other displays or communications lines. For example, calculators like the SR-52 can be interfaced easily with a speech synthesizer to produce a powerful "talking" scientific calculator. ■■

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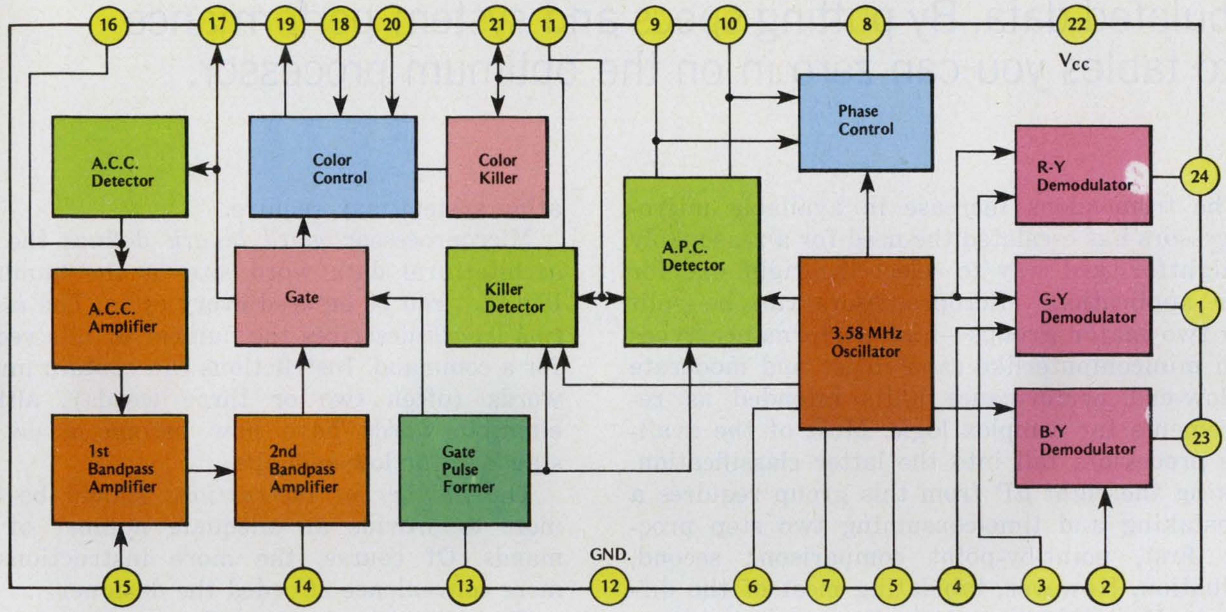

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CIRCLE NUMBER 37

Simplify low-cost μP selection with tabulated data. By putting specs and system performance into tables you can zero in on the optimum processor.

The tremendous increase in available microprocessors has escalated the need for a reasonably straightforward way to select the right one for your application. Microprocessors can be split into two major groups—high-performance types with minicomputerlike capabilities and moderate to low-end performance units intended as replacements for complex logic. Most of the available processors fall into the latter classification. Picking the right μP from this group requires a painstaking and time-consuming two step process: first, point-by-point comparison; second, evaluation. However, tabulating most of the different μP specifications into three major areas—general-processor characteristics, minimum usable system characteristics and maximum usable system characteristics—makes selection of the one or two most likely candidates from a dozen or more very easy.

You'll need more than just tables

Once the best prospects have been selected, you can evaluate them by using applications-oriented comparisons of software and timing called benchmarks. Benchmarking depends heavily on your application, and many experts agree that a general test of execution time really doesn't provide a true comparison.

Don't just pick the μP with the lowest cost. You must also know how much you need in support circuitry, memory, power supplies, input/output requirements, among other things—everything that's necessary to make a completely operating system.

Of course, evaluate the general characteristics of each μP. Some of the important parameters such as word length, cycle times, memory capacity availability of working registers, manipulation capabilities and the available instructions make a good starting point for μP selection. Table 1 summarizes the characteristics of four and eight-bit processors, without regard to what an operating system may require.

Microprocessor *word length* defines the basic architectural data word size of the number of bits that can be entered every cycle. The *instruction length* describes the number of bits required for a command. Instructions can contain multiple words (often two or three words), although eight-bit words have now become a de facto standard for low-end μPs.

The *number of instructions* should be 50 or more to provide an adequate number of commands. Of course, the more instructions, the more convenience afforded the designer.

The speed at which a μP can complete an instruction, or its cycle time, must often be factored into the selection process. To give you a rough idea of various μP speeds, *best, average* and *worst-case cycle times* are provided in Table 1. Actual μP performance must be evaluated on an instruction-by-instruction basis since each μP's instruction-cycle duration will be different even for equivalent commands. In some cases, similar instructions on different μPs can require twice as much time on unit A as on unit B.

Separate the program and data

In many cases, the μP offers *separate program and data memories* so that the instructions and data are contained in two different memories. By separating memories in small systems, programs can be efficiently packed in read-only memory (ROM) storage while data held in random access memory (RAM) can be separately organized and addressed.

The addressing range of the μP is determined by the *range of the program counter* (PC). Maximum program sizes range from 50 to 80% of the maximum PC range, and efficient μPs have a majority of single-cycle instructions to keep program sizes small. However, since most μPs also have multicycle instructions, the range of the PC doesn't always indicate the maximum number of instruction words.

If when a μP uses a separately addressed RAM *data memory* to hold changing data values typical requirements are for less than 256 words of

Howard Raphael, Low-end Product Manager, Intel Corp., 3065 Bowers Ave., Santa Clara, CA 95051.

Table 1. Basic microprocessor characteristics

	TI	Rockwell	National	National	National	AMI	Rockwell	Intel	GI	GI	Fairchild	National	Intel
Characteristic	TMS 1000, 1100, 1200 1300	PPS4/1	MM 5781/82	MM 5799	MM 5734	9209	PPS4/2	MCS-40	1640	1650	F8	SC/MP	8048
Word length	4	4	4	4	4	4	4	4	8	8	8	8	8
Instruction length	8	8	8	8	8	8	8	8	12	12	8	8	8
Number of instructions	46	50	45	45	45	28	50	60	27	27	70	46	96
Typical cycle time (μs)	12	24	10	10	14	15	5	10	1	1	6	20	2.5
Minimum cycle time (μs)	12	23	10	10	14	15	5	10	1	1	2	10	2.5
Maximum cycle time (μs)	12	60	20	20	28	30	10	20	2	2	13	46	5
Separate program/data memory	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
Program counter range (words)	2 k	1.3 k	2 k	1.5 k	630	756	4 k	8 k	256	512	65 k	65 k	4 k
Data memory range (words)	64/128	96	1 k	1 k	55	64	256	1 k +	32	32	65 k	65 k	320
Number of interrupts	0	0	0	0	0	0	0	1	0	0	Mul	1	2+
Number of levels of interrupt	0	0	0	0	0	0	0	1	0	0	1	1	1
Number of working registers	2	5	4	1	0	1	1	24	32	32	16	1	8/16
Number of register banks	–	–	–	–	–	0	–	2	–	–	–	–	2
Bit manipulation instruction	Yes	Yes	No	No	No	Yes	Limited	Limited	Yes	Yes	No	No	Yes
Nibble manipulation	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes
Byte manipulation	No	No	No	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes
Decimal arithmetic	No	Yes	Yes	Yes	Yes	No	Yes	Yes	No	No	Yes	Yes	Yes
Binary arithmetic	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Indirect addressing	No	Yes	No	No	No	No	Yes	Yes	No	No	Yes	No	Yes
Indexing	No	No	No	No	No	No	No	No	No	No	No	Yes	No
Address stack depth	1	2	2	2	1	2	2	7	2	2	1	3	8
Full range jump	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Relative jump	No	Yes	No	No	No	No	No	No	No	No	Yes	Yes	No
Number of conditional jumps	1	30	10	10	8	5	5	16	3	3	9	3	14
I/O expandability	Limited	No	Limited	Limited	No	No	Yes	Yes	Limited	No	Yes	Yes	Yes
Memory expandability	No	No	Yes	No	No	No	Yes	Yes	No	No	Yes	Yes	Yes

RAM (see Table 1). Most low-end μPs use separately addressed data and memory to facilitate organization of data values.

Often during processing, an external device may have to communicate with the μP. One way to do so is to interrupt the processor. The *number of interrupts* the μP can handle tells you how many devices can signal at the same time and be ranked and handled in turn. Every interrupt handled by the processor can be assigned a priority and the *number of interrupt levels* used to determine which input gets serviced first, second, and so on by the processor.

Interrupts come from many sources

However, a μP may have many sources of interrupts—but only one level. An example of a single level is the ability of a device to stop the main processing program and jump to a special service routine that is followed when an interrupt occurs. But if during execution of this new program a more urgent interrupt comes in (a higher priority), the complete interrupt routine being executed must be completed, and operation returned to the main program before the next interrupt can be handled.

On the other hand, more powerful machines are designed to accept another interrupt command even as they execute an interrupt. The process of storing the current routine and jumping to the next is called nesting and the number of possible levels is determined solely by the number of registers used to store the nested information. As you can see from Table 1, most low-cost μPs have only a single level of interrupt capability.

Data entering the processor are usually fed into one of the *working registers*. These registers are as long as a CPU word and can be manipulated by the instructions (the accumulator is considered a working register). Working registers often serve as a source or destination for data manipulated by an accumulator as well as data coming from or going to either an I/O-port, memory or the arithmetic-and-logic section. Ideally, all working registers should be accessible by all register instructions; when they are, they are called symmetrical.

Often, processor operations require that only a single bit in a word be altered. The ability of a μP to perform *bit manipulation*—setting, resetting, testing and so on—is a must for many I/O applications. Although you can circumvent this manipulation by using logic operations for setting, resetting and shifting data into the carry bit for testing, you will need more time for processing.

To process data in four-bit chunks (often referred to as nibbles), some μPs permit *nibble manipulation*—especially μPs intended to handle binary-coded decimal data. A good eight-bit μP should be able to handle both sizes of data words. Eight-bit processors, of course, have flexible *byte-manipulation* capabilities, but the mark of a good eight-bit unit is its ability to manipulate four-bit chunks of data.

Since a great deal of data appear in BCD form, the ability of a μP to do *decimal arithmetic* can be very important. Man-to-machine interfaces can be simplified if μPs can handle BCD data without having to convert to binary for each operation. Nevertheless, every processor chip is designed to handle *binary arithmetic*.

Accessing the available memory of each μP system is often done with direct addressing. But in cases where the address is not within the direct range, *indirect addressing* is available on some μPs to permit the unit to fetch an operand or data word from any memory location. Sometimes, an additional addressing scheme, called *indexing*, is available.

Indexing lets the μP add the contents of a predesignated register to the current address value and use the resulting sum as the new address. This technique is most advantageous when program memories are greater than 8-k words since addresses can be quickly modified. Indexing permits a block of memory to be rapidly pointed to from the current address, and is useful when you must access multiple data fields and tables without changing the basic address.

Stack depth limits subroutine nesting

During execution, a program will often jump to one or more subroutines. Depending upon the *address-stack depth*, the number of jumps can be restricted. This number can be especially important if subroutines must be nested. Three jumps should be the absolute minimum. Seven jumps are desirable if an interrupt operation must also be considered. Not only is the program-counter value stored in the stack, but during an interrupt all processor-status information can be stored there automatically.

Whenever the processor departs from sequential program flow, it jumps to a new address. If a *full-range jump* is possible (a jump to anywhere in the program up to full addressing range), simple programs can be written. Without an available full-range jump, multiple-page jumps are often required to reach the desired program point.

Program operation may be transferred to a location plus or minus some number of instructions from the location of the jump. When this type of *relative jump* is available, addressing can be made very simple. But when a program is developed with a symbolic assembler, relative jump

Table 2. Minimal system characteristics

	TI	Rockwell	National	National	National	AMI	Rockwell	Intel	GI	GI	Fairchild	National	Intel
Characteristic	TMS 1000, 1100, 1200 1300	PPS4/1	MM 5781/82	MM 5799	MM 5734	9209	PPS4/2	MCS-40	1640	1650	F8	SC/MP	8048
Number of required ICs	1	1	3	1	1	1	2	4	1	1	2	6+	1
Program memory size	1k/2k	1.3k	2k	1.5k	630	756	2k	1k	256	512	1k	2k	1k
Data memory (word)	64/128	94	160	96	55	64	128	80	32	32	64	256	64
PROM development available	Yes	Yes	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
PROM/ROM systems-identical (*Phys) (**Elec)	No Yes	No No	No No	No No	No No	No No	No Yes	No Yes	No Yes	No Yes	No Yes	Yes Yes	Yes Yes
I/O lines	23/25/28	31	18	18	24	33	36	21	24	24	32	23	27
I/O lines that can be inputs	4	31	5	5	4	9	30	17	24	24	32	11	24
Strobes, controlling flags and test lines	0	0	5	4	2	12	0	1	5	0	0	9	5
I/O lines that can be outputs	19/21/24	18	13	13	1	8	30	20	24	24	32	12	24
Bidirectional buses (I/O)	No	No	No	No	No	No	Yes	No	Yes	No	No	Yes	Yes
Timers	No	No	No	No	No	No	No	No	No	No	Yes	No	Yes
Timer resolution	–	–	–	–	–	–	–	–	–	–	8	–	8
Timer accuracy μs/bit	–	–	–	–	–	–	–	–	–	–	15.5	–	80
Event counter	No	No	No	No	No	No	No	No	Yes	Yes	No	No	Yes
Serial I/O	No	Yes	Yes	Yes	No	No	No	No	No	No	No	Yes	No
Clock on chip	Yes	Yes	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
Clock R/C controlled	Yes	Yes	No	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes
Reset on chip	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	No	Yes
Reset separate pin	No	Yes	No	No	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Power consumption (mW)	75	70	200	150	125	160	800	1000+	N/A	N/A	600	1000+	400
Low-power standby	No	No	No	No	No	No	No	Yes	No	No	No	No	Yes
Operating supply voltage	15 V	15 V	9 V	9 V	9 V	15 V	5 V, -12 V	15 V	15 V	5 V	5 V, -12 V	5 V, -12 V	5 V
Technology	PMOS	PMOS	PMOS	PMOS	PMOS	PMOS	PMOS	PMOS	NMOS	NMOS	NMOS	PMOS	NMOS
Package pin count	28/40	42	24/24	28	40	40/28	42/42	28	40	28	40/40	40	40

*Physical refers to pin compatibility between ROM and PROM parts.
**Electrical refers only to code compatibility.

instructions aren't as necessary. And, care must be taken in programming when relative jumps are used with multicycle instructions since a jump may inadvertently specify a noninstruction location.

External-system hardware can often determine when a jump occurs, and the *number of conditional jumps* can become important in many control applications. Conditional jumps are often performed after testing the carry flip-flop, special flags, test lines, accumulator bits, register values, and so on. The more conditional jumps available, the better.

The ease of *memory expansion*—if it can be expanded—can be an important factor, especially if high-level development languages are used. Memory expandability can often be likened with *I/O expandability,* since there are many combination circuits that contain RAM or ROM (or both) and I/O ports. However, a high degree of expandability permits dedicated peripheral I/O devices to feed into a single μP, which can cut system cost in the long run.

Look closely at a minimal system

Moving from basic processor characteristics to minimum usable system characteristics should give you a better idea of what's necessary to get a system going. Often, the *minimum number of required ICs* needed to support a system, including the μP, can be an eye opener.

As shown in Table 2, the number can range from one (just the μP) to more than six. The basic system includes the circuitry to generate the clock, handle 16 lines of I/O plus program and data-memory (ROM and RAM) storage.

While one-chip systems are often desirable, the basic system should be flexible and expandable. In many of the small systems, the *program memory* is on the processor chip. In general, at least 1 kword is desirable since it can cover about 70% of all current low-end applications. The *data-memory size* should also be as large as possible—64 bytes is comfortable, and no less than 32 bytes should be considered.

Being able to use programmable ROMs to develop programs is an absolute must. (Of course, the ultimate production line will use masked ROMs.) Without *PROM development,* the only other alternative is software simulation, which can cause several ROM mask iterations before all bugs are eliminated. If possible, *PROM/ROM systems* with identical pinouts for ROMs and PROMs should be used—they minimize the number of circuit alterations and allow rapid field changes with little work.

To control the transfer of data between the μP and peripherals, use the special *I/O lines* available from the μP. However, lines for interfacing only to specialized chips in multichip CPU organizations don't count.

I/O lines help determine flexibility

The number of *I/O lines that serve as inputs or outputs* can make the system more or less flexible than is readily apparent. For example, if a unit has 25 I/O lines but only four can be used as inputs, additional I/O devices may be required for certain applications to get more input lines—even though some output lines aren't used.

Special lines such as *strobes, test lines, flags and control lines* are convenient extensions of the I/O capabilities and should be considered a "bonus" for the extra control functions they provide. In many cases the I/O lines help control the data flow on a *bidirectional bus* that mates with all memory and peripheral circuits. However, some μPs use separate input and output buses to simplify their hook-up to systems.

Processors specifically designed for control applications often have a *timer* that can accumulate elapsed time. It can be an independent register fed by the system clock. To be a useful subsystem, the timer should: (a) operate independently of and simultaneously with the μP and (b) indicate an overflow by means of an interrupt when the terminal value is reached. These features, along with the control instructions included in the command set, allow total asynchronous operation between the timer and μP.

The *timer resolution and accuracy* must also be examined. For instance, an eight-bit timer register can accumulate 256 timing intervals, each as long as the period of the clock. When intervals of time longer than 256 periods must be timed, a software counter must be created to count the number of times the register timer overflows. By knowing the software counter status and how long the service routine takes, you can measure very exact long-time intervals.

Often you don't want to count clock pulses, but rather the occurrences of an external event. To this end some μPs include an *event counter* on the chip—it increments a register every time a transition occurs on the input line specifically enabled to record external event—and not clock—pulses. Instead of, or in addition to, offering parallel I/O capability, some devices provide a *serial I/O* capability. And when available, the serial I/O port should be capable of independent and asynchronous operation; otherwise it is little better than a software-controlled shift register.

Choose between internal or external clocks

To do all the timing, all processors need some form of *clock.* Many have the circuitry already built into the μP chip, with just the crystal or a

Table 3. Maximum operating system options

	TI	Rockwell	National	National	National	AMI	Rockwell	Intel	GI	GI	Fairchild	National	Intel
System support	TMS 1000, 1100, 1200 1300	PPS4/1	MM 5781/82	MM 5799	MM 5734	9209	PPS4/2	MCS-40	1640	1650	F8	SC/MP	8048
Standard memory interfacing	No	No	Limited	Limited	No	No	No	Yes	No	No	Yes	Yes	Yes
Custom memory components with I/O	No	No	No	No	No	No	Yes	Yes	No	No	Yes	No	Yes
General purpose I/O peripheral	No	No	No	No	No	No	Yes	Yes	No	No	Yes	No	Yes-2
UART/USART	Yes	No	No	No	No	No	Yes	Yes	No	No	No	Yes	Yes
Keyboard display peripheral	Yes	No	On chip	On chip	On chip	On chip	Yes	Yes	No	No	No	No	Yes
DMA peripheral	No	No	No	No	No	No	No	No	No	No	Yes	No	Yes
Interrupt peripheral	No	No	No	No	No	No	No	Yes	No	No	Yes	No	Yes-2
Printer peripheral	No	No	Yes	Yes	No	No	Yes	No	No	No	No	No	No
Timer peripheral	No	No	No	No	No	No	No	Yes	No	No	Yes	No	Yes
Slave processor	Yes	No	No	No	No	No	No	No	No	No	No	No	Yes

resistor and capacitor needed to set the clock frequency.

For nonprecision applications, the R-C combination is truly a low-cost alternative. Once started, the minimal system should be easy to *reset*. This capability is often overlooked when a system is being selected. If the signal isn't generated on the chip or with a simple R-C network (during power-up), you must use a comparatively elaborate one-shot circuit that increases system cost.

Operating cost, or *power consumption*, can often limit the choice of usable μPs. Depending upon the technology used to build the μP and the clock frequency, power consumption can vary a factor of 10 or more. In case of power failure, some μPs can be transferred into a sort of *standby*, or "idle" mode to minimize power consumption.

Even the operating *supply voltages* play an important part in device selection—TTL-compatible (+5 V), single-supply operation is the most common requirement, but many processors or memory circuits require one or two additional supplies. The cost of additional power supplies must be added to the basic system cost.

To guarantee system operation, stay with well established technologies and avoid nonstandard packages whenever possible. Exotic technologies may be just beyond the current production capabilities while nonstandard packages may cause production handling problems.

If the μP family of components is expandable, the manufacturers should, ideally, have a large assortment of memory and I/O circuits available. Some of the more commonly sought-after peripheral and I/O support features are listed in Table 3. As indicated, many of the inexpensive μPs do not offer much in the way of peripheral support.

There are two major approaches to memory support for low-cost systems—off-the-shelf and custom memories. The custom memories are usually a form of ROM, PROM or RAM with a built-in I/O capability while the off-the-shelf units can be ROMs, RAMs or combinations thereof. Custom circuits can usually replace two or three standard memories with just a single circuit and thus decrease system cost.

I/O peripheral circuits can shave cost to the bone. Some peripheral control circuits are even more complex than the μP. These peripheral controllers usually operate independently of the μP and, since they permit the processor to perform another function simultaneously, often speed up system performance. ■■

Bibliography

1. Raphael, H., "Evaluating a Microcomputer Input/Output Performance," *Electronics*, Aug. 19, 1976.

2. Raphael, H., "Interfacing μC Displays: Trade Offs and Techniques for Two Basic Strategies," *Digital Design*, September, 1976.

3. Raphael, H., and Hou, S., "Test Equipment For Microcomputers," *Machine Design*, Aug. 26, 1976.

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Control your analog variables digitally.

Once you've got a sensor that transduces your analog variable to frequency, you can close the loop with a μP.

You can control analog functions by discrete steps within a closed loop. Temperature, for example, is a continuous variable well suited to digital feedback control. One digital system for servo control of temperature uses a thermistor-controlled oscillator as the sensor, and gates, counters and a clock for the controller. Or, if you want the controller to be remarkably effective while also adaptable, you can easily design one that uses a microprocessor.

For an example of a basic digitally controlled closed loop, look at the system in Fig. 1. The sensor is a thermistor whose resistance, R_{th}, is inversely proportional to the oven's temperature. Since the frequency, f_b, of the unijunction-transistor (UJT) oscillator is inversely proportional to R_{th}, this frequency is directly proportional to the temperature. The f_b is compared to the constant frequency of the clock, f_c. The comparator is simply an AND gate whose output follows f_b when f_c is high, as shown in Fig. 2.

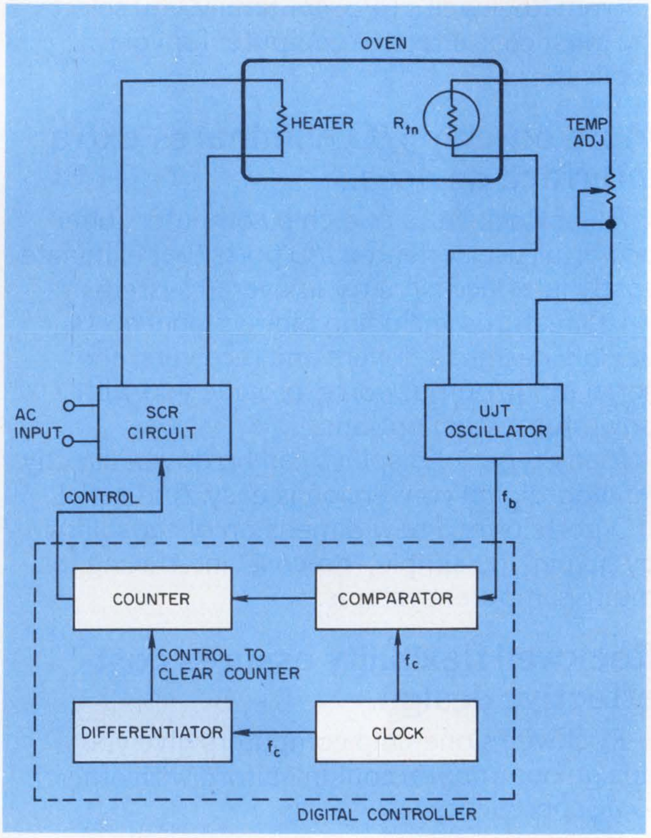
The clock signal is differentiated to extract its positive-going edge, which pulses the clear input of the counter. Thus, the counter is clear at the start of each counting period.

Output pulses from the comparator increment the counter. If the counter reaches a preset limit, its control output turns off the SCR powering the heater.

Therefore, if the counter overflows, f_b—thus the temperature—is too high and the heater is turned off. If, on the other hand, the count doesn't reach the limit, the temperature is too low. The counter's control output then keeps the SCR on and the heater stays energized.

Any microprocessor will do

The digital controller can be made more flexible by incorporating almost any microprocessor. The most widely used, Intel's 4-bit system, which includes the 4201 system clock, 4040 CPU and 4308 ROM with I/O ports (Fig. 3) works well. You can enter the reference temperature through input-port 0 and control the SCR circuit via output-port 1 on the ROM chip. Send the feedback-frequency signal from the UJT oscillator to the CPU's test input. Use the ROM to store the system's control program and then you can start the system with an interrupt.



1. The basic digital controller compares two frequencies. One frequency represents the desired temperature while the other pulse train represents the actual temperature.

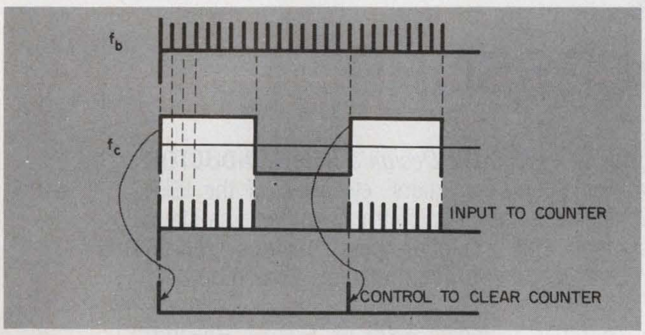
Looking at the system from the μP, code for the required temperature is entered through the input port, and an interrupt starts the system. Since f_b is directly proportional to temperature, its pulse period is inversely proportional. Thus, the time the CPU's test input stays high is also inversely related to temperature.

While its test input is high, the μP executes a counting loop whose result is feedback count. Then, the feedback count, c_b, and the reference code are compared (Fig. 4). If c_b is lower than or equal to the reference, c_r, the temperature is too

A. Singh, Assistant Director, Metropolitan Technical Institute, Saddle Brook, NJ 07662, and **Dr. R. Mekel,** Professor of Electrical Engineering, The City College of New York, 139 St. and Convent Ave., NY 10013.

Table 1. Program for μP feedback temperature control using Intel's MCS-40 system

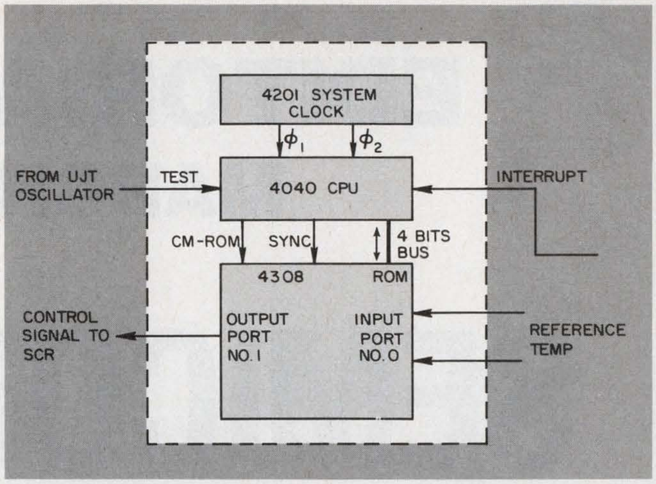
Label	Operation	Explanation
	NOP	; Restart
	NOP	
	JUN START	
	FIMO,OO	; Initialization
	SRCO	
	RDR	
	XCH 15	
	FIM2, 10	
PWROFF:	CLB	; Power off
	SRC 2	
	WRR	
BEGIN:	JCN TN, COUNT	; Count f_b
	JUN BEGIN	
COUNT:	IAC	
	JCN TN, COUNT	
	SUB 15	; Compare c_b and c_r
	JCN CN, PWRON	
	JUN PWROFF	
PWRON:	LDM 01	; Power on
	SRC 2	
	WRR	
START:	EIN	; Interrupt enable



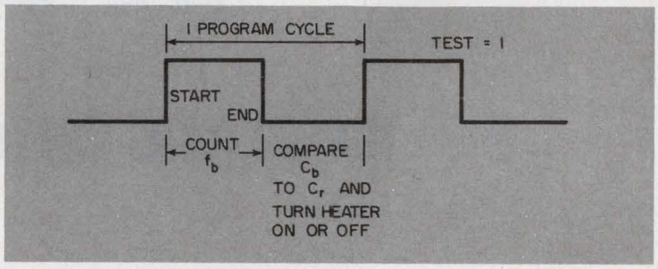
2. **Pulses representing the sensed temperature are gated** into the controller's counter by the reference waveform. The counter is cleared at the start of the reference wave.

high, so the SCR stays off. If c_b is higher than c_r, the temperature is too low, so the heater is turned on. This control strategy is implemented in the flow chart of Fig. 5.

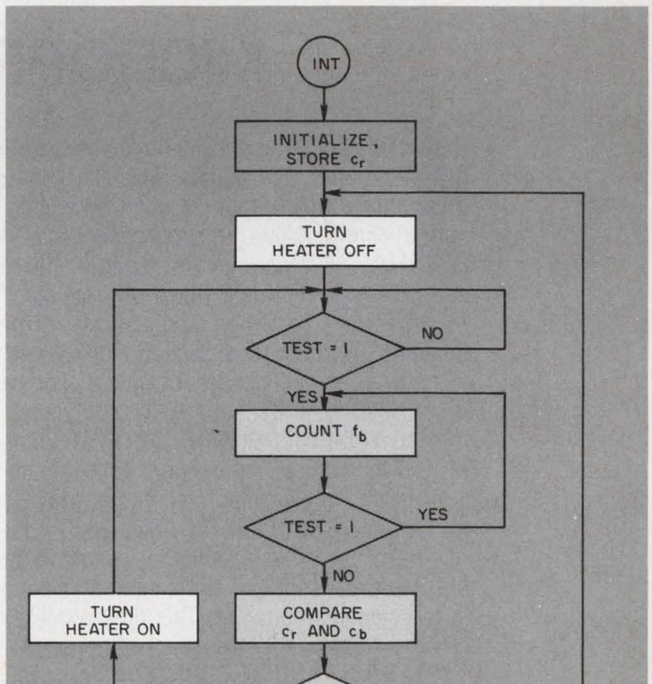
A variable resistance in series with the thermistor (Fig. 1) tunes the UJT oscillator's frequency to correspond to the reference-frequency code, which should be designed to give maximum accuracy. The basic program, shown in Table 1, contains 16 temperature settings. But, by altering the program slightly, you can increase the number of settings up to the maximum the ROM will allow. ■■



3. **The μP-based controller stores the reference** in an index register. The control signal is delivered to the system from ROM output port 1, while the sensor signal enters the CPU via its test input.



4. **The μP controller's program cycle has two phases.** In the first part the temperature-proportional frequency is counted. Then count and reference are compared.



5. **The flow chart leads to one crucial test**—that for $C_b - C_r$. When the result is positive, the temperature is too low and the heater is activated; when negative or zero, the test result shuts off the heater.

EDITORIAL PREVIEW
MARCH 29 ISSUE

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MICROPROCESSORS

Here it comes . . . . the issue you've been waiting for . . . *Electronic Design's* **SEMICONDUCTOR SPECIAL.** First, the editors will take you to Philadelphia for a designers' eye view of the IEEE International Solid-State Circuits Conference. It's a major wrap up of such timely subjects as static and dynamic RAMs, master-slice LSIs, 100-ps bipolar logic, higher-speed designs, MNOS EAROMS, I^2L macromodels, CMOS C^2L microprocessors, user-programmable microcomputers and MOS sampled-date signal processing.

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MICROPROCESSORS. "The 3000 Series Bit Slice" — part 12 of *Electronic Design's* popular microprocessor basic series — describes the operation and advantages of one of the first bipolar bit-slice processors. A companion article continues *Electronic Design's* series on microprocessor-based systems software. This time processing speed and I/O interfaces are examined.

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SEMICONDUCTOR SPECIAL

ANOTHER REASON WHY ELECTRONIC DESIGN IS THE BEST READ ELECTRONICS PUBLICATION IN THE WORLD!

Resolving DMM accuracy: Though many engineers argue otherwise, more digits can bring more accuracy. The problem really lies in what is meant by 'accuracy.'

Is a DMM with 4-1/2 digits inherently more accurate than one with 3-1/2 digits? Contrary to popular opinion, the answer is "Yes"—at least for meters with sensing accuracies of the order of 0.1% of the reading, or better.

Practically speaking, inaccuracy in a DMM reading is the total ambiguity of the displayed value. It consists of a series of terms: the basic front-end sensing accuracy of the meter (through the converter), temperature coefficient, drift with time, short-term stability and resolution. The nominal accuracy usually quoted for a meter is its sensing accuracy.

When accuracy is of primary importance, most users remember to account for tempco and drift with time, but all too often overlook the resolution. In fact, on dc scales with 0.1% nominal accuracy it is not uncommon for resolution beyond 3-1/2 digits to be referred to as "empty," or superfluous, resolution, with no contribution to increased accuracy. But such descriptions are far from true.

Defining terms

Before the importance of the resolution term can be illustrated, some ground rules must be established. (Some potential confusion should also be dispelled by the new ANSI C39.6 DMM standard due for adoption during 1977.) The rules are as follows:

- Define accuracy as a percentage of the reading, not as a percentage of full scale (with or without overrange).
- Assume that both gross instability in the least-significant digit (or last few digits) and the dead zone around zero aren't problems for the DMM under consideration.
- Remember that resolution, the smallest detectable variation in the measured quantity, changes with the scale setting.
- Bypass the confusion caused by the term, "overrange," by defining full scale as the maximum value that can be displayed at a given scale setting. In other words, a scale with a maximum reading of 1.999 is called a 2-V scale, not a 1-V scale with 100% overrange.

Robert Metzler, Product Marketing Manager, TM500 Line, Tektronix, Inc., P.O. Box 500, Beaverton, OR 97077.

Suppose you need to make dc voltage measurements with a maximum inaccuracy approaching 0.1%. Will a 3-1/2-digit meter with a stated accuracy of 0.1% of the reading ±1 count and with scales of 2000 V, 200 V, 20 V and so on, meet your requirements? Is a 4-1/2-digit, 0.1% meter with the same ranges an improvement? Or do you really need a 4-1/2-digit, 0.01% instrument?

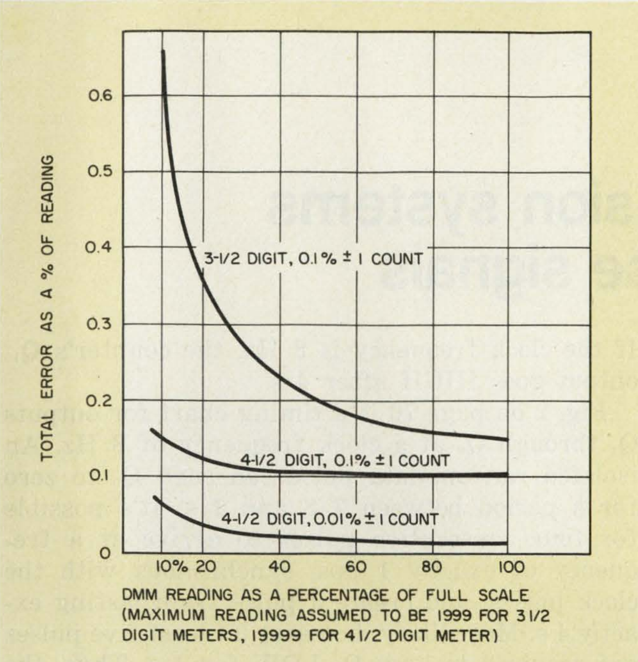
Which fork to take?

Figure 1 shows how a ±1-count factor, when added to the basic percentage accuracy, causes the total error in the displayed value to vary with the percentage of full-scale reading. At the low end of the range, the ±1-count factor dominates the total error of the 3-1/2-digit meter. At 10% of full scale, for example, the resolution factor pushes the total inaccuracy to 0.6%. Obviously, the meter falls far short of the 0.1% accuracy requirement—even before you account for tempco and drift with time.

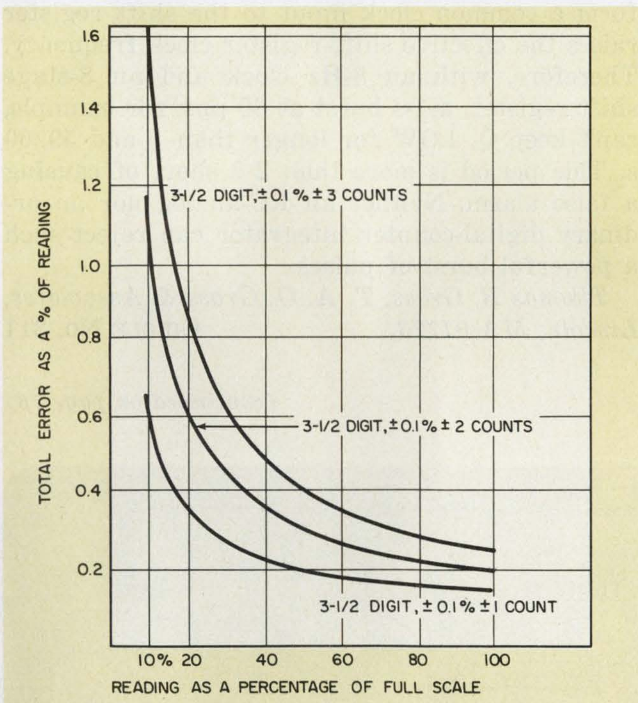
The 4-1/2-digit meter represents a four-times improvement at 10% of full scale, the worst case. Below that point you must, of course, drop to the next scale to maintain accuracy. Chances are the 0.15% maximum error will be close enough to the 0.1% requirement. Note, however, that if 0.1% or better is required across the whole range, you may need a 4-1/2-digit, 0.01% meter —a far cry from what you might have assumed from a casual examination of accuracy.

Of course, if the count uncertainty increases to ±2 or even ±3 counts, the situation becomes dramatically worse (Fig. 2). Such uncertainties may well be encountered on ac scales. Also note that the resolution term in the total-error equation becomes even more substantial in those DMMs that fall short of the so-called 100% overrange case—that is, where the maximum full-scale reading is 1199 or 1499, rather than 1999.

Obviously, then, more digits do improve the ac-



1. **How the ±1-count uncertainty affects** a DMM's accuracy: Error soars at the low end of the scale of a 0.1%, 3-1/2-digit meter. A 0.1%, 4-1/2-digit unit, however, gives four times better accuracy.



2. **When the count uncertainty increases,** as it does in many ac meters, errors get worse. In 3-1/2-digit DMMs, still more error is piled on when 100% overrange doesn't mean a count of 1999.

curacy in a value displayed by a DMM. An overall accuracy approaching 0.1% requires a 4-1/2-digit meter, while 0.01% requires 5-1/2 digits. By their very nature, 3-1/2-digit DMMs are restricted to accuracies on the order of 0.5%. ■■

Ideas for Design

Digital-integrator for intrusion systems discriminates against false signals

Many optical intrusion-sensor systems switch a comparator when a target moves in the optical field of view. However, automobile headlights passing in the night or cloud shadows during the day can cause false alarms. Therefore, some improved systems count several zero-voltage crossings of the comparator output in a given time before "sounding" an alarm. A generally accepted norm is four crossings in 4 s.

Such systems, however, fail to account for the frequency of the zero crossings. The systems can't distinguish between a short burst of pulses generated by static and the slower pulse rate created by an intruder.

Fig. 1 employs a digital-integrator system that not only can be set for a minimum zero-crossing frequency, but also can reject high-frequency bursts.

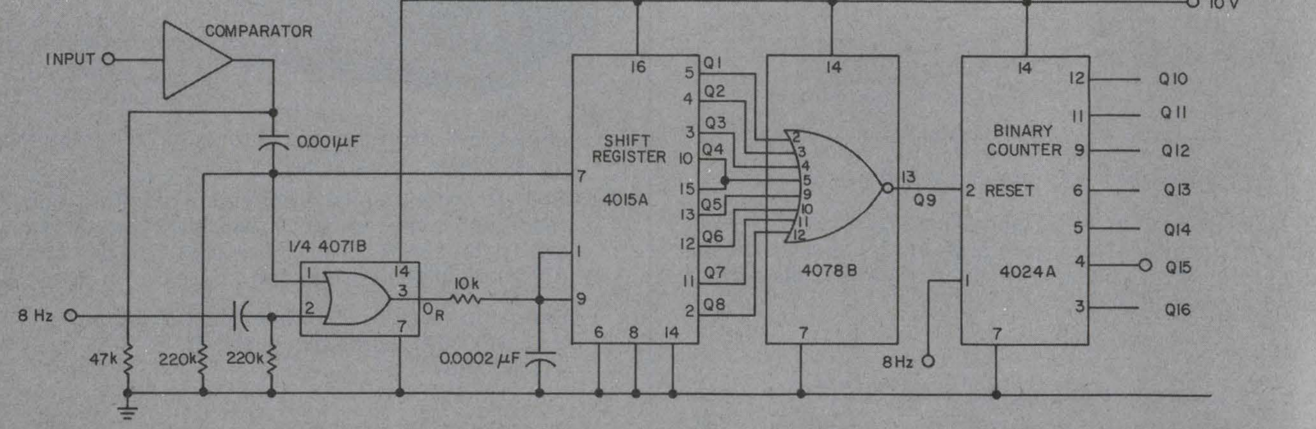
The circuit's clock frequency determines the low-frequency limit, and coupling the zero-crossing data into the shift-register's clock input rejects the high frequencies. An eight-stage shift register (CMOS 4015A) temporarily stores the entry of intrusion data into the system. And an eight-input NOR gate (CMOS 4078B) and a binary counter (CMOS 4024A) determine the presence and duration of the intrusion signals. The NOR-gate output allows the counter to count clock pulses when the gate's output goes LOW. If the clock frequency is 8 Hz, the counter's Q_{15} output goes HIGH after 4 s.

Fig. 2 on page 76 is a timing chart for outputs Q_1 through Q_9 at a clock frequency of 8 Hz. An isolated random-data pulse can send Q_9 to zero for a period between 7/8 and 1 s. It's possible for four consecutive pulses to arrive at a frequency of exactly 1 pps, synchronous with the clock pulses, and create a pulse train lasting exactly 4 s. More likely, however, at least five pulses are required to keep Q_9 LOW for 4 s. Thus, the condition for an alarm to sound is best stated as "more than four pulses arriving at a rate faster than 1 pps, but not so fast that Q_9 can return to a HIGH level before 4 s has elapsed."

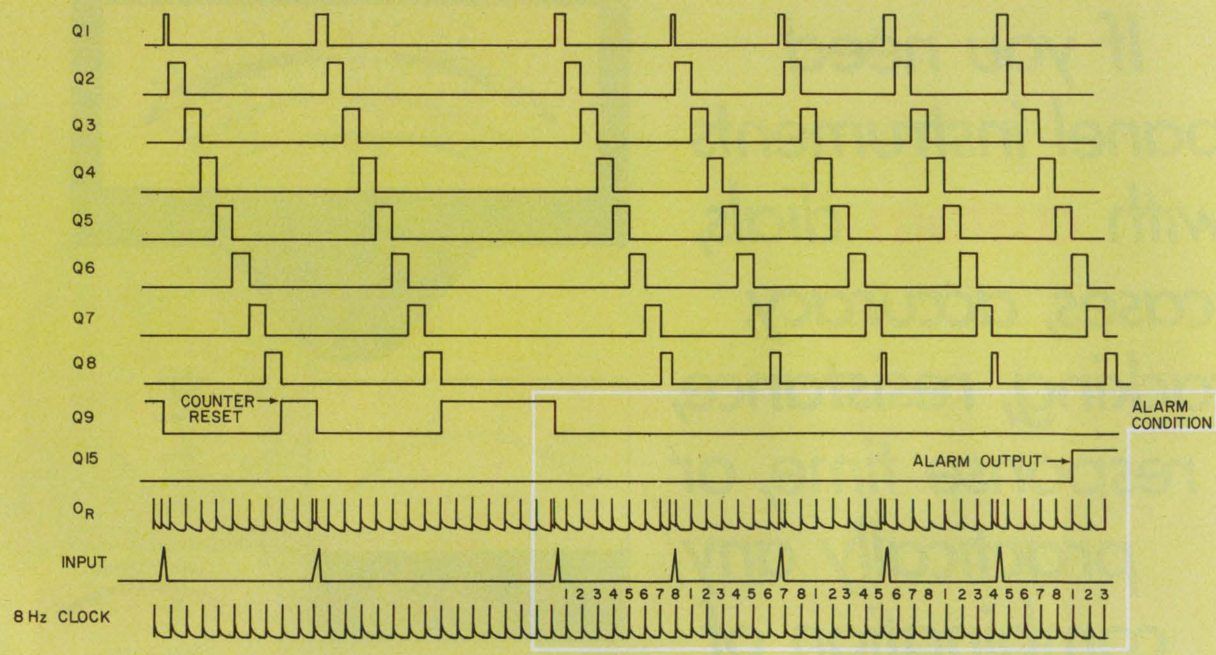
Coupling the data-input and clock pulses to form a common clock input to the shift register raises the effective shift-register clock frequency. Therefore, with an 8-Hz clock and an 8-stage shift register, a 1-s burst at 60 pps, for example, can't keep Q_9 LOW for longer than 1 and 59/60 s. This period is more than 2 s short of causing a false alarm. Neither an RC-analog nor an ordinary digital-counter integrator can reject such a powerful burst of pulses.

Thomas B. Gross, T. A. O. Gross & Associates, Lincoln, MA 01773. CIRCLE NO. 311

(continued on page 76)



1. In this digital integrator, inputs from a comparator enter a serial-in/parallel-out shift register and are shifted through eight stages by positive-going clock transitions or data pulses. When Q_9 is LOW because of data in the register, the binary-counter counts clock pulses.



2. **A high logic level at Q_{15} signifies an alarm.** This condition occurs after 4 s of a continuous-LOW output at Q_9, when four or more pulses enter the shift register faster than 1 pps.

TTL oscillator interfaces data for display by a television set

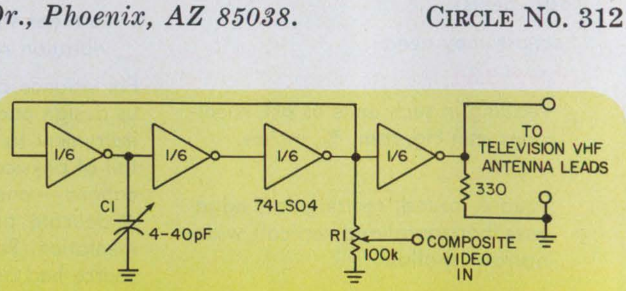
If you have worked with TV displays for data terminals or even electronic games, you know that interfacing to the TV can be a tough problem. Direct connection into the video section of the television is generally a nuisance. Moreover, many television sets aren't transformer-isolated from the power lines, so direct connection to the video circuit can be dangerous to humans and equipment alike. And, of course, broadcasting your composite video signal to the television can generate unwanted rf radiation.

A TTL oscillator running near its maximum switching frequency has harmonics well into the TV-band frequencies. To interface a TV, simply mix the oscillator with the composite video signals and feed the combination into the TV-antenna jack (Fig. 1). The TV set will detect and display the signal in a normal fashion. The mixer and i-f sections of the set pass the TTL signal, and the video section detects and locks onto the superimposed video information.

Three gates of a 74LS04 form the oscillator circuit. Capacitor C_1 allows fine-frequency adjustment to a specific television channel and helps stabilize the circuit. Potentiometer R_1 acts as the mixing input and provides adjustment of the contrast ratio for the best viewing. A fourth gate buffers and helps stabilize the oscillator.

To avoid interference problems, place the circuit in a small metal box and mount the box on the back of the TV. Run the power—which can also be supplied by a small battery within the box—and the composite signal in shielded cables.

Harry L. Latterman, Digital Design Engineer, Courier Terminal Systems, 2202 E. University Dr., Phoenix, AZ 85038. CIRCLE No. 312



A simple oscillator circuit can provide interfacing to an ordinary TV set for displaying games and data-terminal or computer outputs. Capacitor C_1 adjusts the frequency to match available channels, and R_1 sets the contrast ratio of the display.

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3. **Select a programmer system that's approved by PROM manufacturers.** Make sure the programmer manufacturer can supply you with approved programming specifications. Otherwise you run the risk of wasting PROMs and time. Approved specifications reduce your programming costs and help you reach 100% yields.

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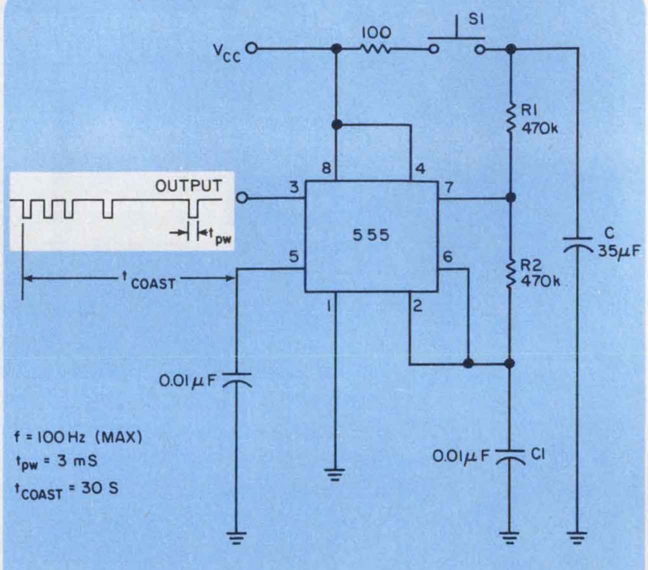
Timer pulses coasting to a stop heighten electronic game realism

An electronically simulated game of roulette can be made more realistic, if the circuit duplicates the action of a real wheel as it slows its spin before finally stopping. And similarly, the excitement of an electronic dice game is heightened, if the flashing numbers come to rest slowly rather than abruptly.

Once again the ubiquitous 555 timer comes to the rescue. The circuit in the figure produces a slowly diminishing clock rate, while maintaining a constant output pulse width. When S_1 is pressed, capacitor C charges to V_{CC} almost immediately and the 555 oscillates at its highest frequency. After S_1 is released, C supplies charge to C_1. But as C discharges, C_1 takes longer and longer to reach 2/3 V_{CC}, the trip point of the internal comparator, so the oscillation frequency slows.

The discharge time, t_{pw}, as C_1 discharges to 1/3 V_{CC} via R_2 and the open-collector output (pin 7) of the 555 remains constant, so the output pulse width, t_{pw}, remains constant, but the time between pulses increases until C no longer can supply enough charge to recharge C_1 to 2/3 V_{CC}. When oscillations cease, the pin-3 output of the 555 remains HIGH.



A train of constant-width pulses at a gradually diminishing rate is produced each time the switch S_1 is pressed.

For small output-pulse widths (C_1 small), C can be a relatively small electrolytic. For example, if R_1 and R_2 are each 470 kΩ and C_1 is 0.01 µF, then C need only be 35 µF for a 30-s coast time. The frequency then starts at 100 Hz with 3-ms negative-going pulses and gradually coasts down to zero frequency, while maintaining the 3-ms pulse width over the total 30-s period.

William D. Kraengel, Jr., Electronics Engineer, Ground Systems Equipment Corp., 65 Sunset Rd., Valley Stream, NY 11580.

CIRCLE NO. 313

IFD Winner of October 25, 1976

Maynard J. Kuljian, Product Manager, Applied Materials, 3050 Bowers Ave., Santa Clara, CA 95051. His idea "Battery Monitor Operates on only a Few Microamperes" has been voted the Most Valuable of Issue Award.

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Redesigned FET looks promising for audio use

High-power, high-frequency static-induction transistors (SITs) from Japan look like promising broadband devices. Audio units containing the SIT have demonstrated low noise, low distortion and high power capacity.

Fabricated at Tohoka University's Research Institute of Electrical Communication and the Semiconductor Research Institute in Sendai, the SITs are redesigned field-effect transistors (FETs) with only a small distance between gate and source that reduces the series-channel resistance. Characteristics include high input impedance, high transconductance and negative temperature coefficients.

Like the standard FET, the SIT uses a flow of carriers from the source electrode to the drain that is controlled by the gate-electrode voltage. Impurity concentrations in the SIT channel region are very low so the region between the gate and drain is depleted by only a small drain voltage.

Increased drain voltage reduces the potential barrier that controls the flow of carriers, and the barrier moves towards the source electrode. Drain current increases.

Two versions of the SIT have been made. One is a 200-MHz, 40-W, UHG SIT that can operate at 1 GHz and produce 6-W output. Its upper-limit frequency is more than 2 GHz. The other is a microwave device with a maximum frequency of more than 29 Hz.

The source and gate of both versions lie on one surface, directly connected by an impurity region. For the microwave transistor, the source width is less than 2 μm. The structure of the device depends on etching accuracy, not on mask alignment.

The UHF SIT has a drain-gate breakdown voltage greater than 300 V, a source-gate breakdown voltage greater than 100 V, a maximum drain current greater than 2 A, an input capacitance less than 30 pF and a maximum frequency of 1 GHz.

With the results obtained from present SITs, Japanese researchers believe it will soon be possible to obtain 30 W at 1 GHz. However, for an output of 100 W at 2 GHz, a new structure will have to be developed.

Stripline packaging made simpler, cheaper

A microwave technique for stripline packaging eliminates conventional heavy and expensive machined castings as well as the undesirable air gap between the two clamped dielectric faces of the stripline. Developed by Exacta Circuits of Selkirk, Scotland, the microwave-bonded packaging method is based on simple bonding and plating operations.

The simplest form of microwave-bonded packaging is incorporated in a single-function passive component, such as a coupler or filter. The copper circuit is produced on a dielectric polytetrafluorethyline (PTFE) substrate with print and etch techniques.

A top PTFE layer is then bonded to the substrate. To do this, a copolymer film with a dielectric constant close to that of the PTFE material is inserted between each half of the dielectric structure. A permanent bond is then made under heat and pressure.

Since the copolymer film flows and conforms to the surface irregularities of the copper pattern, air gaps are eliminated and a sealed, strong homogenous bond with a uniform dielectric constant throughput is provided.

The exposed edges of the composite PTFE package are then metalized. First, a 5-μm layer of copper is deposited on the PTFE with a chemical-mechanical bond. The thickness is then built up to 40 μm by an additional electroplated deposition of copper. This deposit has excellent adhesion and provides a light, pore-free metalization that completely shields the component. (A metal casing isn't needed.) A final finish of gold, nickel or tin-lead is added.

New fabrication method speeds up ECL counters

A new way to build high-speed logic devices has enabled its developer, Toshiba Ltd. of Tokyo, to construct ECL divide-by-four counters capable of operating at 1.4 GHz.

Three features of the technique help increase the operating speed:

- Spacing between the aluminum conductors is reduced to only 2 μm by applying a dual-space lift-off technique developed by Toshiba. This improves the high-frequency characteristics of the transistors fabricated in the IC chip.
- Shallow and uniform-base regions are created with a boron-ion implantation. This increases the transistor's cut-off frequency. Arsenic-doped oxide and polycrystalline silicon doped with arsenic layers are used as the diffusion source for the emitter diffusion. This results in a shallow emitter and a higher impurity concentration.

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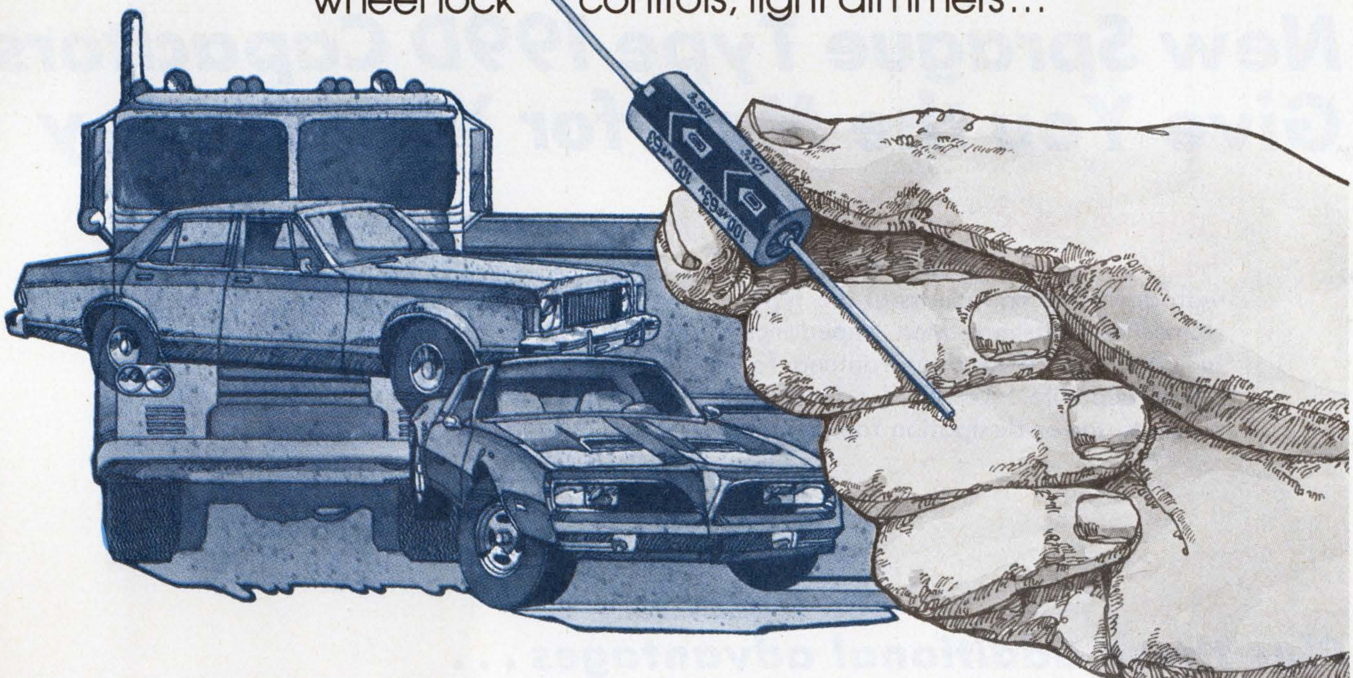

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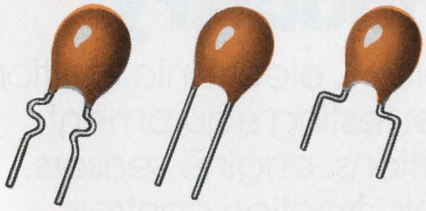

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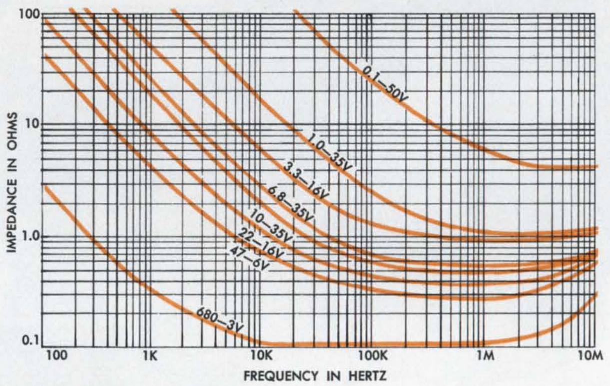

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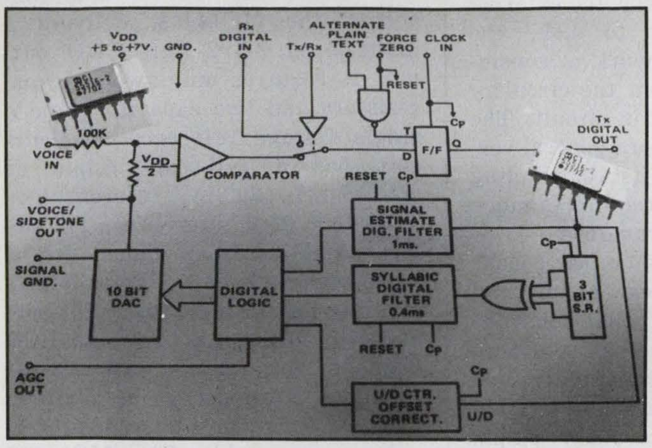
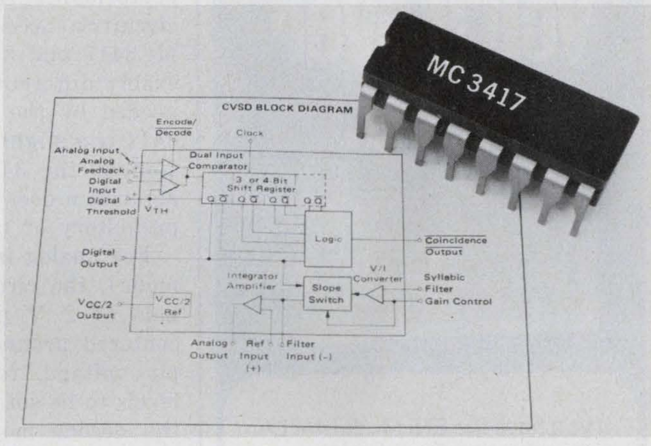
Encoding/decoding circuit handles audio signals of up to 3.3 kHz





Harris Semiconductor, P. O. Box 883, Melbourne, FL 32901. Ron Gadway (305) 724-7045. P&A: See text.

Capable of either encoding analog inputs into serial digital output signals or of decoding digital signals into analog outputs, an all-CMOS circuit, using continuously variable-slope delta modulation (CVSD), can handle analog signals of up to 3.3 kHz. Introduced by Harris Semiconductor, the circuit comes in two versions—identical except that the 55516 uses a 16-kHz clock and the 55532 uses a 32-kHz clock.

While Harris was developing its CVSD encoders/decoders, Motorola was designing similar units—the MC3417 and 3418. Although not pin-compatible with the Harris circuits, the Motorola devices perform an identical task—converting analog inputs into serial digital outputs and visa-versa.

For analog encoding, the Harris circuits are designed to handle a maximum input of 1.4 V rms, while presenting an input impedance to the source of 100 kΩ. The signal, however, must be ac-coupled to the encoder input since it appears in series with half the supply voltage.

When used as a decoder, the circuits deliver a 1.4-V rms signal while again presenting an impedance of 100 kΩ to the load. However, the zero signal-reference level on the output is at one-half the supply voltage.

The CVSD circuits require a clock signal to perform either operation. When the units are used to decode signals, the clock must be phased with the digital input so that a positive clock transition occurs near the middle of each received data bit.

The operating mode is determined for both circuits by a single logic-controlled input line. In addition several other control lines permit the user to force a zero in resetting registers and causing the unit to either go into its "quieting mode" or have an alternate plain-text pattern (quieting pattern) transmitted. (A quieting pattern is an idle-channel audio output of alternate 12-mV steps of 1's and 0's at one-half the clock rate.)

Typically, digital input levels for ONE and ZERO are 4.5 V and 1.5 V, respectively. Digital output levels are usually 5.5 V and 0.5 V, respectively. Also, an automatic-gain-control logic output can go to

Motorola Semiconductor Products, P.O. Box 20912, Phoenix, AZ 85036. Steve Faulkner (602) 962-2294. P&A: See text.

0 whenever the recovered signal reaches one-half of the full-scale value.

The output signal-to-noise ratio of the encoder/decoder depends on both input frequency and amplitude. For a 300-Hz, 1.4-V-rms input, the SNR is 20 dB min, while at 1000 Hz and 500 V rms it drops to 14 dB. And, the reconstituted signal amplitude will be within ±0.5 dB of the original input value. Of course, the lower the input-signal frequency, the lower the distortion since more samples can be taken per period. Signal resolution is specified at 0.1% of the supply voltage, and either unit is designed to operate from 5-to-7-V supplies. When biased at 6 V, the circuit draws a typical supply current of only 1 mA.

Three versions of the Harris encoder/decoder are available: an industrial unit that operates over −40 to +85 C (-9 suffix), a MIL device for −55 to +125 C (-2 suffix), and a fully inspected MIL

(continued on page 84)

INTEGRATED CIRCUITS

(continued from p. 83)

unit, also for the −55 to +125-C range (-8 suffix). All units are available in 14-pin DIPs for $27, $61.50 and $83, respectively (100-up prices). Flat-packs are available at a cost of $54, $109 and $158, respectively. Delivery is from stock.

Either Motorola circuit can encode or decode signals at clock rates of up to 200 kHz and handle audio signals of up to 4 kHz and deliver commercial telephone-grade performance. However, the external circuitry necessary to make the MC3417 and 3418 work is considerably different from the circuitry needed by the Harris circuit. The 3417 is a slightly more general version of the 3418—its companding algorithm does not require as much prehistory of the waveform.

For analog inputs (in the encode mode), the circuit can handle signals of 2 V pk-pk that must be centered around one-half the supply voltage, for proper threshold levels to be set. Analog outputs (in the decode mode) are 2-V pk-pk, maximum, and also centered at one-half the supply voltage. Input and output impedances are approximately 100 kΩ and 600 Ω, respectively.

All logic control inputs and outputs are CMOS or TTL-compatible, with a drive-current capability of 3.5 mA, maximum, for low levels and −0.38 mA, minimum, for high levels. An offset voltage of 20 mV, maximum, for the 3417 and 2 mV, maximum, for the 3418 appears at the output, in addition to the level-shift mentioned earlier.

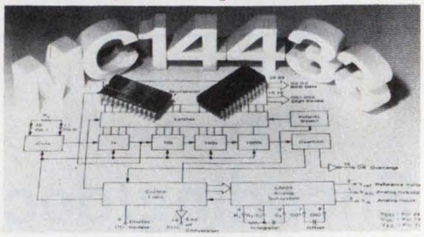
When biased at 12 V and operating at a 37.5 kilobit clock and a 1-kHz input with c-message weighting, the signal-to-noise ratio ranges from 20 to 33 dB, depending upon input level (inputs vary over a −48 to +18 dBm range). Signal resolution (sensitivity) depends on the supply voltage and can be as small as 5 mV.

The 3417 and 3418 are built with I^2L technology and can operate from 4.75-to-15-V supplies. Power consumption with a 5-V supply is a low 20 mW. Available in a 16-pin ceramic DIP, the 3417 costs $6.95 and the 3418, $7.95. Either type is available from stock.

Harris Semiconductor **CIRCLE NO. 302**

Motorola **CIRCLE NO. 303**

3-1/2-digit DVM IC needs just 5 parts



Motorola, 3501 Ed Bluestein Blvd., Austin, TX 78721. (512) 928-2600. From $9.97 (100-up); stock.

A single-chip CMOS a/d converter, the MC14433, delivers a multiplexed 3-1/2-digit BCD output. It requires only two external resistors and two capacitors and a single voltage reference. The circuit has a full-scale range of ±199.9 mV (200-mV reference) or ±1.999 V (2-V reference). The device boasts an input impedance of more than 1000 MΩ. Typically dissipating only 8 mW, the unit operates well with both LED and LCD displays. Accuracy is ±0.05% of reading, autopolarity is built-in and overrange or underrange signals are available. The MC14433 is packaged in a 24-pin DIP in either plastic ("P" suffix) or ceramic ("L" suffix).

CIRCLE NO. 306

Line transceivers use differential data lines

Texas Instruments, P.O. Box 5012, Dallas, TX 75222. Dale Pippenger (214) 238-2011. From $1.97 (100-up); stock.

Four differential line transceivers, the SN55118, SN55119, SN-75118 and SN75119, interface between TTL digital systems and differential data transmission lines. They are especially useful for party-line (data-bus) applications. Each circuit combines a three-state differential line driver and a differential-input line receiver in one package, both of which operate from a 5-V supply. Driver inputs and receiver outputs are TTL compatible. The SN55118 and SN-55119 operate over −55 to 125 C and the SN75118 and SN75119 operate between 0 and 70 C. The 55118 and 75118 come in 14-pin DIPs and the 55119 and 75119 come in 8-pin mini-DIPs. Both the 75118 and 75119 are housed in plastic.

CIRCLE NO. 307

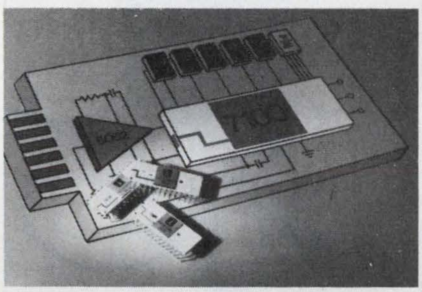
Clock generator delivers MOS and TTL-levels

National Semiconductor, 2900 Semiconductor Dr., Santa Clara, CA 95051. Hashmukh Patel (408) 737-5000. From $4.50 (100-up); stock.

A clock generator, the DP4201, is designed for use with the 4004 family of microcomputers. The unit meets the signal requirements for 4004 and 4040 microprocessor components in the four-bit integrated processing system, and in MCS-4 and MCS-40 microcomputer based systems. Used with an external crystal, the DP4201 generates TTL and MOS-level clock signals. It also has a power "ON" and external reset control, plus a single-step function. The clock generator has a frequency range from dc to 6 MHz and is available in either a ceramic (DP4201-J) or a molded epoxy (DP-4201-N) DIP.

CIRCLE NO. 308

A/d converter pair gives 3-1/2 or 4-1/2 digits

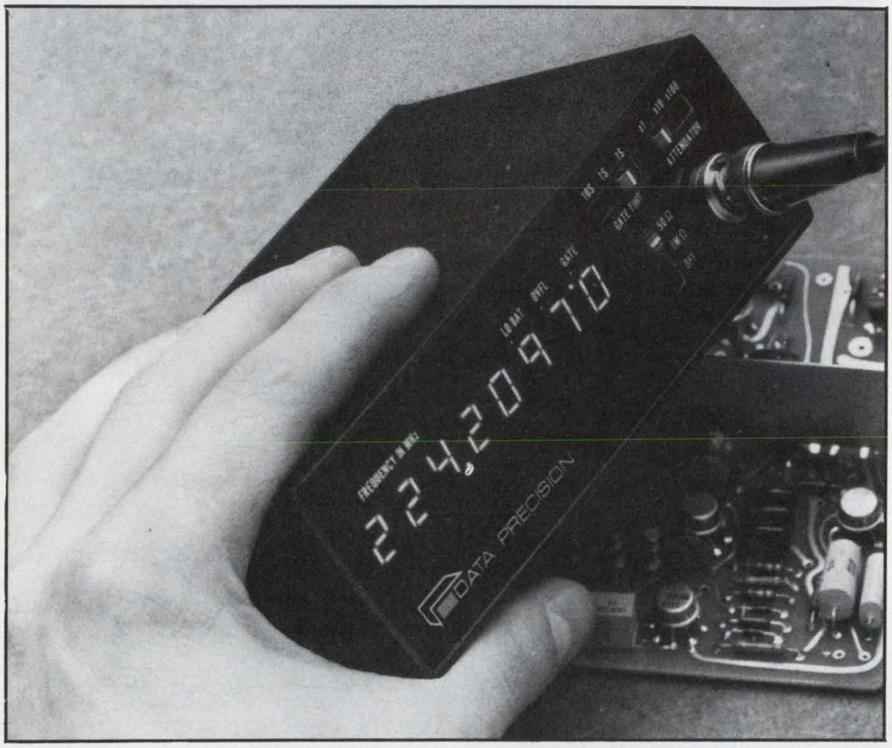


Intersil, 10900 N. Tantau Ave., Cupertino, CA 95014. (408) 996-5000. $10.50/pair (100-up); stock.

To complement the 8052 analog signal processor, the 7103 digit processor provides all necessary logic circuitry for a ±1999 count a/d converter. "A" versions, the 7103A and 8052A, provide circuitry for a ±19999 count instrument. Both pairs provide a multiplexed BCD output suitable for LED displays. The 7103/7103A functions include auto-zero, autopolarity switches, converter, latches, multiplexer and associated logic. When paired with an 8052, the converter thus formed has JFET-input buffer amplifiers and a JFET-input integrator, which typically contribute less than 5 pA of input leakage and provide a 1000-MΩ input impedance.

CIRCLE NO. 309

Miniature 250-MHz counter works from NiCd batteries



Data Precision, Audubon Rd., Wakefield, MA 01880. (617) 246-1600. P: See text; 30 days.

Measure frequencies directly up to 250 MHz in the field without line power and with an instrument that measures only 5-1/2 × 1-3/4 × 3-1/2 in., and weighs just 1-1/4 lb. Impossible? Well, not only does Data Precision's 585 miniature counter enable you to accomplish all that, it doesn't cost an arm and a leg, either. The price is $345.

Internal, rechargeable NiCd batteries give the counter up to four hours of operation on a single charge. Both the batteries and the charger are included in the price, as is a vinyl carrying case.

One other counter, also small, works from rechargeable batteries —the FM-7 from Non-Linear Systems. But unless accompanied by the SC-5 prescaler, the tiny FM-7 (2.7 × 1.9 × 4 in.) can reach only 60 MHz. Combine the FM-7 with the SC-5 and you can measure as high as 512 MHz—twice as high as the Data Precision counter.

Although the FM-7/SC-5 beats the 585 on price by $23, it offers one less digit (seven), two less gate periods, less sensitivity and no input attenuator. Data Precision's counter offers three gate periods: 0.1, 1 and 10 s. Resolutions are 10, 1.0 and 0.1 Hz, respectively. Non-Linear's FM-7 comes with just one 1-s gate period.

Sensitivities of the competing units stack up as follows: for the 585, 10 mV rms from 10 Hz to 10 MHz and 50 mV rms beyond; for the FM-7, 30 mV rms to 30 MHz and 100 mV rms to the top. The input sensitivity of the prescaler is 30 mV.

If noise is a problem, as it often is in the field, you can attenuate the 585's input by a factor of 10 or 100 with a front-panel slide switch. Another slide switch lets you set the input impedance to 1 MΩ/25 pF or 50 Ω.

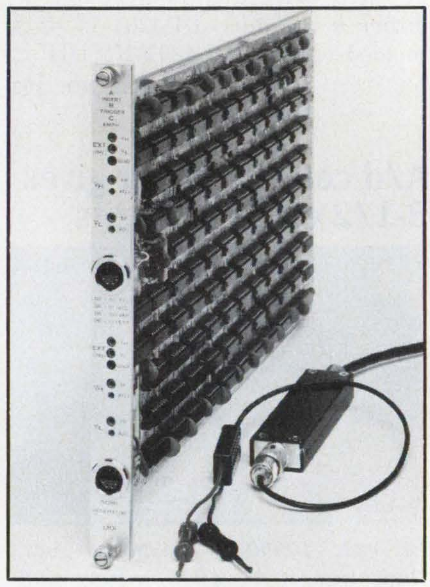
There are no input controls on the Non-Linear FM-7/SC-5. Impedance is 1 MΩ/50 pF (below 0.5 V rms) on the FM-7 and 50 Ω on the prescaler.

How long you can work without recharging is a major concern, of course, with any portable equipment. The 585's four-hour operating time outstrips the FM-7's two-hour operating time (3 hours for the prescaler, which has its own battery supply).

The 585 drifts 5 ppm from 10 to 40 C. For more stability, a temperature-control crystal oscillator is available. The 585's time base stays at 0.01 ppm/s, 0.6 ppm/month and 4 ppm/year. The FM-7/SC-5's tempco is 10 ppm over the wider span of 0 to 40 C, and its time stability better than 10 ppm/year.

Data Precision CIRCLE NO. 304
Non-Linear Systems CIRCLE NO. 305

Logic analyzer becomes word generator too



EH Research Laboratories, 515 11th St., Box 1289, Oakland, CA 94604. (415) 834-3030. $1120 w/o probes; 90 days.

Model 1301 word generator plugs into the company's Model 1320 Digiscope logic analyzer. With the 1301, the Digiscope not only receives data, but can also generate data at up to 50-MHz rates. The unit under test can be stimulated with a desired input pattern, and the same instrument records the output response. Each word generator plug-in has two independent stimulus channels consisting of up to 100 bits of serial data per channel. The output drive signal is provided through active remote Model 1392 driver probes. Logic levels are adjustable over a range of +11 V.

CIRCLE NO. 310

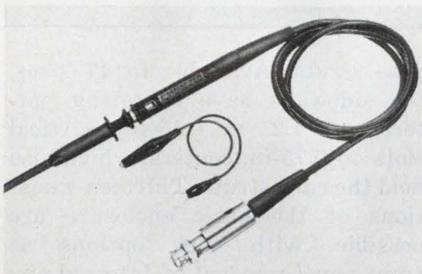
Signal generator delivers 1000 MHz

Systron-Donner, 10 Systron Dr., Concord, CA 94518. (415) 676-5000. $4150; 30 days.

Systron-Donner has entered the signal-generator market with a synthesized design that covers the 100-Hz-to-1000-MHz range. Model 1702 features 100-Hz resolution, ±1-dB output-level accuracy, and a residual AM noise of less than 0.1% at +13 dBm. Frequency is selected with digital-switch controls and output levels are displayed on a calibrated output attenuator. A three-digit calibrated LED readout displays FM-AM deviation. Modulation modes can be operated internally, externally, or in combination. Output level is variable from 1 V to 0.1 μV.

CIRCLE NO. 320

Scope probe offers 'slim-body' styling

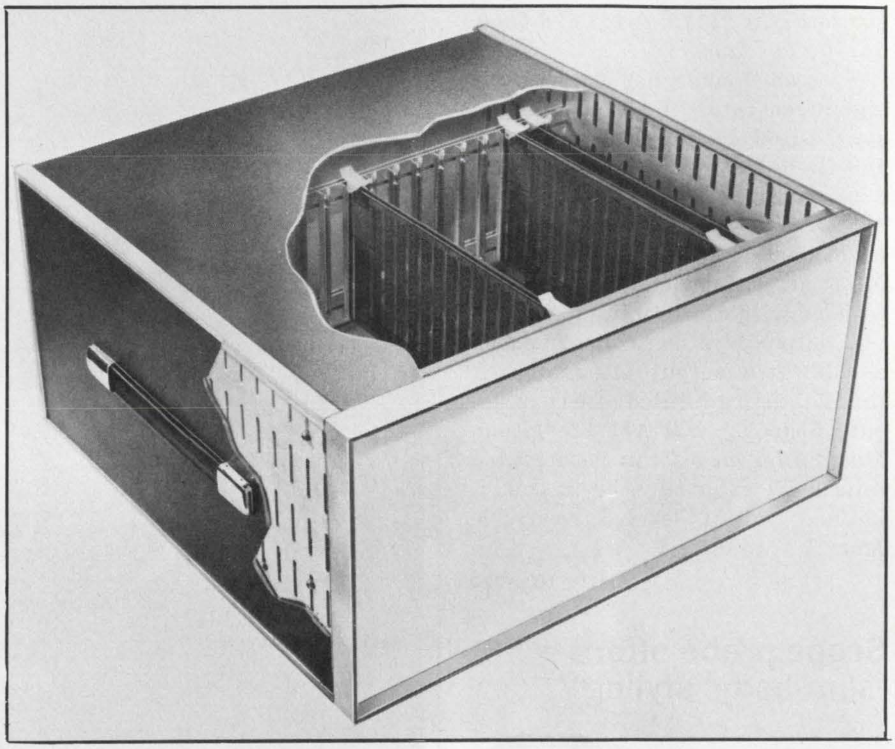


B&K Precision, 6460 W. Cortland Ave., Chicago, IL 60635. (312) 889-9087. $30; stock.

A new oscilloscope probe features modern slim-body construction and 10:1/direct capability. Model PR-35 is designed for any scope using a BNC connector and having a bandwidth up to 15 MHz and an input capacitance of 10 to 35 pF. The probe is constructed with a steel inner structure, encapsulated by a rugged plastic shell. "Pull-apart" hidden-switch design prevents accidental position switching of the 10:1/direct switch. PR-35 has an impedance of 10 MΩ/18 pF (10:1) and 1 MΩ/120 pF (1:1). Maximum voltage is 500 V pk-pk.

CIRCLE NO. 321

Inexpensive metal cabinets come in a variety of sizes



Vector Electronic Co., 12460 Gladstone Ave., Sylmar, CA 91342. (213) 365-9661. P&A: See text.

Capable of holding almost any type of circuit board, the Vector-Pac series of metal enclosures offers many features not available in cabinets costing much more.

The cabinets come in more than 15 sizes, and, with the wide variety of internal hardware available, can accept almost any size circuit card. All units are available with clear or black-anodized aluminum finishes or with mar-resistant textured vinyl covers in 10 off-the-shelf colors. Cabinet sizes range from 2.76 × 12.73 × 10.4 in. for the VP3-12-10 to 9.01 × 17.58 × 21.6 in. for the VP9-17-21.

Prices for the cabinets start at $59.75 for an unassembled VP3-12-10. Hardware is also available so that circuit cards can be mounted either front to back or sideways within the cabinet.

The internal cabinet structure consists of 0.08-in.-thick aluminum sidewalls joined by four multipurpose struts. Available in 17 sizes, the sidewalls have repeating patterns of 1.2 × 0.15-in. vertical slots on 0.75-in. centers, which also hold the card struts. Thirteen variations of the basic enclosure are possible, with such options as front-panel removal of internal circuit cards or a recessed front panel.

Side-trim extrusions on the cases provide channels for upper, lower and side panels of 0.062-in.-thick aluminum. Extruded bezels can accommodate either a verticle or sloped front panel. The interlocking extrusions and panels can be secured with two screws in the rear frame. And the bottom cover of the cabinet comes with non-mar rubber feet.

The cabinets may be purchased with or without the interior structure assembled. Internal struts and card supports normally add $40 to $60 to the cabinet's basic $60 to $90 cost. Delivery of standard units is from stock to 4 weeks.

CIRCLE NO. 301

Thermal seals replace the 'greasy kid stuff'

Bergquist Co., 4350 W. 78th St., Minneapolis, MN 55435. (612) 835-2322. See text; stock.

Applying heat-sink compound can be not only messy, but often inadequate. And, of course, it does not provide electrical insulation. Sil-Pads 400 are a laminate of silicone rubber and fiberglass. They resist leaking and cut-through, yet retain low thermal resistance. The gasket-like pads are easy to apply, accommodate surface irregularities, and tolerate soldering temperatures. A wide variety of shapes is available, and die charges for special shapes run typically $30.

CIRCLE NO. 322

Film diffuses light from LEDs

3M Co., P.O. Box 33600, St. Paul, MN 55133. (612) 733-9534. $3.10/ft² (1-up); 3 wk.

A series of four kinds of polyester films mounts in front of LEDs to diffuse their light. They have a transmitted gain, defined as brightness in ft-L divided by illumination in ft-C, of either 3 or 5, and come in two thicknesses. The light-diffusing films come in rolls, with widths of 11 in. The 3-mil thick types are: LDF3003N (gain, 3) and LDF5003N (5). The 8-mil types are LDF3008N (3) and LDF-5008N (5). They transmit 55% of the incident light and have a neutral-gray color.

CIRCLE NO. 323

Desolder tool yanks DIPs from board top

Edsyn Inc., 15958 Arminta St., Van Nuys, CA 91406. (213) 989-2324. $95.45; stock.

The DE180 extractor with an AV125 desoldering tip removes DIPs from the component side of PC boards—gripping either from the side, or from the ends. You place the heating head directly over the DIP package, align the removal claws, and built-in springs automatically lift the package as the solder melts. The desoldering tool is designed for use with Edsyn's Atmoscope system.

CIRCLE NO. 324

CIRCLE NUMBER 55

CIRCLE NUMBER 56

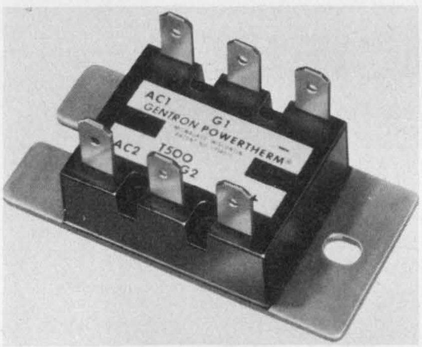
Fast switching Xistors have t_{on} of 0.45 μs

Solitron Devices Inc., 1177 Blue Heron Blvd., Riviera Beach, FL 33404. (305) 848-4311. $12: 14304, $15: 14305 (1-99); 2 wks.

Two new 20-A, fast-switching npn silicon power transistors, SDT 14304 and 14305, are packaged in either the standard TO-3 or TO-61/I cases and feature single-planar chip construction. Switching time is $t_{on} = 0.45$ μs, $t_s = 2.5$ μs and $t_f = 0.45$ μs. Other typical specifications include V_{CEO} (sus) from 300 V (SDT 14304) to 400 V (SDT 14305); I_C (cont) is 10 A and I_C (peak), 20 A; h_{FE} of 15 to 75 at 5 A, 5 V; $f_T = 7$ MHz; and thermal resistance is $R_{\theta JC} =$ 0.8 C/W. The transistors are designed for applications including push-pull inverters, switching regulators and pulse-width modulators.

CIRCLE NO. 325

SCR bridges feature low thermal resistance

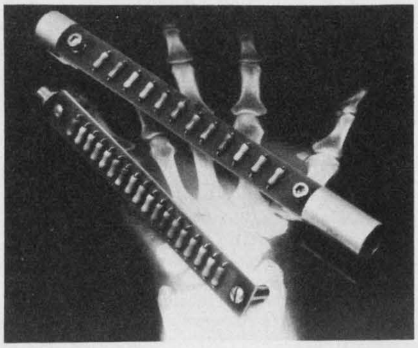


Gentron Corp., 6667 N. Sidney Pl., Milwaukee, WI 53209. (414) 351-1660.

New 25-A SCR Powertherm bridge-rectifier circuits, the T500 series, with the low thermal resistance of 0.5 C/W, are available in 120, 230 and 460-V types. Heat-sink mounting plates are electrically isolated; breakdown to the plate exceeds 2500 V. Eight circuit combinations are offered. Options such as voltage-transient suppression and free-wheeling diode protection are available. The Powertherm package also lends itself to special custom power circuits that include both active and passive components.

CIRCLE NO. 326

Aerospace-rectifier prices reduced

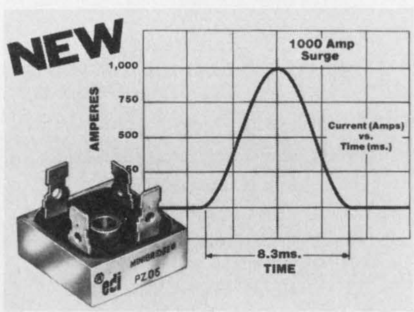


Semtech Corp., 652 Mitchell Rd., Newbury Park, CA 91320. (213) 628-5392. $17 to $23 (100 up); 10 days.

X-way Stic, a new series of open rectifier sticks specifically designed for X-ray power supplies, consists of hermetically sealed Metoxilite multichip avalanche rectifiers mounted on a PC board. These rectifiers, originally developed for high-reliability aerospace programs, are now available at reduced prices. They can be efficiently used in most standard single and polyphase circuits. Individual rectifiers have PIVs of 100, 125 or 150 V and handle an average rectified current of 150 mA at 55 C (in oil).

CIRCLE NO. 327

Bridge rectifier takes 1000-A surges



Electronic Devices Inc., 21 Gray Oaks Ave., Yonkers, NY 10710. (914) 965-4400. $10 (1000 up).

Called the PZ Series Minibridge rectifier, the unit can withstand a 1000-A surge current. The new bridge has a peak reverse-voltage rating to 400 V, a 30-A current rating, 0.25-in. quick-connect terminals and a small 1-1/8 × 1-1/8-in. size. The high surge capability of the design makes the rectifier particularly suited for use in high-capacitive load circuits.

CIRCLE NO. 328

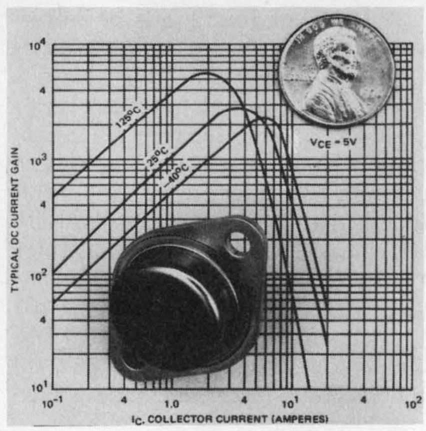
Conveniently packaged SCRs interconnect easily

Semikron International Inc., 542 Columbian St., South Weymouth, MA 02190. (617) 337-7220. $38; 40A, 600 PIV (100 up).

Semipack offers the engineer a modular building block that is electrically isolated and mechanically compatible for heat-sink mounting. The units can be connected into single, three-phase or other circuit configurations with small bus-interconnects. Heat sinks are available from the manufacturer. The modules are available in ratings from 10 to 90 A per device with up to 1600 PIV. Both standard and fast SCRs, and also diodes, are packed in Semipack. The center-to-center dimension of mounting holes is 3-1/8 in.

CIRCLE NO. 329

Npn Darlingtons handle 100 W at 600 V

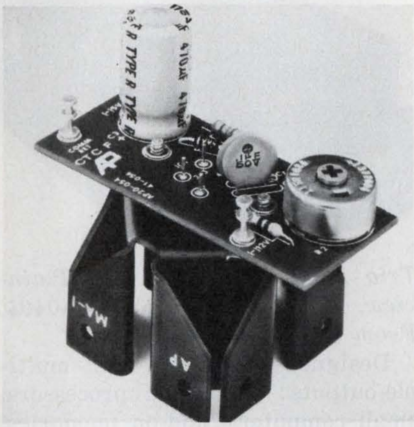


International Rectifier, 233 Kansas St., El Segundo, CA 90245. (213) 322-3331. $5.29 to $7.06 (100-999); stock.

Npn power Darlingtons with power ratings to 100 W and collector-emitter voltage ratings to 500-V (sustaining) are designated IR4039, 4041, 4059 and 4061. The new units offer triple-diffused processing to achieve the high-voltage operation. Rise time for the Darlingtons is 2 μs, storage time 4 μs and fall time 2.6 μs in typical applications. Continuous collector-current rating for all units in the line is 20 A. The units are packaged in industry-standard JEDEC TO-3 metal cases with maximum thermal resistance (junction-to-case) of 1.25 C/W.

CIRCLE NO. 330

Does your µP system need another voltage?



Adtech Power, Inc., 1621 S. Sinclair St., Anaheim, CA 92806. George Mousel (714) 634-9211. $8.95 (1000 qty); stock.

Particularly intended for µPs, the MA series of output adapters takes an existing ±12 or ±15-V-dc (regulated or unregulated) voltage and delivers ±5 to ±9 V at 1.0 A. Available in two models, the MA−1 for negative output and the MA+1 for positive output, the adapters also operate from ±16 to ±24-V-dc power supplies, to give ±5 V at 0.5 A. Both devices can be operated from a 12-V battery to provide 5 to 9 V at 1 A for standby power. Units measure 3 × 2 × 2.6 in.

CIRCLE NO. 331

On-board switchers deliver 3.5 W

CEA, 1 Aerovista Park, San Luis Obispo, CA 93401. (800) 235-4151. $120; stock to 2 wks.

Two switching dc supplies, the TL5-700 delivering 5 V at 0.7 A and the TLD 15-125 delivering ±15 V at 0.125 A, are intended for recessed PC board mounting. The 0.5 × 2.5 × 2.5 in. (excluding tabs and terminals) modules handle 3.5 W from −20 to +71 C. Operating from 105-to-125-V, 50-to-400-Hz or 140-to-170-V-dc input, they feature ±0.01% tempco, 30-C base rise, 50-µs response time and greater than 50-MΩ and 500-V-dc isolation. Line and load regulation is ±0.03% for the 5-V unit and ±0.01% for the 15 V. Both devices are current limited with foldback.

CIRCLE NO. 332

Efficient switchers give you isolation

Gould, 3631 Perkins Ave., Cleveland, OH 44114. W. Roth (216) 361-3315. $125 (1-9); stock.

You get efficiencies of from 75 to 85% from MMG-type switching power supplies. The units operate from 110/120 V or 220/240 V ±10%, 50 or 60 Hz, and use optical coupling to provide 4-kV-rms isolation (5.7-kV pk) between input and output. Four models provide dc outputs of 5, 12, 15, or 24 V at currents from 1.4 to 5 A. Output voltages are adjustable ±10% by a multiturn potentiometer. Units can be used in series or parallel. Regulation is 0.1% max. for the worst-case combination of 0-to-100%-load-change and ±10%-line-change. Ripple does not exceed 10-mV rms or 50-mV pk-pk measured over a 30-MHz bandwidth. For a step load-change of 100% to 10% or 10% to 100%, the voltage deviation is typically 300 mV and returns within the regulation band in approximately 2 ms. The operating temperature range is −10 to +70 C, with full-output ratings to +50 C and derating of 2.5%/°C thereafter. Dimensions of the 1.2-lb units are 6.3 × 3.5 × 1.3 in. Remote sensing plus overcurrent and overvoltage protection are standard.

CIRCLE NO. 333

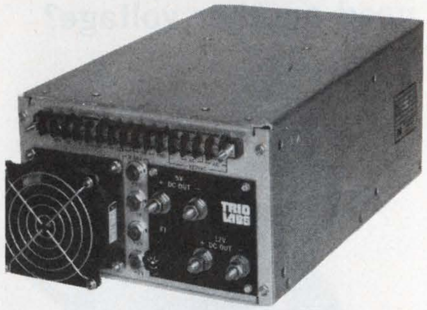
µP supplies carry UL recognition

Deltron Inc., Wissahickon Ave., North Wales, PA 19454. J. Phillips (215) 699-9261. $99-$142; stock.

Containing 20 models, Quad series µP power supplies are now UL recognized per UL 478. Each dc supply in the series provides four outputs. All offer a 5-V output and another output in the 5-to-24-V range. Other voltages of from ±12 to ±15 V, 12 V and 9 to 12 V are available. All units feature line-and-load regulation of 0.1% and ripple and noise of 1.5-mV rms. Features included are barrier-block output terminals and infinite-resolution adjustments. All units are capable of 115/230-V-ac-operation.

CIRCLE NO. 334

475-W switcher gives you four output rails

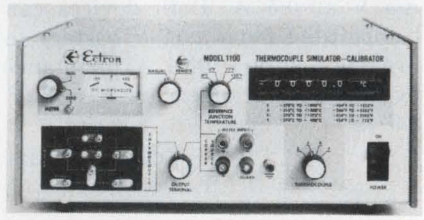


Trio Labs, 80 Dupont St., Plainview, NY 11803. (516) 681-0404. From $635; 2-4 wks.

Designed specifically for multiple-outputs: for microprocessors, small computers, add-on memories, etc., the Model 675 features a main 2 or 5-V output for logic, a second 12-V output for memory, and two additional 15-V outputs for accessory power needs. The unit weighs 15 lb, has an efficiency of over 60%, an MTBF exceeding 30,000 h, is UL recognized, and measures 5 × 8 × 14.33 in.

CIRCLE NO. 335

Unit calibrates four thermocouples to 0.1 deg



Ectron Corp., 8159 Engineer Rd., San Diego, CA 92111. (714) 278-0600. $1970; stock to 30 days.

The Model 1100 thermocouple simulator/calibrator allows the user to simulate any of four common thermocouple types (E, J, K and T) over the entire range of NBS tables. The desired temperature is dialed directly in degrees C or F on five decade thumbwheel switches and the proper voltage automatically appears on output terminals constructed of the chosen thermocouple type material. Conformity to NBS tables is within 0.1°. The instrument may also be used as a precision linear dc standard with a resolution of 1 µV, or as a high-precision differential voltmeter. Optional features include remote programming and a rack-mounting kit.

CIRCLE NO. 336

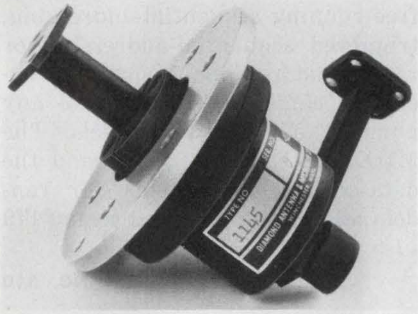
Tiny thin-film VCO beats tough specs

Watkins-Johnson Co., 3333 Hillview Ave., Palo Alto, CA 94304. (415) 493-4141.

Miniature thin-film VCO, Model WJ-V201, is varactor tuned over the 2-to-4-GHz band. It weighs in at a feather-light 1.5 oz (42.5 grams) and offers MIL-spec performance. Its output of 10 mW is obtained with 15 V dc, 120 mA max, input power. Available options include a TO-8 package.

CIRCLE NO. 337

Rotary joint turns on high power levels



Diamond Antenna & Microwave Corp., 35 River St., Winchester, MA 01890. (617) 729-5500. 10 wks.

Model 1145 Ka-band rotary joint features a frequency coverage of 26.5 to 40 GHz, and if pressurized handles 3-kW peak, 500-W cw. The L-type unit is 3 in. long and weighs 1-1/4 lb. Similar units for 18 to 26.5 GHz and lower frequencies have also been announced. Prices depend on specific features.

CIRCLE NO. 338

Directional couplers now coaxed to 26 GHz

Narda Microwave, Plainview, NY 11803. J. P. Schindler (516) 433-9000. $450.

Coax stripline couplers can now take over from waveguide units in the 18-to-26.5-GHz range. The Model 4017 is available in 6 and 10-dB values, and handles 30 W av, 2 kW pk min. Insertion loss (excluding coupled power) is 0.5 dB max, operating temperature without degradation is 105 C.

CIRCLE NO. 339

Units boost acquisition to 48 channels

Datel Systems, 1020 Turnpike St., Canton, MA 02021. Eugene Zuch (617) 828-8000. $199 (1-9 qty); 4 wks.

MDXP-32 and MDXP-32-1 are companion devices to the company's MDAS-16 and MDAS-8D modular data-acquisition systems. Both are expander modules containing 32 analog multiplex channels for extending the MDAS-16 from 16 to 48 single-ended channels and the MDAS-8D from 8 to 24 differential channels, using single-level multiplexing. With the MDXP-32 you can operate the expanded system in three modes: free-running sequential-addressing, triggered sequential-addressing or random-addressing. Sequential operation can be short-cycled to any number of desired channels. The MDXP-32-1 is used to expand the data-acquisition systems for random addressing only and costs $179 (1-9 qty).

CIRCLE NO. 340

Small d/s drives torque receiver

Computer Conversions Corp., 6 Dunton Court, East Northport, NY 11731. (516) 261-3300. $575 (singles); 4-to-6 wks.

You can drive torque-receiver synchros (up to 3 VA) with the DSC series of 14-bit d/s converters. The 2.6 × 3.1 × 1-in. devices are the smallest of their type to provide ±5-minute accuracy when driving this heavy a load (size-11 TR). These units accept a 14-bit natural-binary angle and convert it into a 3-wire-synchro or 4-wire-resolver signal. Standard output voltages are 11.8 or 90 V, 60 or 400 Hz. Digital inputs are TTL/DTL compatible and the synchro output and reference are transformer isolated. The output is short-circuit protected and ±15 and +5-V-dc power supplies are required. Converters in the series operate from 0 to 70 or −55 to +85 C.

CIRCLE NO. 341

DATA PROCESSING

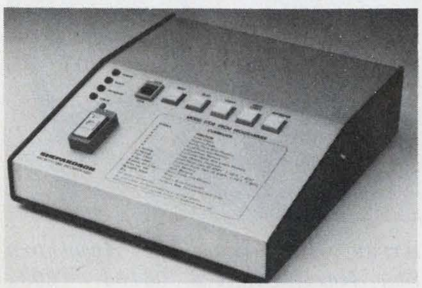
This computer terminal is ready to move about

Informer, Inc., 8322 Osage Ave., Los Angeles, CA 90045. Will Little (213) 649-2030. $1890; 6 wks.

The Model D301 compact desktop CRT display with keyboard was specifically designed to be truly mobile. It is intended for IBM 3740 or similar applications, and can be plugged directly into the computer, or into a telephone line. With a weight of only 10 lb, even the frailest secretary can put the electronic genie in its place.

CIRCLE NO. 344

PROM programmer is versatile, low-cost



Shepardson Microsystems Inc., 20823 Stevens Creek Blvd., Bldg. C4-H, Cupertino, CA 95014. (408) 257-9900. $850.

If you already have a computer terminal, the Model 2708 PROM programmer may save you some money. This intelligent device permits use of an RS232 or current-loop terminal for programming type-2704 and 2708 PROMs. You can move, alter and store data in the programmer's buffer, be they binary, octal, decimal or hex. The Model 2708 reads or outputs the PROM data in ASCII, BNPF or BHLF, and automatically adapts to the terminal's speed up to 600 baud.

CIRCLE NO. 345

Field/lab instrument clocks 12 Mbit/s

Pioneer Magnetics Inc., 1745 Berkeley St., Santa Monica, CA 90404. (213) 829-3305. $9895, 12 wks.

If your rotating memories need a portable clock and sector writer, the compact (18-1/2 × 11 × 15-1/4 in.) PM2390 may be worth a spin. It records open or closed clock tracks at bit rates up to 12 Mbit/s, and eliminates bit-to-bit jitter, closure error, and cumulative phase error. The PM2390 permits the measurement of amplitude and frequency modulation, area and pinhole defects, and servo performance.

CIRCLE NO. 346

Interface ties tape systems to PDP-11

Emerson Electric Co., 3300 S. Standard St., Santa Ana, CA 92702. Ron Carroll (714) 545-5581. $1500 (1 up); 8 to 12 wks.

Emerson Tape-Pac recorder systems can now be interfaced efficiently with PDP-11 systems through the Model 2061 interface adaptor. It is contained in two modules that can be installed in the PDP-11, using the DEC M920 Unibus jumper module. You can connect two of Emerson's Model 2050-PE formatters to a single Model 2061 adaptor, and each formatter can handle four tape drives. The Model 2061 operates off existing software, and is software-transparent to DEC's TM11/TU10 tape drives.

CIRCLE NO. 347

Convert mag-card data to paper tape

Tycom Systems Corp., 26 Just Rd., Fairfield, NJ 07006. Peter Polizzano (201) 227-4141. $8500; 4 wks.

If you want to convert magnetic-card data to paper tape, the IBM MCST-compatible Model PTR/P will do it at 50 characters per second. Although intended to handle ASCII the PTR/P can accommodate any code through its built-in code converter. An editor option skips characters, words, or paragraphs. The RS-232 output offers speeds from 75 to 2400 baud.

CIRCLE NO. 348

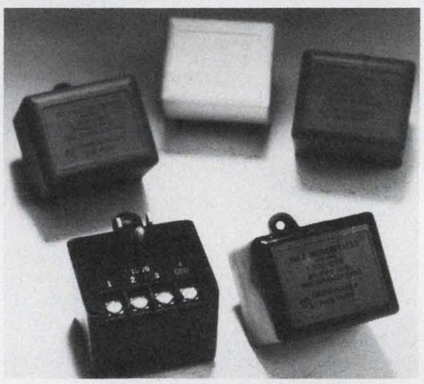
Single-turn trim caps feature zero tempco

Sprague Electric Co., North Adams, MA 01247. (413) 664-4411. $0.20 to $0.80 (25,000 up); 4 to 6 wks.

Plastic-film single-turn trimmer capacitors called Filmtrim are available in three basic body sizes: 8, 10 and 16 mm and each can be had in top-mount or side-mount configurations. In both configurations, screwdriver slots are provided at either end of the adjust shaft. The capacitors are furnished with three different dielectric materials—polytetrafluoroethylene, polypropylene and polycarbonate—and cover a broad range of capacitance values from 1.4 to as high as 300 pF. Essentially zero temperature coefficient of capacitance is featured.

CIRCLE NO. 349

Plug-in transformers feature circuit breaker

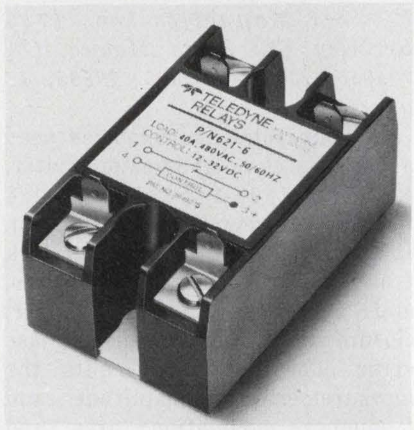


Adult Inc., 1700 H. Freeway Blvd., Minneapolis, MN 55430. (612) 560-9300. $4 (OEM qty).

UL-listed plug-in transformers with four output terminals provide a center-tapped 24-V-ac output and a power ground. Other features include extremely low interwinding capacitance—less than 30 pF—for line-noise rejection; primary and secondary windings are nonconcentric for increased dielectric isolation; and the core is grounded for reduced line-noise transfer (without electrostatic shielding). An integral thermal circuit-breaker with automatic reset protects against short-circuits. Two models—7 VA to 10 VA—are available.

CIRCLE NO. 350

Solid-state relays handle 800-V transients



Teledyne Relays, 3155 W. El Segundo Blvd., Hawthorne, CA 90250. (213) 973-4545. $22.10 (1000 up).

The 621 Series of optically isolated high-voltage ac solid-state relays are designed for high line voltages of 480 V rms (45 to 70 Hz). The relays feature a transient peak voltage rating of 800 V capable of handling three-phase line voltages encountered in European systems. The 800-V peak rating also permits the effective use of MOV transient suppressors to protect the relays against overvoltage transients. The relays meet UL and CSA safety requirements and the more stringent VDE and IEC European specifications. Six models with load current ratings of 15, 25 and 40 A are available, each with input control voltages of 3 to 14 V dc or 12 to 32 V dc. All have peak surge current ratings of up to 10 times the maximum steady state rating for 16 ms.

CIRCLE NO. 351

Silicon chip capacitors provide high-values/area

Microwave Associates, South Ave., Burlington, MA 01803. (617) 272-3000. $1.00 (1-99); stock to 2 wks.

The MA-4M0000 series of silicon MIS chip capacitors uses a nonoxide insulator as the dielectric layer. This series exhibits higher capacitance per unit area than capacitors using oxide layers, because of the larger dielectric constant. Refractory metallization with gold contacts provides excellent metal-to-semiconductor adhesion. All chip capacitors in this series are saw-cut from the wafer.

CIRCLE NO. 352

Thin-film resistor chips epoxy or reflow attached

California Micro Devices Corp., 733 Palomar Ave., Sunnyvale, CA 94086. (408) 738-3214. Typically $0.10 (OEM qty); 4 wks.

Thin-film chip resistors, Type RX, for hybrid microelectronics applications are designed to be bonded with conductive epoxy or reflow-solder techniques. The resistors employ a glass substrate and the company's TN II tantalum-alloy resistive material. The devices exhibit a low TCR of −200 ppm/°C, low noise and high stability that exceeds the requirements of MIL-R-55342. Power dissipation is 100 mW at 70 C with a dc operating-voltage rating of 100 V. The chip measures 75 × 40 mils and is 20-mils thick. The bonding areas are plated gold, 1.5 microns thick and measure 20 × 34 mils. The resistor element is passivated with silicon nitride. Resistance values are available to 25 MΩ in a variety of tolerances.

CIRCLE NO. 353

Assemble PB switches with designer's kit

Arrow Hart Inc., 103 Hawthorn St., Hartford, CT 06105. (203) 249-8471. $22.99 (unit qty).

A versatile lighted and unlighted pushbutton-switch demonstrator kit is available for designers. Pushbutton switches can be built for prototypes or testing new equipment such as instruments, transportation panels, computers and communications equipment. The kit contains nine lenses in a variety of colors. Included are three actuators to accommodate the three lense shapes (square, round and rectangular) for momentary and alternate switch actions. Six snap-on blocks with NO or NC contact are part of the kit. Contacts are rated 5 A, 125 V ac; 2 A, 250 V ac; and 5 A, 28 V dc, resistive.

CIRCLE NO. 354

Application Notes

Magnetic sensors

How to select the proper magnetic sensor for a given application is covered in an eight-page catalog. Dimensions and detailed specifications are provided. Electro Corp., Sarasota, FL

CIRCLE NO. 355

Low-noise amplifier

The design and construction of a single-stage, state-of-the-art bipolar-transistor amplifier at 4 GHz is described in a brochure. It includes design data, describes I/O-matching networks, computer simulation, performance and construction. Hewlett-Packard, Palo Alto, CA

CIRCLE NO. 356

Memory refresh

"Introduction to Refreshing TI 4-k Dynamic RAMs" reviews refresh principles and their implementation. It compares static and dynamic RAMs in terms of speed, power consumption, refresh requirements, relative costs, and power-supply requirements. Texas Instruments, Dallas, TX

CIRCLE NO. 357

Equalizers and filters

Subjects covered in an applications manual on group-delay equalization in communication systems include definition of group delay, passive vs active designs, frequency effects, computer optimization, and how to specify. Comstron Seg, Freeport, NY

CIRCLE NO. 358

Array programming

A full explanation of SWAP (Stewart-Warner Array Programming), pricing and entry information and technical diagrams are given in a four-page brochure. Stewart-Warner, Sunnyvale, CA

CIRCLE NO. 359

New Literature

Peripheral equip supplies

A 56-page catalog describes 200 replacement and enhancement items for use with Digital Equipment's peripherals. Communications Services, Northboro, MA

CIRCLE NO. 360

MOS ICs

Standard MOS-integrated-circuit and LCD-display products are covered in a 32-page catalog. The catalog includes an industry cross-reference guide and block diagrams. American Microsystems, Santa Clara, CA

CIRCLE NO. 361

Components

A literature package includes a catalog describing the company's line of components, another describing test systems and the third jackfields. ADC Products, Minneapolis, MN

CIRCLE NO. 362

Core memory system

The SEMS-9-PI planar core memory system is featured in a data sheet. Electronic Memories & Magnetics, Chatsworth, CA

CIRCLE NO. 363

Semiconductors

A 175-page semiconductor catalog and replacement guide offers replacements for over 75,000 part numbers from major semiconductor manufacturers. Workman Electronic Products, Sarasota, FL

CIRCLE NO. 364

Radio performance analyzer

A 16-page radio performance-analyzer catalog describes a telecommunication instrument used to test microwave-radio performance. Scientific-Atlanta, Atlanta, GA

CIRCLE NO. 365

Discrete semiconductors

Discrete semiconductor components are shown in a 36-page catalog. General Instrument, Semiconductor Div., Hicksville, NY

CIRCLE NO. 366

Recorder supplies

A 66-page catalog describes recorder paper, pens and other consumable supplies available for HP's plotters, X-Y, strip-chart, oscillographic recorders and magnetic-instrumentation tape recorders. Hewlett-Packard, Palo Alto, CA

CIRCLE NO. 367

Digital indicators

A brochure describes the series 50GS selectable-parameter digital indicators. Consolidated Controls, Bethel, CT

CIRCLE NO. 368

Coaxial cable assemblies

Specifications, technical data and prices for coaxial cable assemblies are given in a 12-page catalog. Pasternack Enterprises, Huntington Beach, CA

CIRCLE NO. 369

D/a converters

Series 877-80 d/a converters are described in a six-page bulletin. Block diagrams, typical connection configurations and tables round out the bulletin. Beckman Instruments, Fullerton, CA

CIRCLE NO. 370

Logic analyzers

Microprocessor and logic analyzers are covered in a 12-page brochure. Operational features of each model and photographs illustrating display modes for each product are included. Biomation, Cupertino, CA

CIRCLE NO. 371

μC products

Microcomputer products, software and development systems are presented in a catalog. Control Logic, Natick, MA

CIRCLE NO. 372

Bench-top LSI tester

Complete with photos, illustrations and block diagrams, a six-page brochure describes the operational performance, characteristics and specifications of the MD-104 LSI tester system. Macrodata, Woodland Hills, CA

CIRCLE NO. 373

Film capacitors

Size, performance, electrical characteristics and rating information for metallized polycarbonate capacitors are included in a catalog. Union Carbide, Greenville, SC

CIRCLE NO. 374

245 and 400-A SCRs

Fast-switching inverter SCRs rated for operation at 245 and 400-A rms are described in an eight-page data sheet. International Rectifier, Semiconductor Div., El Segundo, CA

CIRCLE NO. 375

Synchros, resolvers

Brushless synchros and resolvers for machine-tool and airborne equipment are described in a bulletin. Clifton Precision, Clifton, Heights, PA

CIRCLE NO. 376

Film resistors

Specifications and dimensional information for high-performance film resistors can be found in a 20-page catalog. Caddock Electronics, Riverside, CA

CIRCLE NO. 377

Bulletin Board

Two free program libraries with a suggested retail price of $59.90 are available to purchasers of the **Texas Instruments** SR-52 magnetic-card programmable calculator between Jan. 20 to March 31, 1977. The prerecorded libraries cover mathematics, statistics, finance or electrical engineering.

CIRCLE NO. 378

Philips Telecommunications has introduced a **coaxial cable transmission system**, that meets the increasing demand for additional channel capacity by providing 18 MHz of traffic-handling bandwidth at 12-MHz cost.

CIRCLE NO. 379

Digital Systems' Model 140 distributed processing computer with two CPUs, 128-k main memory and two DMA channels has been reduced from $72,600 to $60,800. Model 150 with three CPUs, 256-k main memory and three DMAs has been reduced from $157,680 to $120,960.

CIRCLE NO. 380

Rapidata has announced the **1+1 data access,** which serves time-critical applications that require around-the-clock data access. With this implementation on its RAPIDTEN systems, Rapidata becomes the first time-sharing company to offer this capability on DEC systems.

CIRCLE NO. 381

Data Translation has reduced the price of its **analog I/O system interface, Model DT1751,** from $1195 to $895.

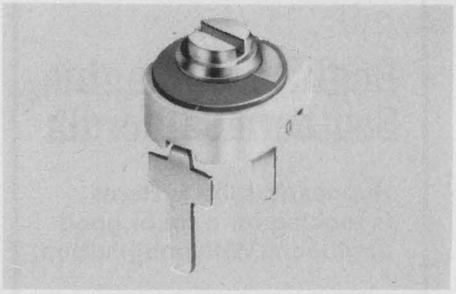
CIRCLE NO. 382

National Semiconductor has reduced the price of its **16-bit single-chip PACE μP,** Model ISP-16A/520D, from $40 to $20 (100 qty.), from $30 to $15 (1000 qty.), and from $26 to $13 (5000 qty.).

CIRCLE NO. 383

quick ads

New and current products for the electronic designer presented by their manufacturers.

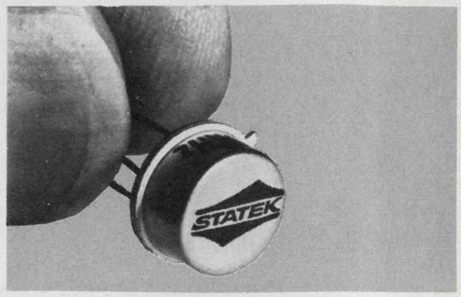


MINIATURE CERAMIC TRIMMER CAPACITORS 9371 series of ceramic trimmer capacitors are compact, economical and rugged. They are 50% smaller than other trimmers of this type yet provide high capacitance values. Available in 4 capacitance ranges, 1.5 to 4, 3.0 to 10, 3.5 to 18 and 5.0 to 25 pf with Q's > 300 at 10 MHz. They have an overall diameter of .225" with .215" above board height. JOHANSON MANUFACTURING CORPORATION, Rockaway Valley Road, Boonton, N.J. 07005 201-334-2676

TRIMMER CAPACITORS 181

Free New '77 catalog contains over 34,500 quality power supplies from the world's largest manufacturer, Power/Mate Corp. Power Supplies for every application including submodulars, open frame, varirated, encapsulated, laboratory & system. All units UL approved and meet most military and commercial specs for industrial and computer uses. Power/Mate Corp., 514 S. River St., Hackensack, NJ 07601 (201) 343-6294

POWER SUPPLIES 184



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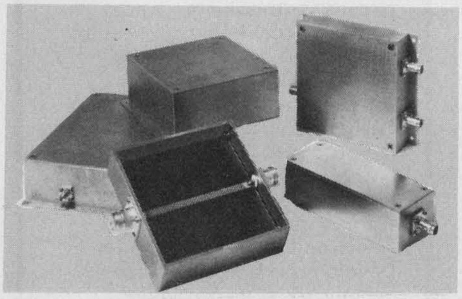

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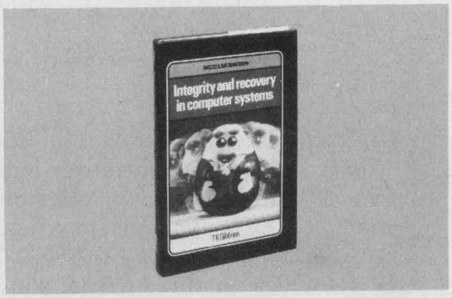

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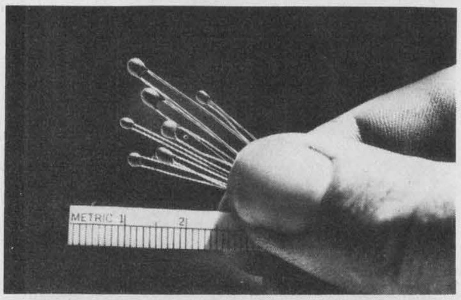

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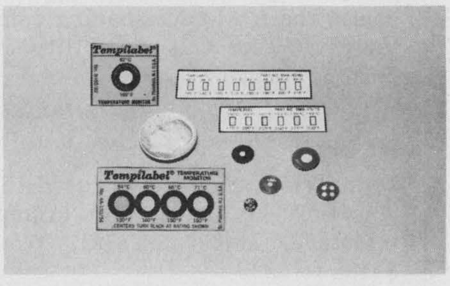

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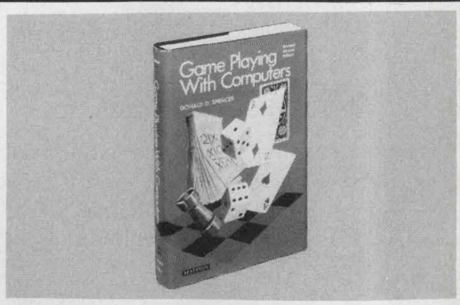

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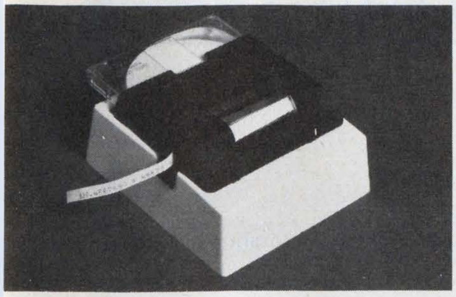

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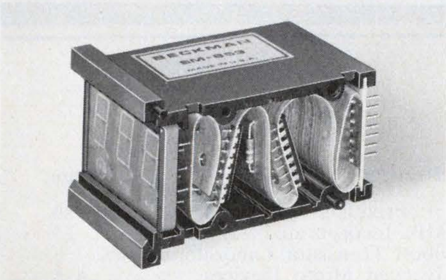

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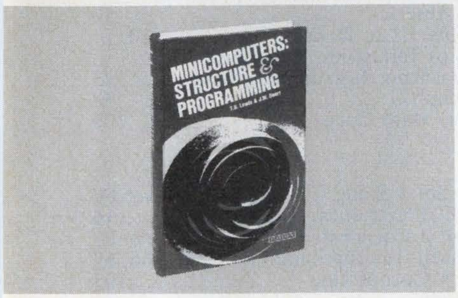

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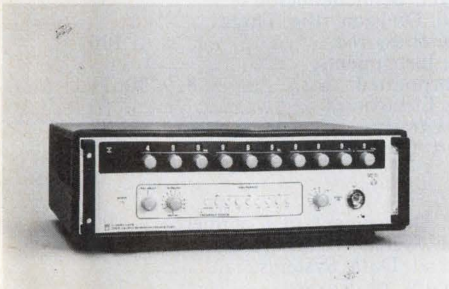

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Robert W. Gascoigne
Daniel J. Rowland
Thomas P. Barth
50 Essex St.
(201) 843-0550
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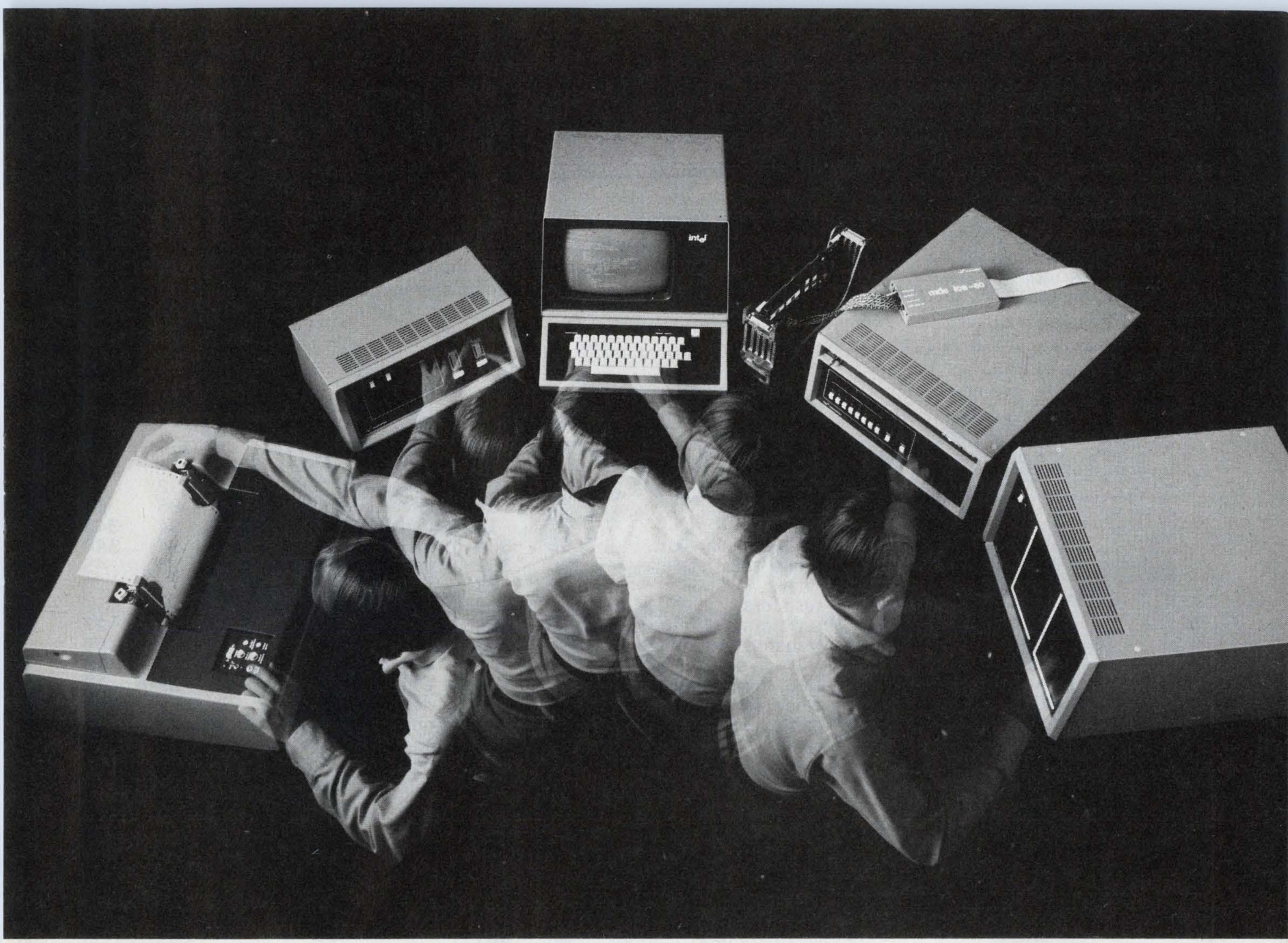

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Product Index

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new literature

application notes

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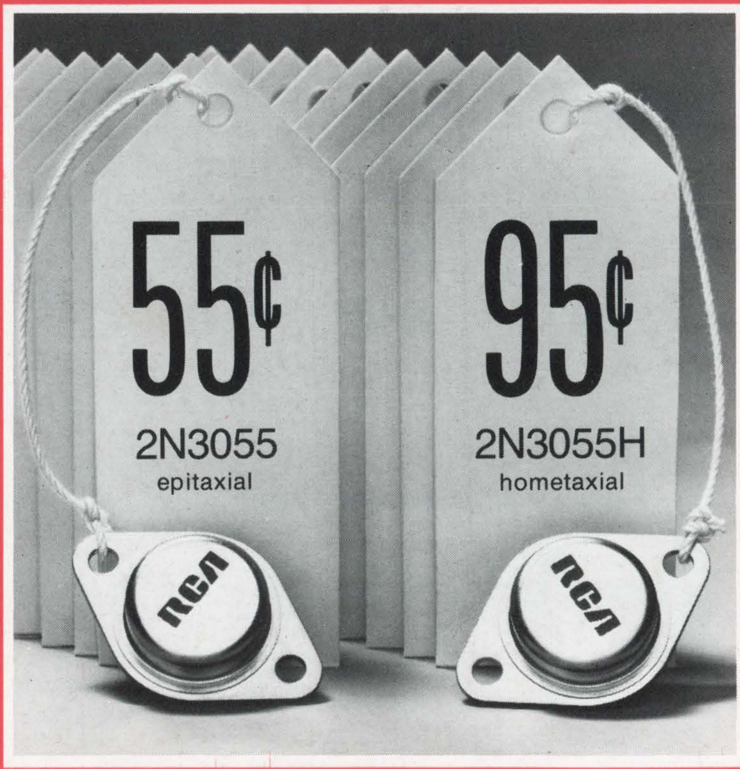
RCS617	RCS618	80	2.87A@40V	20-70@5A	0.88
2N3055	MJ2955	60	2.87A@40V	20-70@4A	0.55
2N6569	2N6594	40	2.87A@40V	15-200@4A	0.50
2N6254		80	1.87A@80V	20-70@5A	1.20
2N3055H		60	1.95A@60V	20-70@4A	0.95
2N6253		45	2.55A@45V	20-150@3A	0.55

*Optional distribution resale price. U.S. only.



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