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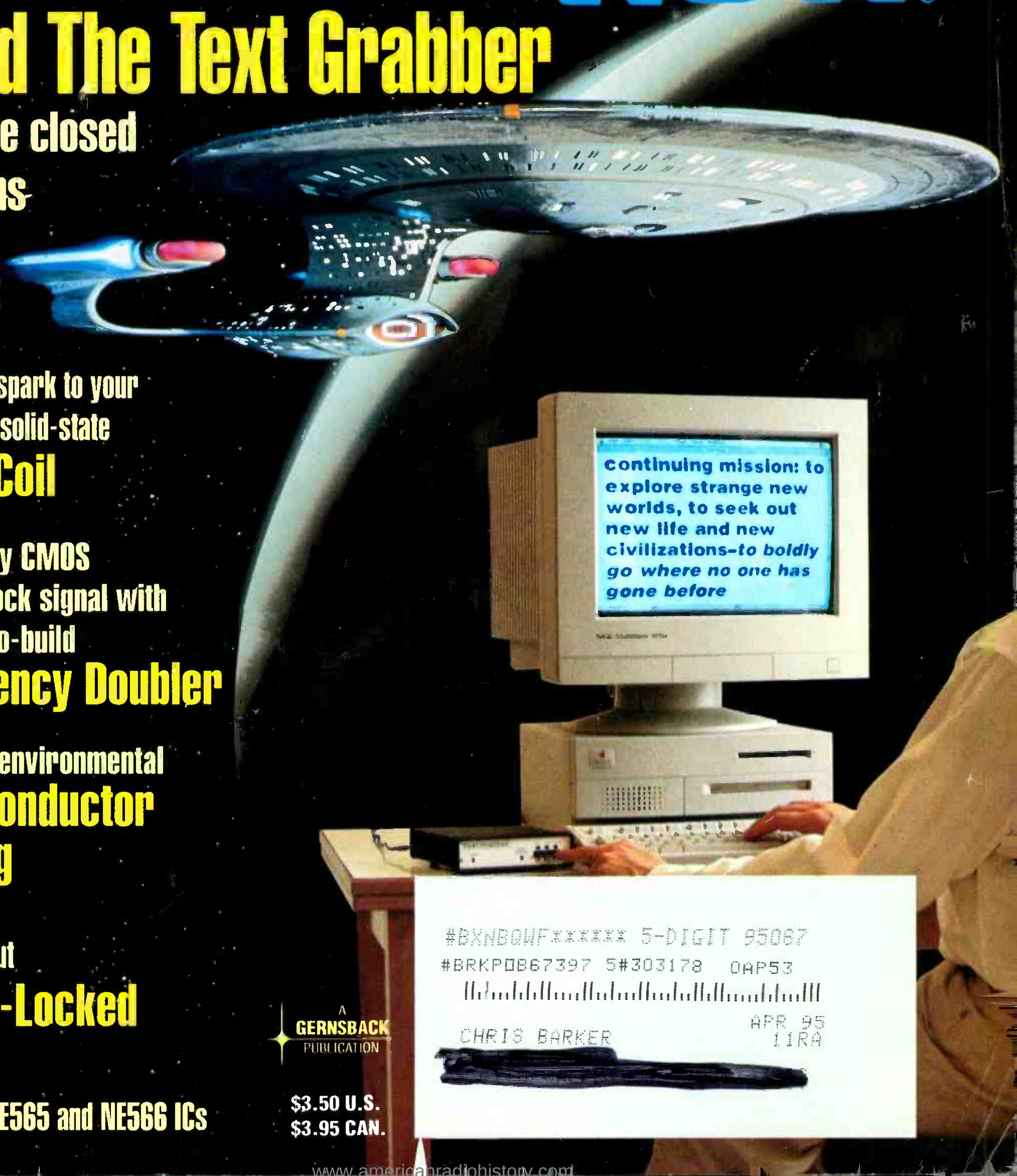

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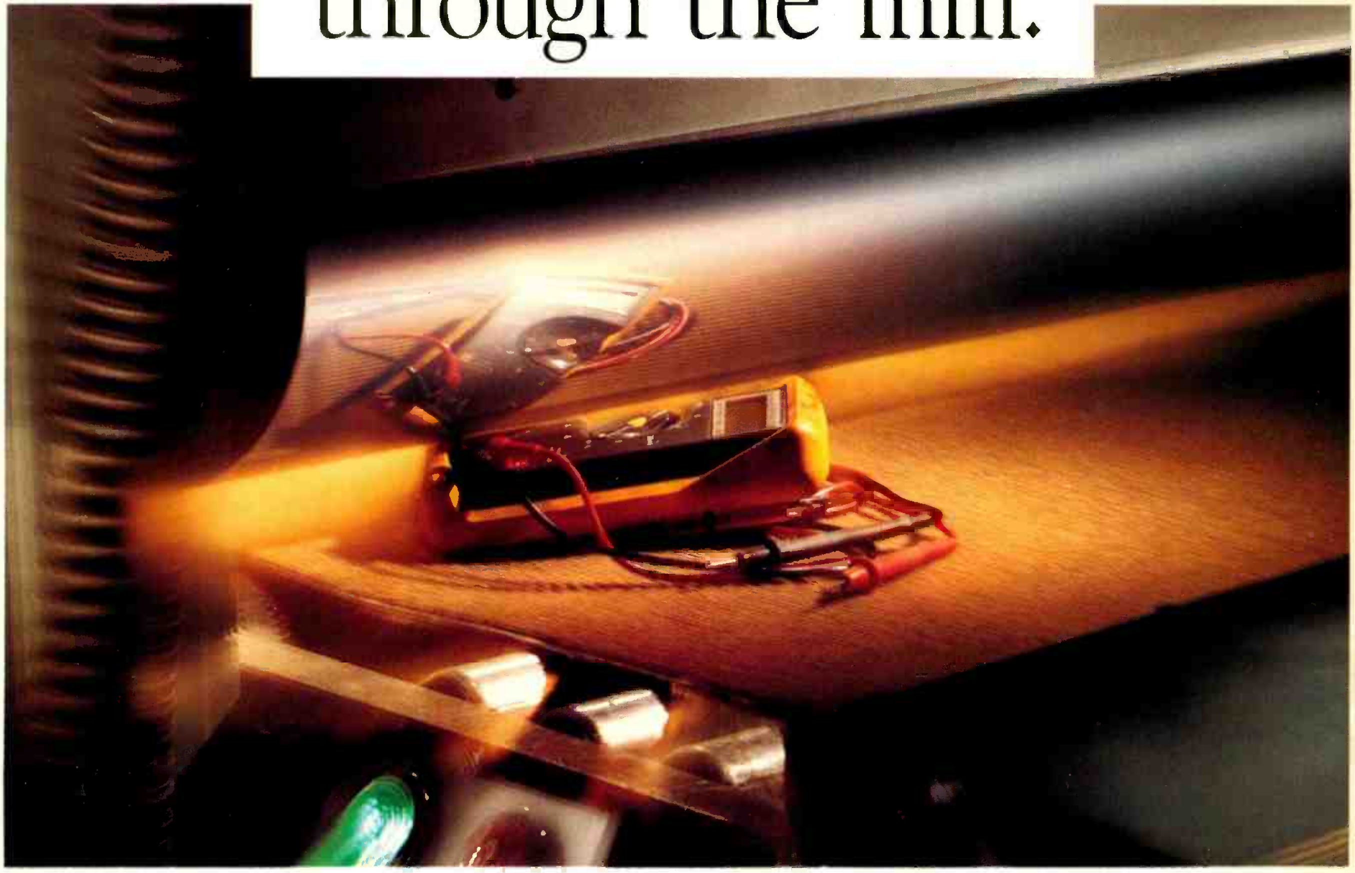

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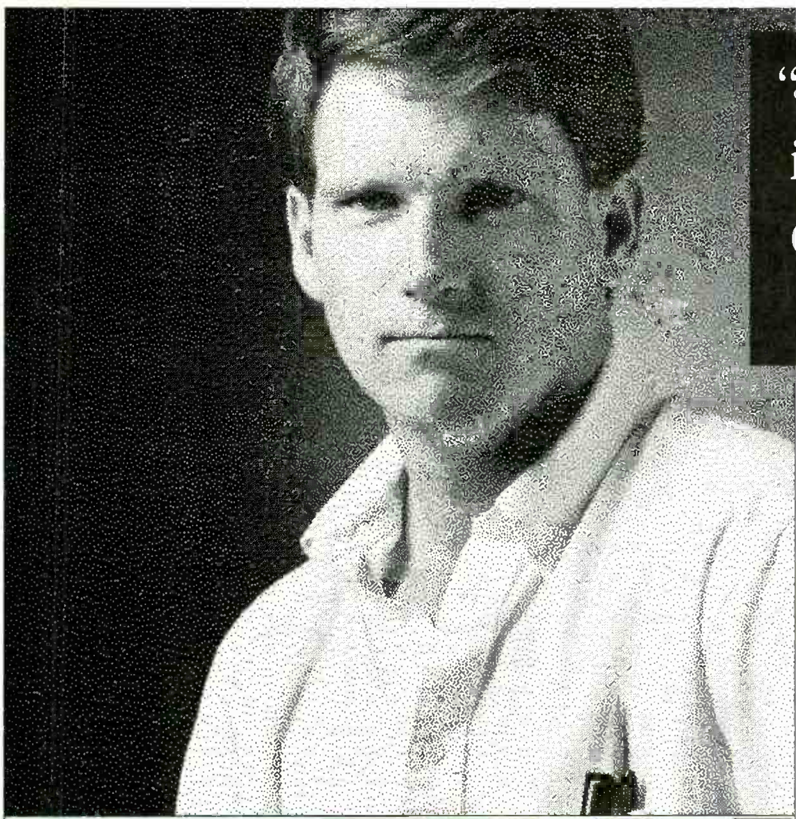

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Gordon MacDonald
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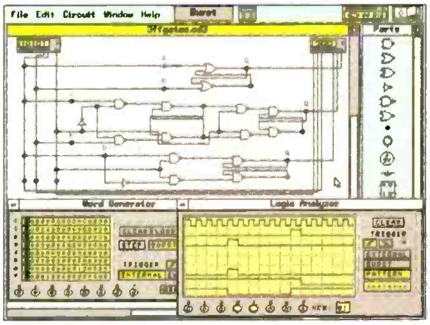

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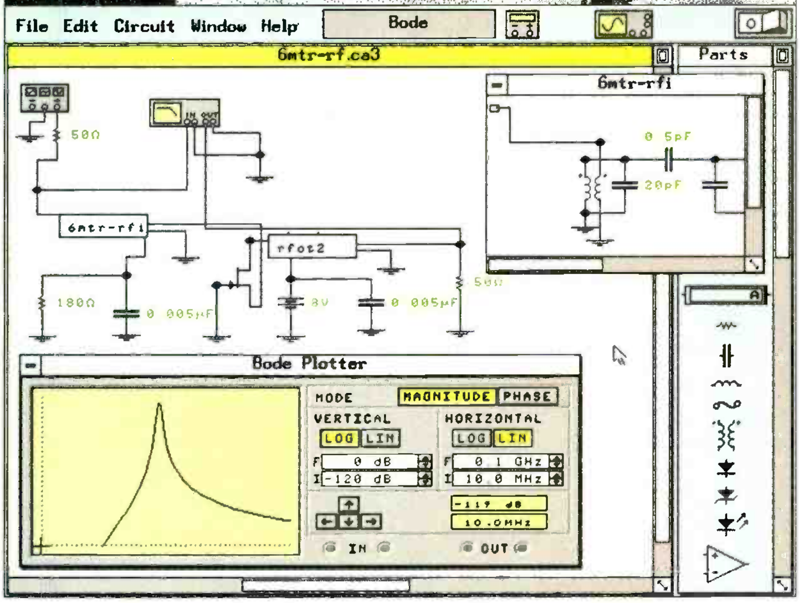

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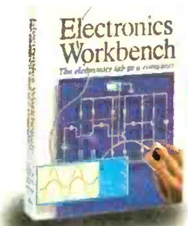

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POSTMASTER: Please send address changes to ELECTRONICS NOW, Subscription Dept., Box 55115, Boulder, CO 80321-5115.

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Microfilm & Microfiche editions are available. Contact circulation department for details.

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WHAT'S NEWS

A review of the latest happenings in electronics.

Solar cells by the roll

Research is underway to develop "solar cells in a roll," that resemble rolls of kitchen plastic wrap. When stretched over a frame with wires attached, the thin film will become a solar cell that converts sunlight directly into electricity.

The Advanced Research Development, Inc, (ARDI) of Athol, Massachusetts, and the U. S. Department of Energy's (DOE) Argonne National Laboratory have begun a three-year, $1.8 million research project to develop solar cells that will be made by coating plastic film with photoactive chemicals rather growing layers of N- and P-type semiconductor material.

Thin sheets of a plastic only 1 micrometer thick will be coated with photoactive molecules by a process that is similar to the one for making polarizing film materials. The joint venture researchers plan to apply photoactive molecules developed by the Argonne laboratory onto an electrically conductive, stretchable plastic film similar to polyester developed by ARDI.

Argonne's molecules are based on the perylene dyes similar to those used the photocopying process and in liquid-crystal displays. By themselves, the molecules can convert solar energy into electrical energy with more than 99% efficiency. They will be deposited as a large continuous crystal on the film which can be rolled and cut to meet the customer's requirements. The researchers hope the combination will yield solar cells that are at least 70% efficient.

Sunlight will strike a photoactive molecule, causing positive and negative charges to separate and migrate to electrically conductive strands in the substrate film. Current results when positive charges flow in one direction and negative charges flow in the other way.

Another objective of the project is the development of compatible flexible leads for connecting the film to the electrical load.

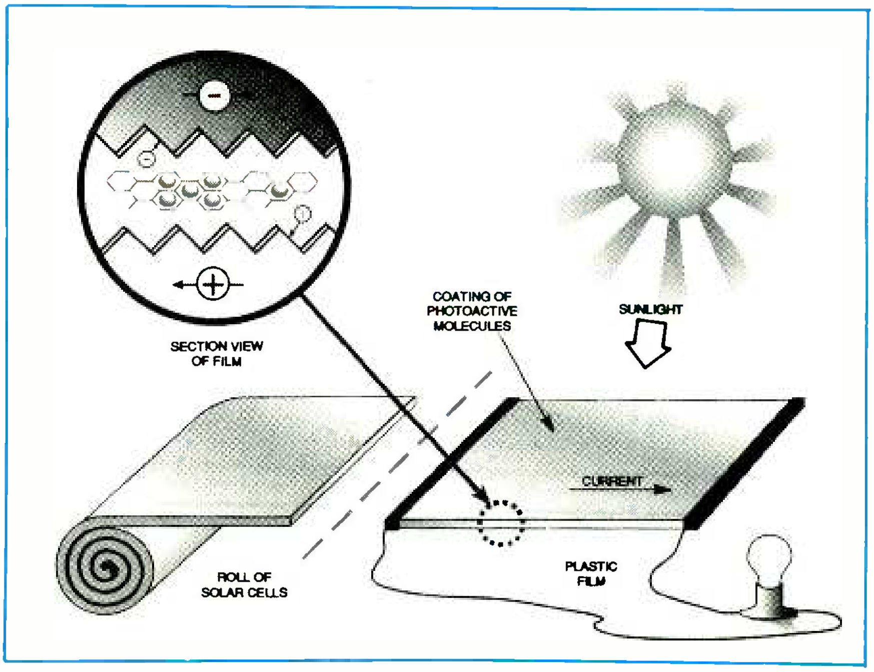


FIG. 1. SUNLIGHT STRIKES PHOTOACTIVE MOLECULES on a thin plastic film causing positive and negative charges to separate and jump to electrically conductive strands in the plastic film. Positive charges flow one way and negative charges flow the other way, causing current to flow.

High-density, three-level gate arrays

A new technology based on novel programming elements and an array of non-dedicated logic gates called a "sea-of-gates" promises low-cost, field-programmable gate arrays (FPGAs). The FPGAs, developed by Xilinx, Inc. of San Jose, California, will be be built with a stacked, three-layer metal-CMOS process.

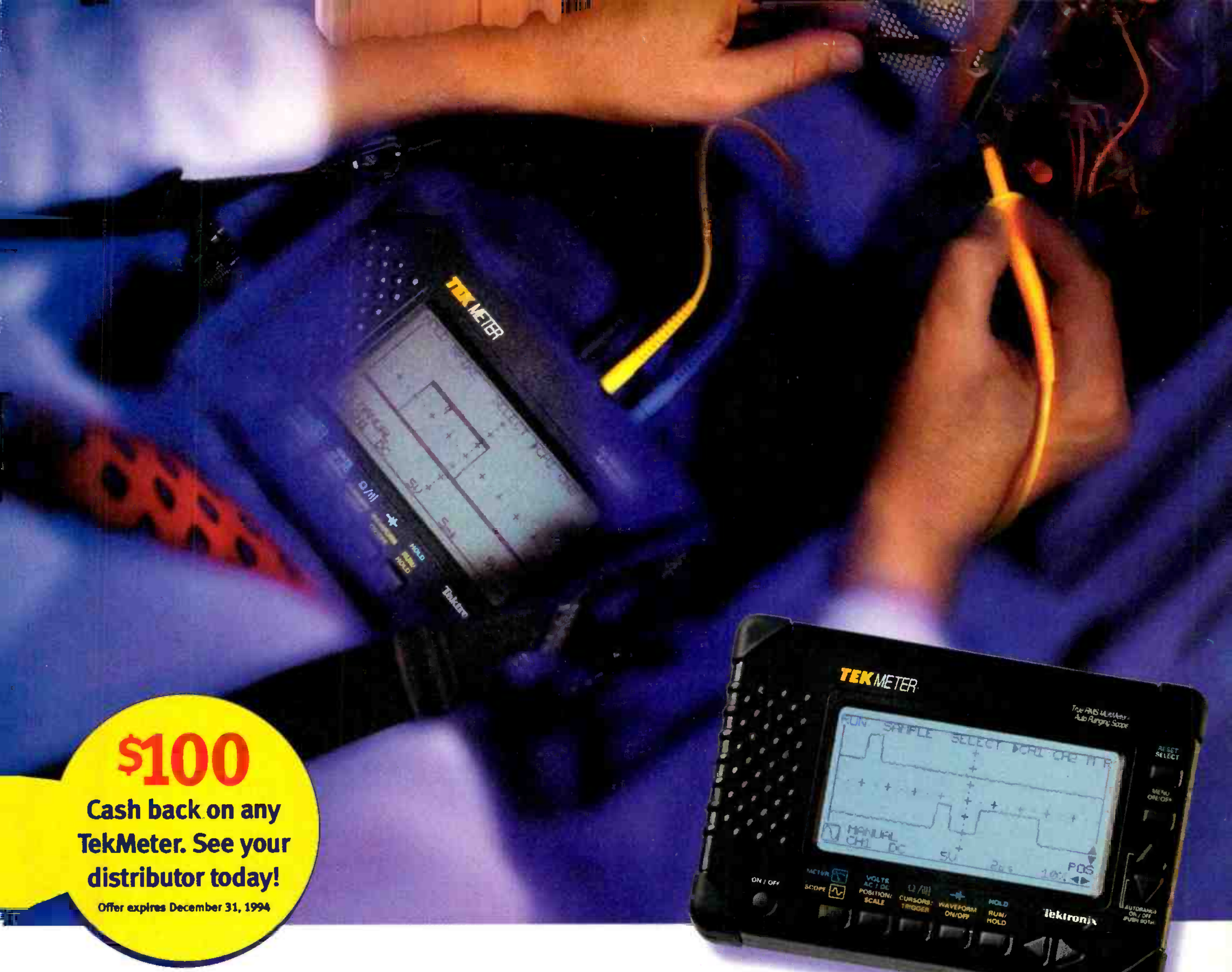
The substrate for the new device will be a wafer full of unconnected CMOS logic gate elements. This layer will be covered with a second metallic layer containing X-direction rounting wires which is, in turn, covered by a layer of amorphous silicon. A third or top layer will contain the Y-direction routing wires for programming the device.

Antifuses are formed from the amorphous silicon layer sandwiched between the second and third routing wire layers. When the FPGA is programmed, current will pass between selected X and Y wires to form permanent conductive paths that connect the desired logic elements to dedicate the device for a specific application.

According to Xilinx, the combination of these three metal layers will permit the development of FPGAs with many possible routing paths and high gate density in a very small area on the silicon wafer. The process will eliminate the tradeoff now required in making conventional FPGAs: extensive routing capability has meant low gate density, or conversely, high-gate density has restricted routing.

The sea-of-gates (SOG) concept for making FPGAs allows routing wires and programming elements to be stacked above the device's CMOS logic. The concentration of the logic gates in a substrate makes

Continued on page 79



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VIDEO NEWS

What's new in the fast-changing video industry.

DAVID LACHENBRUCH

• **Interactive program guide.** Although there are many different candidates for navigational aids to guide viewers through the intricacies of tuning in the 1000-channel age, it currently appears that the StarSight interactive on-screen guide is far in the lead. The system, developed by StarSight Telecast and now in operation, permits viewers to pick programs from an on-screen grid by title, subject, or type of program. It also lets them switch on the name of the program and episode, along with time remaining, while viewing the program, even during the commercial breaks. As an added attraction, it makes possible VCR recording at the push of a button, merely by selecting the name of the program from the guide.

At our press time, the StarSight system was incorporated into three different types of hardware: Zenith is offering it in eight TV models, it is featured in several Uniden satellite integrated receiver/decoders (IRDs), and it can be found in cable boxes serving Viacom's Castro Valley, California system. Enough of the top television manufacturers have agreed to incorporate it into their future receivers to make it the *de facto* standard.

The latest company to sign a deal with StarSight is Thomson Consumer Electronics, manufacturer of RCA TV sets, the nation's brand. Philips, the number two manufacturer (Magnavox TVs), has also signed up. Both companies will be entitled to sell StarSight sets after a brief exclusive period for Zenith, which happens to rank as the third manufacturer in terms of sales. Mitsubishi, Goldstar, and Samsung are also licensees.

The StarSight data is transmitted in the vertical blanking interval (VBI) of PBS stations and some cable channels, enabling it to reach an estimated 95% of the population. StarSight-equipped TVs seek out the VBI data, no matter which channel they're tuned to. Each set receives the automatic program guide tailored to the individual viewer-subscriber, on the basis of the subscriber's location and reception system (broadcast, cable, or satellite). StarSight costs $3.50 to $4.30 monthly, depending on the length of the contract purchased.

StarSight's ability to tune a VCR depends on its use of an "IR blaster," a cable from the TV set to the video recorder that activates the infrared remote control receiver on the VCR. StarSight-equipped VCRs are also in the works.

• **Small-dish satellite.** Two months after the launch of the United States' first high-powered Ku-band satellite service, receivers and 18-inch dishes were selling as rapidly as they could be built. According to one source close to the scene, viewers in the first markets had purchased nearly 100,000 of the RCA-brand Digital Satellite System (DSS) receivers. The manufacturer said that the receivers will be in short supply until cumulative shipments total 500,000 to 600,000 units later this year.

Two Hughes satellites eventually will broadcast 150 channels, but at press time fewer than half that number were on the air, pending activation of the second bird, which was launched in August. Sales of receivers started late in June in a few selected areas with low cable TV penetration, fanning out to 12 states by August and scheduled to be nationwide by year-end. Of the two receiver models, RCA said that the more expensive $899 unit initially was outselling the $699 model by a two-to-one margin. The cheaper package includes an 18-inch parabolic dish antenna, an integrated receiver/descrambler (IRD), a low noise block downconverter (LNB), and a remote control. The higher priced system adds a dual-output LNB and a universal remote. The company said that a surprisingly large number of buyers are choosing to install the systems themselves rather than pay for professional installation.

Thomson's small-antenna DSS satellite system has been selling faster than the company can ship them out.

• **Widescreen vs. HDTV.** Even as the United States was completing field tests for a digital-high-definition TV system, HDTV was faltering in other parts of the globe. Meanwhile viewers increasingly were becoming attracted to widescreen TV sets without the high-definition feature. In Japan, where analog HDTV has been on the air for three years from satellite transmission, there is talk of scrapping the Hi-Vision system and starting over to develop a digital one (*Electronics Now,* October 1994). But the basic attraction of HDTV—digital or analog—is being debated as well. In the three years of Hi-Vision broadcasting, only 25,000 HDTV sets have been sold. However, in the first five months of 1994 alone, Japanese viewers bought 223,000 widescreen TVs with 16:9 aspect ratio screens—and only 3000 Hi-Vision sets, which cost more than twice as much.

In Europe, too, widescreen TVs are beginning to catch on—particularly in France, where dot of pro-

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LETTERS

Write to Letters, Electronics Now, 500-B Bi-County Blvd., Farmingdale, NY 11735

VINTAGE-GEAR RESTORATION

Gary McClellan's article, "Restore It Right!" (*Electronics Now*, August 1994) was very informative, and his list of sources for components was especially welcome.

Those who restore old electronic gear should be aware of some changes in electronic terminology that have taken place over the years. For example, most of us know that a capacitor was once known as a condenser, but many people might be confused about the values of resistors shown on old schematics.

Circuit diagrams drawn prior to 1930 often specified resistance in "M-ohm,"values. However, they are not megohms, as one might initially suspect. "M," the Roman numeral for 1000, denotes thousands of ohms here, not millions. Thus, if you intend to replace a 47 M resistor on an old schematic that followed that convention, it should be replaced with a 47 K resistor, or the circuit will not work.

It's easy to determine if that convention applies in an old schematic diagram by noting the absence of kilohm resistance values; seemingly large-value resistors are located where smaller values would be more appropriate in more modern circuits that perform essentially similar functions.

DAVE ELEY
Surrey, BC, Canada

NEW, BUT NOT IMPROVED, TELEPHONE RING AMPLIFIER

In the "Letters" column in the August 1994 issue, a schematic for an "improved" telephone ring amplifier was published as Fig. 2 on page 26. That schematic contains a number of errors that should be corrected if the builder wants the circuit to operate correctly and safely.

Most telephone systems have two different voltage levels. First, there is the static voltage that exists on all phone lines when the handset is hung up and not ringing. It is usually 48 volts DC. (Capacitor C4 will eventually charge to this value.) Second, there is a ringing voltage that is impressed on the DC voltage. It is about 110 volts AC at 20 Hz and the instantaneous peaks of this ringing voltage are at about 155 volts.

First changes should be in diode ratings. Diodes D3 and D4 (1N4148s) will "see" the 155 volts peak, plus the 48 volts across C4. This value is considerably higher than the 100-volt rating of the 1N4148s specified in Fig. 2. Therefore, 400 PIV diodes, such as 1N4004s, should be substituted for all four 1N4148 diodes. (Another good reason for having some safety margin here is to protect the circuit against line transients that can occur during electric storms.)

The second correction should be in the value of resistor R4. Capacitor C4 will typically charge to about 48 volts DC from the telephone line. When a ringing signal appears, transistor Q1 will turn on. With Q1 conducting, +48 volts is applied from the plus side of C4 to the left side of R4. That could destroy Q1, R4, or Q2—or possibly all three. This can be prevented if resistor R4 has a value of 10,000 ohms.

The third correction relates to buzzer BZ1. As stated earlier, C4 will charge up to the approximate phone line voltage. With the values of the diodes and resistor R4 changed, a ringing situation could turn on Q2. Transistor Q2, acting like a switch, applies the full voltage of C4 across BZ1.

After checking with a number of piezoelectric buzzer vendors, I found that most are rated in the 6- to 16-volt DC range, with the highest rating 28 volts DC. A voltage of 48 volts would destroy most of these buzzers.

A simple fix for this limitation is the placement of a Zener diode in series with the top end of BZ1. The diode will drop the 48 volts down to a safe voltage range for most buzzers. For example, if you want to use a 12-volt buzzer, install a 36-volt Zener diode (or three 12-volt Zener diodes in series). The cathode end of the Zener diodes is directed toward the +48-volt source.

Notice that Fig. 2 does not show the polarity of the buzzer, a serious oversight. The negative side of the buzzer should be directed toward Q2.

Many transistors that are popular with experimenters have maximum voltage ratings of only 40 volts. The transistors in Fig. 2 should have at least a 60-volt maximum rating (because of the 48 volts supplied to the circuit by C4).

The only other comment I'll make is that the circuit builder should be aware of the fact that if the handset remains off hook for long periods,

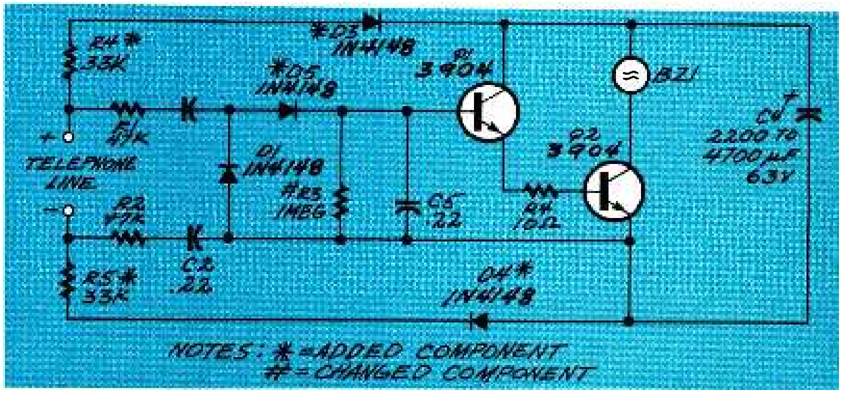

FIG. 1

capacitor C4 will self-discharge. Its discharge rate will depend on its internal leakage and the phone line voltage. In an off-hook situation, that could be from 5 to 30 volts.

When the handset is restored to the on-hook condition, C4 will recharge. That is also something to keep in mind when the circuit is installed. The capacitor charges through resistors R4 and R5 and their combined time constant with C4 is about 310 seconds! So allow at least 15 minutes after installing the circuit before attempting to use it or it will not work properly.
DONALD G. CHESSIER
Garland, TX

ADDRESS AND PRICE UPDATE

Thank you for featuring Progressive Concepts' MasterSwitch in "New Products" in the July issue of *Electronics Now*. However, since we sent you the information about the MasterSwitch, the company has moved and the price has changed.

The new address is: Progressive Concepts, 1424 North Mills Avenue, Claremont, CA 91711. Fortunately, our phone number is still the same: 909-626-4969.

The MasterSwitch now costs $36 in kit form and $46 fully assembled.
ERIC HOPPE
Claremont, CA

CHANGING TONER CARTRIDGES

I am writing to comment on the "Hardware Hacker" column (*Electronics Now*, August 1994) in which the refilling of the Canon-EX toner cartridge was discussed. The article describes briefly the remanufacturing of this cartridge for the end user and also for people who might be interested in starting a cartridge-recycling business.

The instructions and illustrations are too simplistic and do not cover the total inspection and cleaning procedure that a competent remanufacturer will use to produce a superior product.

Those who follow the two refilling methods described in the column are asking for trouble every time they put the cartridges in their printers. Cartridges that spill toner from the toner collection bin will scatter toner over the interior of the machine. This could jam the main drive train which in turn can break gears and clutches, and even ruin fusing rollers.

The rotating blade of the toner collection bin is rotated by the drive train of the cartridge. The rotation of the blade can be restricted by overfilling the bin. Under certain conditions the blade might be stopped completely.

That is only one of many problems that can be caused by an improperly remanufactured cartridge. There are a lot of other potential problems related to remanufacturing. For example, many manufacturers and distributors of remanufacturing supplies require a minimum purchase of at least $50. That is a high price for the consumer of only one cartridge every six months.

Consumers must also contend with the deterioration of the organic compounds in the drum and toner. Those products have a finite useful life. If they are exposed to the environment for too long a period, their degraded performance could result in poor prints.

Anyone who wants to enter the recycling business should extensively research the products they intend to remanufacture. The production of quality remanufactured toner cartridges requires an understanding of how each type of cartridge should function normally.

I have seen many cartridges that worked well for the first 100 test pages but started to print poorly after that. You should be aware of the problems that might occur and the corrective action that must be taken before a single cartridge is shipped. You won't be in business long if your customers are your test subjects.

Be prepared to compete! There are many remanufacturers with excellent reputations in business with high-powered sales forces. If you enter the market with a poorly conceived sales plan and an even poorer quality remanufactured cartridge, you will not be there for long. Customer service, informative advertising, and a quality product at the right price will keep you going.

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remanufacturers have expanded their companies to provide printer, computer, copier, and fax machine sales and service. The prices of remanufactured cartridges no longer provide profit margins that are high enough to cover overhead.

Summing up, the consumer should seek out a quality cartridge remanufacturer. Most good ones will either let you try one of their cartridges before you buy it, or offer a written money-back guarantee. It's not really worth the time and money spent in repairing an expensive printer—not to mention the aggravation—just to get your per-page costs down close to zero.

KEVIN D. BUSTO
Toner Cartridge Services, Inc.
Richville, OH 44706

MORE ON TONER CARTRIDGES

I am writing to call your attention to some of the *facts* about toner refilling that appeared in *Q&A* in the May 1994 *Electronics Now.*

As a remanufacturer of laser-printer toner cartridges since 1985, and a recycler since 1978, my firm, Mag Tech, produces more than 2000 cartridges per month. Each cartridge works as well as a new one. Our customers are satisfied with the remanufactured units. Some last as long as eight years! Moreover, the remanufacture of cartridges prevents thousands of them from ending up in the nation's already overflowing landfills.

In my opinion, a properly remanufactured toner cartridge will work as well as a new one—perhaps even better. Service personnel from Hewlett-Packard, Apple, and Canon might argue that statement, but they sell new toner cartridges and don't want to be bothered with remanufactured ones.

It's true that some poor quality "refillers," have given the entire industry a bad reputation. Out of the estimated 8000 firms now recycling laser toner cartridges in the U.S., approximately 800 are considered by those of us in the industry to be experts. Those companies know what they are doing, and offer high-quality products and service.

Q&A obviously had a bad experience with one of the 7200 others. It bothers me to hear that, but this only encourages me to renew my efforts to publicize the existence of the expert companies.

Q&A made an excellent point in his answer: "See what they offer as a guarantee, before you sign up, because the cost of repairing a laser printer is substantially more than the savings you will get on the toner cartridge." If everyone followed that good advice, my company alone might be selling 10,000 remanufactured cartridges a month rather than 2000!

MICHAEL W. JOHNSON
Magnetic Technologies, Inc.
Hempstead, NY

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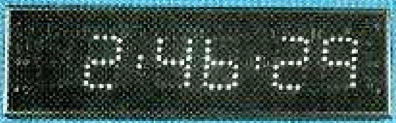
EQUIPMENT REPORTS

Jameco Electronics JE725 Digital Clock Kit

Build a kit that you'll use every day!



CIRCLE 15 ON FREE INFORMATION CARD

Over the years *Electronics Now* has presented many different clock projects and described various clock technologies—everything from clocks with Nixie-tube displays to clocks that receive WWV broadcasts and provide accuracy approaching that of an atomic clock. Microprocessor-driven clocks have been popular, and clocks that display time in binary numbers provide a fun diversion.

Building an electronic clock from scratch can be a rewarding and educational experience. However, unless you have the mechanical skills and tools to do a professional job, building one from a complete kit will result in a clock that has a better fit and finish.

Clocks are great construction projects because clocks are always useful. Many of the projects built from this magazine are used only sporadically and end up being tucked away the rest of the time. But a working clock—especially one you build—will always be displayed prominently.

When we heard about the new JE725 digital clock kit from Jameco Electronics, we were anxious to build one. (Jameco Electronic Components/Computer Products, 1355 Shoreway Road, Belmont, CA 94002-4100, 415-592-8097, 800-831-4242.) The clock has six 2½-inch high display digits and the double-sided PC board measures a whopping 17½ × 3½ inches. This means the clock is large enough to be seen from up to 50 feet away. The clock can be set to operate in either the 12- or 24-hour mode, has fast and slow time-setting switches, and also has a hold switch to synchronize its display with another clock. The 183-piece kit for building this unique clock sells for $69.95.

A single IC, a National Semiconductor MM5314N, is dedicated to time-keeping and keeps the clock's circuit simple, completely reliable, and very accurate. Most of the circuitry in the kit is for driving the large display, not for timekeeping. The display consists of the six 2½-inch tall digits made up from 126 individual LEDs. (Each digit is essentially a seven-segment display and each segment includes three discrete LEDs.) The display is unusually attractive and eye-catching.

The finished clock board is attractive enough to be displayed by itself, but two optional enclosures are also available: a semi-open enclosure reveals much of the PC board, and an extruded aluminum enclosure hides the board completely. Each enclosure has a red plastic filter to make the display more visible. Both enclosures are priced at $29.95. We opted for the sleek black-anodized extruded aluminum enclosure that measures 18½ inches wide—it really looks great.

Discounts are available on orders of 10 or more clocks, which might make the JE725 attractive as a project for an electronics class. In addition, for people who want a good-looking clock but who don't trust their electronics assembly skills, it's also available completely assembled. Mounted in the semi-open enclosure the price is $139.95; totally enclosed, the price is $149.95. We believe that everyone who regularly reads *Electronics Now* will want to build the clock, so let's see what's involved in building it.

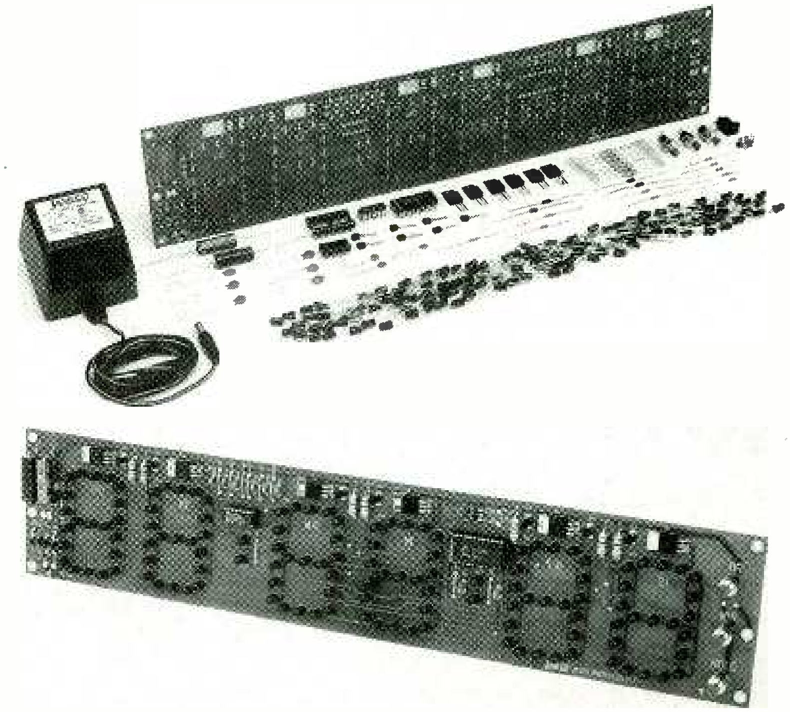


FIG. 1—183 PARTS (top) are combined to make an eye-catching clock (bottom).

Assembling the kit

The clock can be built in one evening, but the job shouldn't be rushed if you want to end up with a neat-looking timepiece. All components, including 126 LEDs, are mounted on the single printed-circuit board. No components are taller than the LEDs, so that the flat plastic filter can lie flush across the entire board.

The display is multiplexed to conserve drive circuitry. Thirteen transistors—six power and seven general-purpose—drive the six digits. Power is supplied sequentially to each of the six digits. When power is applied to a digit, the seven smaller transistors enable the appropriate segments for the intended digit.

One power transistor supplies power to each 21-LED digit. A power transistor is required because up to 21 LEDs can draw current at one time. General-purpose transistors are sufficient for strobing power to the segments.

The most time-consuming task in building the kit is mounting the LEDs. Although the LEDs mount flush with the board, it's very easy to solder them slightly out of alignment, no matter what you do to hold them in place. The assembly instructions recommend tack-soldering one lead of each LED while the PC board rests face-down on a dry sponge. Then the board is held in one hand, and pressure is applied to each LED while the solder is remelted. The procedure, although time-consuming, is actually easy to do and results in a professionally manufactured appearance.

Power is supplied to the clock from a wall outlet-mounted AC to DC power adapter, so no dangerous AC voltages are present on PC board. This provides a hazard-free kit that is ideal for beginners. However, beginners might be intimidated by the large number of LEDs. For kit-building beginners and veterans alike, observing the polarity when installing the 126 LEDs requires double- and triple-checking.

Finishing touches

The finished board can be installed in the aluminum enclosure, a four-piece frame with corner mounting hardware that makes assembly a breeze. The assembled frame is perfectly square and quite sturdy. A plastic backplate (part of the optional enclosure) mounts on the back of the PC board with screws and nuts. Cutouts on the backplate allow access to the 12/24 hour switch, the power jack, and the time-set and -hold buttons. The board and the red plastic filter slide into a partially assembled three-piece frame; the fourth piece holds the board and lens in place.

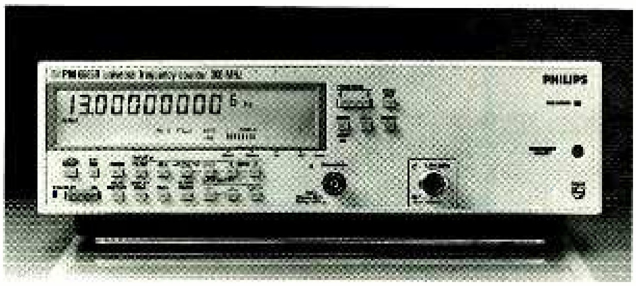
Four rubber feet mount on the bottom corners of the frame so that it can lie flat and securely on a desk or coffee table. The frame can also be hung on a wall so the clock can be seen by just a few people in your home or by hundreds of people in a large factory. The clock really is quite handsome—even to a spouse who has no interest in electronics. Ω

NEW PRODUCTS

Use the Free Information Card for more details on these products.

RUBIDIUM TIMEBASE FREQUENCY COUNTER. The Fluke PM 6685R rubidium timebase frequency counter is the latest of a series of portable frequency counter/calibrators. It offers a 2.5×10^{-10} relative measuring solution. Warm-up time is six minutes to reach 1×10^{-9} and it takes 30 minutes to reach 1×10^{-10}.

This portable, "connect-and-go" frequency calibration tool is suitable for both field and bench use. It provides 10 reliable read-out digits in about one second. Aging decay of the counter accuracy is only 5×10^{-11} per month and 5×10^{-10} per year.



CIRCLE 20 ON FREE INFORMATION CARD

The PM6685R has a standard input frequency range of 300 MHz, with options that extend the range up to 1.3, 2.7, or 4.5 GHz. This allows high-frequency digital calibration measurements without the need for synthesizers, mixers, and filters to achieve the required resolution.

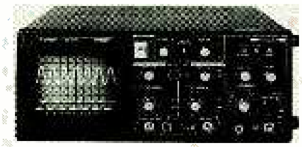
To ensure maximum safety and security, the PM 6685R has automatic overload protection on all inputs. The optional RF inputs (up to 4.5 GHz) are PIN-diode protected to withstand input levels in excess of 12 volts RMS.

The PM 6685R rubidium timebase frequency counter is priced at $10,645. Options include a GPIB/IEEE-488.2 serial interface.

Fluke Corporation
P.O. Box 9090
Everett, WA 98206
Phone: 800-44-FLUKE
Fax: 206-356-5116

20-MHz OSCILLOSCOPE. The Model P-3502C 20-MHz, dual-trace oscilloscope from Protek is suitable for measuring resistors, capacitors, coils, Zener diodes, diodes, and other components in and out of a circuit.

Its key features include a six-inch CRT with 2-kilovolt acceleration, a five times magnification for all time and division settings, and five vertical mode selections. It offers a 20-step horizontal sweep speed from 0.5 second per division to 0.2 microsecond per division. The oscilloscope includes an auto/normal switch; in the auto position it allows a free-running sweep mode for fast trace location.



CIRCLE 21 ON FREE INFORMATION CARD

The P-3502C, priced at $440, includes two probes, a power cord, a fuse, and an operating manual.

HC Protek
154 Veterans Drive
Northvale, NJ 07647
Phone: 201-767-7242
Fax: 201-767-7343

PC16C71/PC16C84 PROGRAMMER/DOWNLOADER. The TrueFlight programmer from Parallax for the PIC16C71 and PIC16C84 microcontrollers can become a downloader by adding a ribbon cable and ultraviolet eraser.

The programmer/downloader has an 18-pin low-insertion force socket that will hold either the PIC16C71 or PIC16C84. The device's pins are duplicated on the end of an 18-pin cable, which can be substituted for a PIC microcontroller in a target system.

When TrueFlight needs to program or read the PIC microcontroller, it breaks the connection between the PIC and the target system, accesses the PIC, and then reconnects it to the target. No relay is needed, so its operation is transparent.

CIRCLE 22 ON FREE INFORMATION CARD

If the PIC has been previously programmed, the flash ultraviolet eraser is positioned over the microcontroller in its socket. Before reprogramming a microcontroller, TrueFlight checks to see if it has been erased. If it has not been erased, TrueFlight turns on the eraser and periodically checks the controller. TrueFlight will reprogram the device only when it has been erased.

A cycle time to erase and program a PIC16C71 is about 65 seconds, but it is only nine seconds for the PIC16C84.

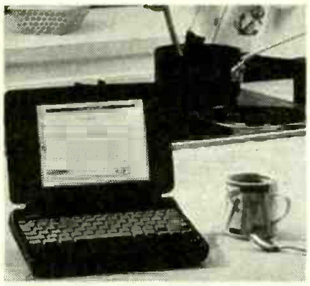
A TrueFlight package, including all software and cables, is priced at $299.

Parallax
3805 Atherton Road #102
Rocklin, CA 95765
Phone: 916-624-8333
Fax: 916-624-8003

PORTABLE PC. The Contura Aero portable personal computer from Compaq is said to be 45% lighter and 33% smaller than most notebook PCs. It weighs only 3½ pounds, and it has an outline smaller than an 8½ × 11-inch sheet of typewriter paper.

The Contura Aero has an Intel 486 microprocessor and up to a 250-megabyte hard-disk drive. Its display is a backlit liquid crystal screen. Six hours of operation are possible with an optional, standard-sized rechargeable battery.

Other features include a



CIRCLE 23 ON FREE INFORMATION CARD

standard keyboard with a palm rest and a built-in trackball, a PCMCIA slot, and a two-prong power cord that fits into any standard electrical outlet. It can be connected to full-size monitors or other keyboards.

Pre-installed software includes DOS 6, Windows 3.1, TabWorks, Lotus Organizer, and WinLink File Transfer software, which allows users to maintain files between the portable and a desktop computer. Consumer models also include Microsoft Works and Microsoft Entertainment Pack.

The Contura Aero with a monochrome screen is priced at $1399; with a color screen it is priced at $2199.

Compaq Computer Corp.
P. O. Box 692000
Houston, TX 77269-2000
Phone: 1-800-759-1533

SERIAL EEPROM DESIGNER'S KIT. The Serial EEPROM Designer's Kit from Microchip Technology is intended to help engineers select and design in serial EEPROM nonvolatile memories. It includes all the circuitry, PC-based software tools, and on-line reference materials needed to create, model, integrate, debug, and test systems with serial EEPROMs.

The kit includes the SEEVAL serial EEPROM programming and evaluation system, Total Endurance software tool, the Serial EEPROM Handbook, and assorted support materials.

SEEVAL enables the designer to learn serial EEPROM operational theory and applications, load an EEPROM with known data before a test, modify all or part of an EEPROM array, evaluate the effect of microcontroller code on a serial EEPROM, save or restore data to or from a disk, and program special device features.

CIRCLE 24 ON FREE INFORMATION CARD

Total Endurance allows the designer to model a serial EEPROM within a specific application environment and analyze the effects of density, temperature, voltage, write mode, bytes per cycle, and cycles per day on erase and write endurance.

The handbook is a handy reference source on EEPROMs. It includes Microchip serial EEPROM data sheets, application notes, qualification reports, and other useful EEPROM reference documentation. A power supply, RS232 cable and samples of Microchip serial EEPROMs are included.

The Serial EEPROM Designer's Kit costs $149.

TECHNOLOGY UPDATE

900 MHz breakthrough!

New technology launches wireless speaker revolution...

Recoton develops breakthrough technology which transmits stereo sound through walls, ceilings and floors up to 150 feet.

Breakthrough wireless speaker design blankets your home with music.

By Charles Anton

If you had to name just one new product "the most innovative of the year," what would you choose? Well, at the recent *International Consumer Electronics Show*, critics gave Recoton's new wireless stereo speaker system the *Design and Engineering Award* for being the "most innovative and outstanding new product."

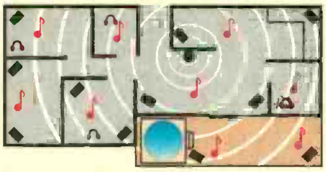
Recoton was able to introduce this whole new generation of powerful wireless speakers due to the advent of 900 MHz technology. This newly approved breakthrough enables Recoton's wireless speakers to rival the sound of expensive wired speakers.

Recently approved technology. In June of 1989, the *Federal Communications Commission* allocated a band of radio frequencies stretching from 902 to 928 MHz for wireless, in-home product applications. Recoton, one of the world's leading wireless speaker manufacturers, took advantage of the FCC ruling by creating and introducing a new speaker system that utilizes the recently approved frequency band to transmit clearer, stronger stereo signals throughout your home.

150 foot range through walls!

Recoton gives you the freedom to listen to music wherever you want. Your music is no longer limited to the room your stereo is in. With the wireless headphones you can listen to your TV, stereo or CD player while you move freely between rooms, exercise or do other activities. And unlike infrared headphones, you don't have to be in a line-of-sight with the transmitter, giving you a full 150 foot range.

The headphones and speakers have their own built-in receiver, so no wires are needed between you and your stereo. One transmitter operates an unlimited number of speakers and headphones.



Recoton's transmitter sends music through walls to wireless speakers over a 75,000 square foot area.

Crisp sound throughout your home. Just imagine being able to listen to your stereo, TV, VCR or CD player in any room of your home without having to run miles of speaker wire. Plus, you'll never have to worry about range because the new 900 MHz technology allows stereo signals to travel over distances of 150 feet or more through walls, ceilings and floors without losing sound quality.

One transmitter, unlimited receivers. The powerful transmitter plugs into a headphone, audio-out or tape-out jack on your stereo or TV component, transmitting music wirelessly to your speakers or headphones. The speakers plug into an outlet. The one transmitter can broadcast to an unlimited number of stereo speakers and headphones. And since each speaker contains its own built in receiver/amplifier, there are no wires running from the stereo to the speakers.

Full dynamic range. The speaker, mounted in a bookshelf-sized acoustically constructed cabinet, provides a two-way bass reflex design for individual bass boost control. Full dynamic range is achieved by the use of a 2" tweeter and 4" woofer. Plus, automatic digital lock-in tuning guarantees optimum reception and eliminates drift. The new technology provides static-free, interference-free sound in virtually any environment. These speakers are also self-amplified; they can't be blown out no matter what your stereo's wattage.

Stereo or hi-fi, you decide. These speakers have the option of either stereo or hi-fi sound. You can use two speakers, one set on right channel and the other on left, for full stereo separation. Or, if you just want an extra speaker in another room, set it on mono and listen to both channels on one speaker. Mono combines both left and right channels for hi-fi sound. This option lets you put a pair of speakers in the den and get full stereo separation or put one speaker in the kitchen and get complete hi-fi sound.

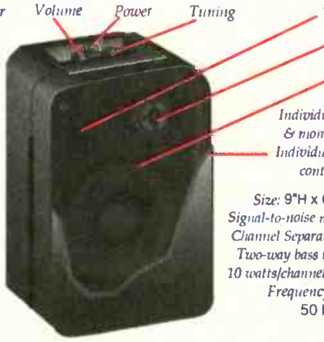
These wireless stereo headphones have a built-in receiver.

Factory direct savings. Our commitment to quality and factory direct pricing allows us to sell more wireless speakers than anyone! For this reason, you can get these speakers far below retail with our 30 day *"Dare to Compare"* money-back guarantee and full one year manufacturer's warranty. For a limited time, the Recoton transmitter is only $69. It will operate an unlimited number of wireless speakers priced at $89 and wireless headphones at $59 each. Your order will be processed in 72 hours and shipped UPS.

AWARD WINNING WIRELESS SPEAKER

Built-in receiver and amplifier:

The wireless speaker and headphones both contain a built-in receiver and amplifier. Signals are picked up and transmitted as far as 150 feet away through walls without the use of wires.



Size: 9"H x 6"W x 5.5"L
Signal-to-noise ratio: 60 dB
Channel Separation: 30 dB
Two-way bass reflex design
10 watts/channel RMS amps
Frequency Response: 50 Hz-15 KHz

Don't take our word for it. Try it yourself. We're so sure you'll love the new award-winning Recoton wireless speaker system that we offer you the **Dare to Compare Speaker Challenge.** Compare Recoton's rich sound quality to that of any $200 wired speaker. If you're not completely convinced that these wireless speakers offer the same outstanding sound quality as wired speakers, simply return them within 30 days for a full "No Questions Asked" refund.

Recoton's Design and Engineering Award

Recoton Transmitter (you must have a transmitter to operate speakers and headphones)............**$69** $7 S&H

Wireless products compatible with the Recoton transmitter:

Recoton Wireless Speaker...............**$89** $9 S&H

Recoton Wireless Headphones......**$69** $6 S&H

Please mention promotional code 165-ET1100.

For fastest service call toll-free 24 hours a day

800-992-2966

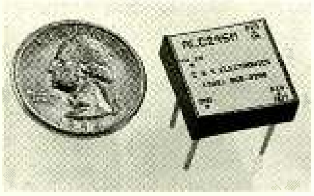
To order by mail send check or money order for the total amount including S&H (VA residents add 4.5% sales tax). Or charge it to your credit card by enclosing your account number and expiration date. Send to:

COMTRAD INDUSTRIES

2820 Waterford Lake Drive Suite 106
Midlothian, Virginia 23113

Microchip Technology Inc.
2355 West Chandler Blvd.
Chandler, AZ 85224-6199
Phone: 602-786-7200
Fax: 602-899-9210

AUTOMATIC AUDIO LEVEL CONTROLLER. The ALC245M automatic audio-level controller module from C & S Electronics produces a nearly constant output level of 100 millivolts RMS for a wide range of input AC voltages. Any AC signal above the crossover point (unity gain level) is attenuated while any signal below that crossover level is amplified.


CIRCLE 25 ON FREE INFORMATION CARD

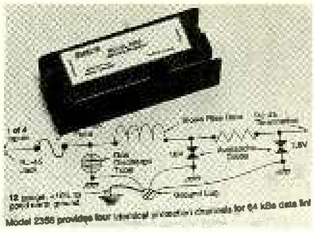
The module, powered from the host equipment, requires 7 to 30 volts DC at 10 milliamperes or less. It is intended for applications in radio transceivers, scanners, and experimental hearing aids.

The single unit price of an ALC245M audio-level controller module is $29.95.

C & S Electronics
P.O. Box 2142
Norwalk, CT 06852-2142
Phone: 203-866-3208

TELECOMMUNICATIONS LIGHTNING PROTECTOR. The Model 2356 lightning protector module from Telebyte Technology protects four-wire (dual twisted pair) telecommunications lines from data error, equipment damage, or personal injury caused by lightning and power surges. It is intended for ISDN networks and telecommunications lines to 64 kilobits.

Four identical stages of


CIRCLE 26 ON FREE INFORMATION CARD

protection are provided for each of four wires. They a fuse, gas-discharge tube, and dual avalanche diodes. The 250-milliampere fuse opens within 500 microseconds to provide communications-link isolation in the presence of surges. It meets the UL1459 requirements for isolation against accidental contact between telecommunications wiring and utility power lines.

The gas-discharge tube can divert a 5000-joule lightning surge to ground. An avalanche diode with a delay circuit clamps spikes that elude the gas-discharge tube to 18 volts. A second avalanche diode clamps the remaining transient energy at 7.5-volts.

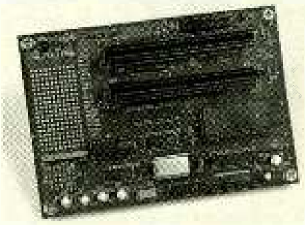
Model 2356 is priced at $97 quantities of less than ten.

Telebyte Technology, Inc.
270 Pulaski Road
Greenlawn, NY 11740
Phone: 1-800-835-3298 or 516-423-3232
Fax: 516-385-8184

PIC MICROCOMPUTER BOARD. The SXT-55 microcontroller board from Unified Microsystems is a single-board microcontroller board for use as an OEM componenent in stand-alone systems. It contains either a PIC16C55 or PIC16C57 microcontroller from Microchip Technology.

The input/output capacity of the SXT-55 can be expanded with two IBM PC/XT 8-bit I/O modules. In addition to its two PC bus connectors, the board has user-programmable switches and LEDs, TTL-level input and output lines, and interface circuitry for direct connection to standard liquid-crystal displays.

An open area on the board is reserved for prototype and custom circuitry. Signals inputs are located adjacent to the prototyping area, but they can be taken off the board with ribbon cables.


CIRCLE 27 ON FREE INFORMATION CARD

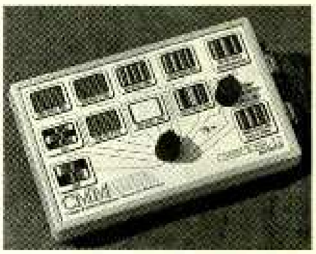
The SXT-55 is intended for applications that cannot be adapted to a host personal computer because of cost, size, or power restrictions. It can also serve as a dedicated test platform for PC I/O modules for factory production and field service as well as a portable PC card demonstration unit.

The single unit price of a SXT-55 PIC microcontroller board is $124.95.

Unified Microsystems
P. O. Box 133
Slinger, WI 53086
Phone: 414-644-9036

COMPUTER-MONITOR PATTERN GENERATOR. The Checker 12 from C&M is a handheld, battery-operated pattern generator for servicing computer color-monitors in the field and shop. It permits the isolation of faults in computer monitors to be isolated without opening the monitor enclosure or swapping video cards or monitors.

The Checker 12 supports CGA; EGA; MACII


CIRCLE 28 ON FREE INFORMATION CARD

640 × 786 sync on green; VGA modes 1, 2, 3, 800 × 600; 1024 × 768 interlaced; 1024 × 768 non-interlaced, and 1024 × 768 non-interlaced with sync on green. The device has been programmed to match the recommended VESA standard for each operating mode.

The Checker 12 provides various test patterns for VGA monitors. The pattern and mode can be selected with a single mode switch. Both size and position can be set. A color-bar/8-step gray-scale pattern allows the evaluation and adjustment of color balance and tracking.

The Checker 12 has a price of $295.

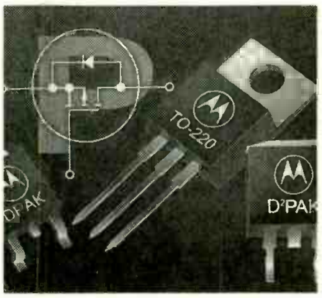
CMM, Inc.
6649-N1 Peachtree Industrial Blvd.
Norcross, GA 30092
Phone/Fax: 404-662-5633

HIGH-CELL-DENSITY P-CHANNEL MOSFETS. *Motorola* has introduced HDTMOS high-cell-density, P-channel, power MOSFETs that exhibit about 50% lower on-resistance than its previous generation of P-channel MOSFET devices.

On-resistance, RD(on), now ranges from 150 megohms to 30 megohms. This makes the devices suitable for applications in which earlier P-channel MOSFETs were inefficient. According to Motorola, lower on-resistance makes the HDTMOS devices an effective alternative to the

N-channel MOSFET switch.

A potential application for the logic-level P-channel devices is in high side switches that can disable or enable an H-bridge motor-drive circuit. Other prospective applications include their use in switching power supplies, motion-control systems, power management circuits for portable computers and peripherals, and in some personal communications products.



CIRCLE 29 ON FREE INFORMATION CARD

The devices include an improved body diode. HDTMOS devices have a shorter and softer reverse recovery time and less stored charge than previous MOSFETs, so they are said to generate less noise during switching. The first four devices introduced are in DPAK, D²PAK, and TO-220 cases. They are rated 60 or 30 volt $V_{(BR)DSS}$.

Pricing for the MPT50P03HDL (TO-220) package is $2.52 each in volume quantities.

Motorola Inc.—MD Z-311
5005 East McDowell Road
Phoenix, AZ 8501856
Phone: 602-244-3071

SYNTHESIZED FUNCTION GENERATOR. The Model 2003 synthesized function generator from Global Specialties has a frequency range of DC to 1.6 MHz, with sine, square, triangle, and ramp waveforms. Up to 16 preset frequencies can be programmed into memory and automatically sequenced in the "frequency hop" mode. Tone burst can be generated with the external trigger/gate feature, while internal linear/log sweep is available across the entire frequency range.

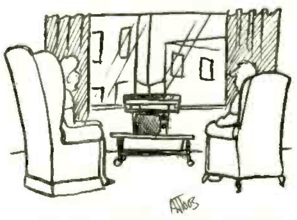

CIRCLE 30 ON FREE INFORMATION CARD

The function generator has a 32-character, two-line liquid-crystal display with a keyboard and rotary encoder for selecting functions and tuning frequencies. The rotary encoder allows analog-style tuning, while the keyboard provides direct access and mode selection.

The digitally controlled output is 20 volts peak-to-peak into an open circuit, 10 volts peak-to-peak into 50 ohms, with DC offset adjustment. An optional RS-485 serial interface is offered. Resolution to 0.001 Hz is stated, and frequency stability is guaranteed to ± 10 ppm. It offers six operational modes.

The Model 2003 synthesized function generator has a price of $499.95.

Global Specialties
70 Fulton Terrace
New Haven, CT 06512
Phone: 800-572-1028
Fax: 203-468-0060

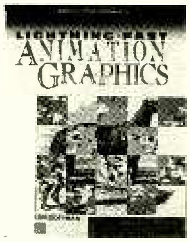

"Do you realize that we have a $600 VCR and a 75 TV?"

NEW LITERATURE

Use The Free Information Card for fast response.

Lightning Fast Animation Graphics; by Len Dorfman. Windcrest/McGraw-Hill, Blue Ridge Summit, PA 17294-0850; Phone: 1-800-233-1128; Fax: 717-794-2103; $34.95 including diskette.

This book and computer disk package is intended for C programmers who develop high-speed graphics and special effects for the personal computer without the benefit of a graphics coprocessor. The book includes a disk library of sprite management routines that emulate segments of the graphics coprocessor. These routines allow programmers to create graphic elements easily for full-motion game, animation, and multimedia programs.



CIRCLE 337 ON FREE INFORMATION CARD

The C code published here demonstrates the process of creating bit-plane graphics for video applications and is compatible with any DOS-and VGA-equipped PC. It also shows how to represent on screen the fast, smooth movement of sprite graphics in all directions, with full collision detection support.

Step-by-step instructions lead readers through the process of creating three types of graphics objects found in arcade-style animation programs: sprites, missiles, and bullets. By emulating some elements of a graphics coprocessor, the disk of C library functions allows users to animate those graphics objects more easily for video games and special effects.

An explanation of how to integrate the bit-plane animation functions with Borland's and Microsoft's Graphic Interfaces is included. It presents functions and corresponding source code for smoothly moving graphics objects within a bit-plane in all directions, the detection of collisions between sprites, missiles , and bullets, and the design of multi-colored sprites.

1994 IC Master. Hearst Business Publishing/UTP Division, 645 Stewart Avenue, Garden City, NY 11530; Phone: 516-227-1314 (for credit-card orders: 1-800-833-7138); Fax: 516-227-1453. $180 plus $10 shipping and handling.

The 1994 edition of the IC master is an updated and expanded three-volume, 3000-page catalog that provides technical and sourcing information on all commercially available integrated circuits. It is also available on CD-ROM. Among the more than 100,000 commercially available ICs are listed more than 17,000 that appear for the first time.

Volume 1 lists ICs by type, function, and key parameters.

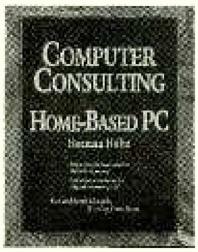
CIRCLE 338 ON FREE INFORMATION CARD

Volume 2 is presents part-number identification, military parts, and alternate sources. The part number index helps to find specific devices by starting with base number or complete part number.

Volume 3 contains technical data pages submitted by the manufacturers on their newest and most popular devices and information on their availability. Two free updates are included in the price.

Computer Consulting on Your Home-Based PC; by Herman Holtz. Windcrest/McGraw-Hill, Blue Ridge Summit, PA 17294-0850; Phone: 1-800-233-1128; Fax: 717-794-2103; $14.95.

This book explains how you can make use of your computer expertise and a home personal computer to set up your own computer consulting business. Holtz answers many of the obvious general questions one might have about a home consulting practice.



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It offers practical guidance on deciding what services you are best able to provide, how to market those services effectively, and how to build a professional reputation. Other topics covered are the identification and winning of clients, how to set competitive prices and how to get referrals.

DC/DC Converter Product Guide. Calex Mfg. Co. Inc., 2401 Stanwell Drive, Concord, CA 94520-4841; Phone: 800-542-3355; Fax: 510-687-3333; free.

Calex has included more than 100 new power-con-

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version products in its new 35-page DC/DC converter guide. The catalog also provides information on Calex's linear power supply and instrumentation products. The guide includes key specifications, product descriptions, case dimensions, and UL approval information. It also introduces Calex's FaxFACTS fax system for obtaining complete specifications and applications notes on the company's DC/DC converters and other power products.

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Never before has so much professional information on the art of detecting and eliminating electronic snooping devices—and how to defend against experienced information thieves—been placed in one VHS video. If you are a Fortune 500 CEO, an executive in any hi-tech industry, or a novice seeking entry into an honorable, rewarding field of work in countersurveillance, you must view this video presentation again and again.

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You know that the Russians secretly installed countless microphones in the concrete work of the American Embassy building in Moscow. They converted

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what was to be an embassy and private residence into the most sophisticated recording studio the world had ever known. The building had to be torn down in order to remove all the bugs.

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The open taps from where the information pours out may be from FAX's, computer communications, telephone calls, and everyday business meetings and lunchtime encounters. Businessmen need counselling on how to eliminate this information drain. Basic telephone use coupled with the user's understanding that someone may be listening or recording vital data and information greatly reduces the opportunity for others to purloin meaningful information.

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The professional discussions seen on the TV screen in your home reveals how to detect and disable wiretaps, midget radio-frequency transmitters, and other bugs, plus when to use disinformation to confuse the unwanted listener, and the technique of voice scrambling telephone communications. In fact, do you know how to look for a bug, where to look for a bug, and what to do when you find it?

Bugs of a very small size are easy to build and they can be placed quickly in a matter of seconds, in any object or room. Today you may have used a telephone handset that was bugged. It probably contained three bugs. One was a phony bug to fool you into believing you found a bug and secured the telephone. The second bug placates the investigator when he finds the real thing! And the third bug is found only by the professional, who continued to search just in case there were more bugs.

The professional is not without his tools. Special equipment has been designed so that the professional can sweep a room so that he can detect voice-activated (VOX) and remote-activated bugs. Some of this equipment can be operated by novices, others require a trained countersurveillance professional.

The professionals viewed on your television screen reveal information on the latest technological advances like laser-beam snoopers that are installed hundreds of feet away from the room they snoop on. The professionals disclose that computers yield information too easily.

This advertisement was not written by a countersurveillance professional, but by a beginner whose only experience came from viewing the video tape in the privacy of his home. After you review the video carefully and understand its contents, you have taken the first important step in either acquiring professional help with your surveillance problems, or you may very well consider a career as a countersurveillance professional.

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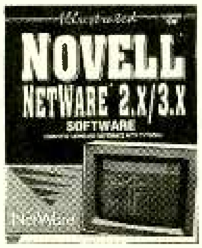
Illustrated Novell NetWare 2.X/3.X Software; by Timothy K. McDonald. Wordware Publishing, Inc., 1506 Capital Avenue, Plano, TX 75074; Phone: 214-423-0090; $23.95.

This book was written as a guide to Novell NetWare's solutions to data and resource sharing. It explores the features, limitations, and options involved in configuring and installing the hardware and software required for a customized network.



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Software commands are illustrated with examples, and common mistakes are pinpointed and explained. The book features alphabetized commands for easy reference, hundreds of examples, practice exercises, hands-on learning activities, and a simple-to-complex recommended learning sequence.

Consumer-Electronic Repair Parts and Accessories Catalog. MCM Electronics, 650 congress Park Drive, Centerville, OH 45459-4072; Phone: 1-800-543-4330; free.

The latest catalog

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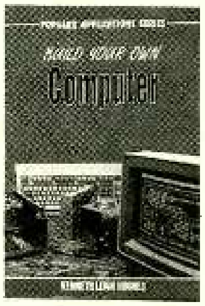
Number 33 from MCM Electronics lists more than 21,000 products that the company is offering, including more than 2800 new items. The company distributes semiconductors, speakers, connectors, test equipment, computer products, and parts for the repair of audio and video equipment.

Build Your Own Computer; by Kenneth Leigh Hughes. Wordware Publishing, Inc., 1506 Capital Avenue, Plano, TX 75074; Phone: 214-423-0090; $12.95.

The writer of this book, Ken Hughes, asserts that his book can even teach those with no knowledge of computers how to assemble a complete IBM-PC/AT or compatible personal computer system. It also contains the necessary in-



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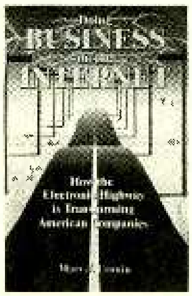
structions in software installation to help the do-it-yourselfer get his new computer up and running.

The book is organized into sections that introduce the reader to computer concepts before presenting instructions on how to assemble and operate the computer. It includes an overview of the IBM personal computer, and describes its separate components and their functions. Hughes also offers advice on how to shop for components needed to build a new computer or upgrade an old one.

Doing Business on the Internet: How the Electronic Highway is Transforming American Companies; by Mary J. Cronin. Van Nostrand Reinhold Publishing Company, 115 Fifth Avenue, New York, NY 10003; Phone: 1-800-544-0550; $29.95.

This non-technical guide is filled with facts and strategies on the Internet that hold enormous promise for businesses seeking to im-



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prove productivity and expand in the global marketplace. It is intended to reassure those who might be too intimidated by the technology to take advantage of the Internet's abundant information resources.

Cronin's book explains the basics of the technology, including how to get connected. Case histories of the benefits of Internet to businesses illustrate the various different ways that the Internet can be used effectively.

The book is based on an analysis of the results that were obtained by more than 100 large and small companies that are now on Internet. It examines, from a management perspective, the costs and benefits of various business applications.

The book also explains how to customize the Internet for product development, business partnerships, research, marketing, entrepreneurial opportunities, and customer support. Practical advice on the most important resources, services, and technical developments is offered.

The U.S. Consumer Electronics Industry in Review:1994 Edition. The Electronic Industries Association Consumer Electronics Group, 2001 Pennsylvania Avenue, NW, Washington, DC 2006-1813; Phone: 202-457-8700; Fax: 202-835-8939; single copy, free (send self-addressed envelope with $1.44 in postage); 2 to 49 copies, $1.50 each; 50 to 99 copies, $1.25 each; more than 100 copies, $.75 each.

This 110-page booklet is the latest version of a review updated annually by the Consumer Electronics Group of the Electronics Industries Association (EIA/CEG). It reports the achievements, breakthroughs, milestones, and

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trends that are constantly occurring in the consumer-electronics industry.

The review contains statistics, tables, and charts covering factory and unit sales, product development and marketing trends. The booklet also includes a history of the consumer-electronics industry, a list of available publications and participating firms, and a list of allied associations. Ω

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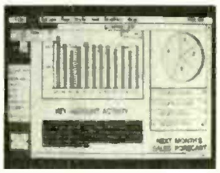

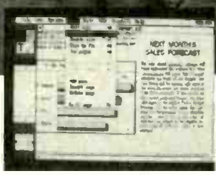

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LETTERS

continued from page 12

COMPUTER CONNECTIONS CLARIFICATION

I want to comment on Jeff Holtzman's "Computer Connections" column in the August 1994 *Electronics Now*. I have been a software engineer for several decades so I believe I am qualified to make my comments. I wrote my first software program back in 1959 on an IBM 650 computer with vacuum-tubes and relays.

First, Mr. Holtzman implies that the architecture drawing shown as Fig. 1 on page 16 is new, but it is not. I first saw a similar diagram years ago in the IEEE POSIX.0 working group. (POSIX is a group working on a generic operating-system standard.) I believe the original diagram, which was somewhat more detailed than Fig. 1, was submitted by Hewlett-Packard.

Second, Mr. Holtzman refers to *widgets*, and says they came from the Taligent effort. That is definitely not true. Widgets originated at MIT as part of the X Windows effort on the Athena Project. Widgets are dynamic objects, visible on the front panel of the computer, that are used for control purposes. Examples are a file list, a pushbutton, or a menu bar. Taligent simply cannot take credit for inventing widgets.

I believe that Fig. 1 is misleading. Holtzman's text stated layer five is the user layer, yet layer five is also shown as the graphics user interface (GUI) layer. I reviewed my notes and found a similar diagram presented in POSIX.0. The major distinction is that the POSIX diagram bound the operating system between the platform and the applications. It was shown as three boxes, not one.

Fig. 1 would be more realistic if the POWER/INTEL box were removed from the super box and put below it. Then a new box labeled APPLICATIONS should be placed above the existing super box. I don't agree with the location of the GUI and WIDGET boxes, but that is more a matter of style than concept.

I believe that referencing the POSIX.0 guide document would help to describe the present state of operating-system technology. Then it would be informative to contrast it with the IBM strategy.

Holtzman's article also said: "Another way that IBM's model differs from previous architectures... ." The sentence would be more accurate if IBM were inserted so the sentence reads, "... previous *IBM* architectures." IBM's model does not differ from other vendor models at the level described. Yes, the architecture is a significant departure from IBM's past, but then IBM is trying to catch up with the industry.

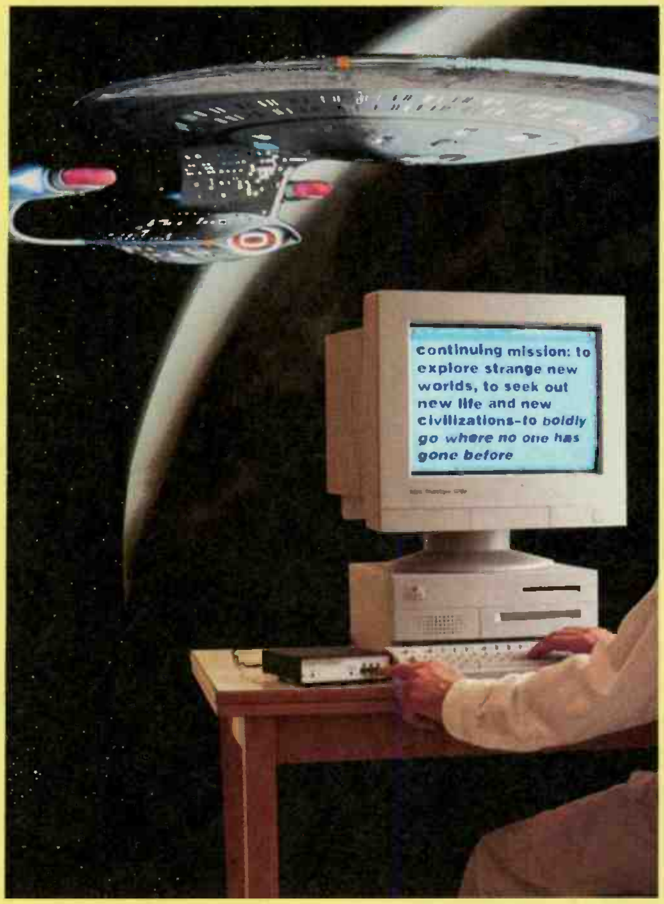
IBM played ostrich for too long a period while the industry took off in another direction, leaving it behind technically. Unfortunately, I think the same arrogance that caused IBM to

Continued on page 89

The TextGrabber

Make transcripts of your favorite television programs and download them to your PC.

KELLY McARTHUR



HAVE YOU EVER WANTED A HARD copy of the script from your favorite television program? Do you wish you could receive transcripts of important news programs without the trouble and expense of sending for them through the mail? The TextGrabber will let you capture a transcript of any closed-captioned television program for the hearing impaired. All you do is connect a video source to the TextGrabber, and connect the TextGrabber to your personal computer through its serial port. Then by running suitable communications software, you can capture the text encoded with the broadcast TV signals! Note that the TextGrabber works by itself, and does not require a separate closed-caption decoder.

VBI data transmission

Closed captions are added to the NTSC television signal as serial bit streams that occur on line 21 of the odd field during the vertical blanking interval (VBI). Figure 1 shows the data format in which two characters are sent on line 21. The text transmission rate of the VBI data system is determined by the number of VBI lines transmitted, the number of characters per line, and the frame rate of the television signal. For closed-captioning, the data rate is:

Two characters/line × one line/frame × 30 frames/second = 60 characters/second

VBI data transmission can deliver different kinds of information. With an inexpensive, settop, closed-caption decoder or a newer television set with built-in decoding, the hearing-impaired can read what is being said during the program as the words flash on the screen. Closed captioning is now included in most programming on the major networks.

Teletext information is also sent by the VBI transmission. In this mode, a decoder blanks normal programming and displays other information on the full screen. Teletext is not widely used in the United States, but it is popular in some countries in Europe.

Closed caption and teletext transmissions both use line 21 of the odd video field. Multiplexing permits the two data streams to be transmitted on the same television channel. Moreover, captions and teletext each support two different languages. Therefore, the following four separate data streams can exist on a single television channel simultaneously:

1) Captions Language 1
2) Captions Language 2
3) Teletext Language 1
4) Teletext Language 2

In the United States, Teletext and second language information is normally transmitted only during prime-time programming. The Teletext mode, for example, can transmit a programming guide listing upcoming shows that are closed-captioned. The second language mode (Language 2) usually displays a message advising the user to switch his decoder back to Language 1 to receive program captions. The vast majority of closed captioning is seen with a decoder set to the Caption mode for Language 1.

Figure 2 shows the format of the serial data in the VBI. Each "block" shown represents a start bit and two seven-bit characters with parity. Several of the important control codes are shown. Those are the only codes to which the TextGrabber responds. There are other control codes that affect different parts of the display of an on-screen caption decoder. Those include codes for italics, underlining, text color, and position. Those codes are ignored by the TextGrabber and eliminated from the output unless its "raw" data mode is selected. The TextGrabber has no use for those codes. The raw data mode is provided in case you have an application that can use them.

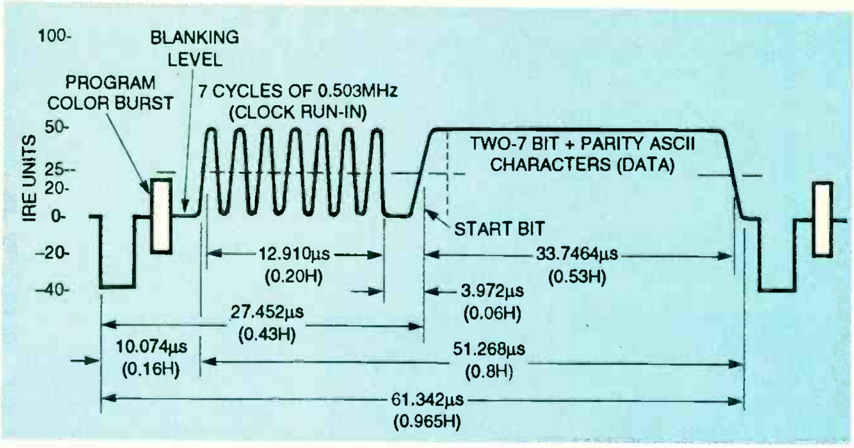


FIG. 1—CLOSED CAPTION DATA FORMAT. Captions are added to the television signal as serial bit streams that occur on line 21 of the odd field during the vertical blanking interval (VBI).

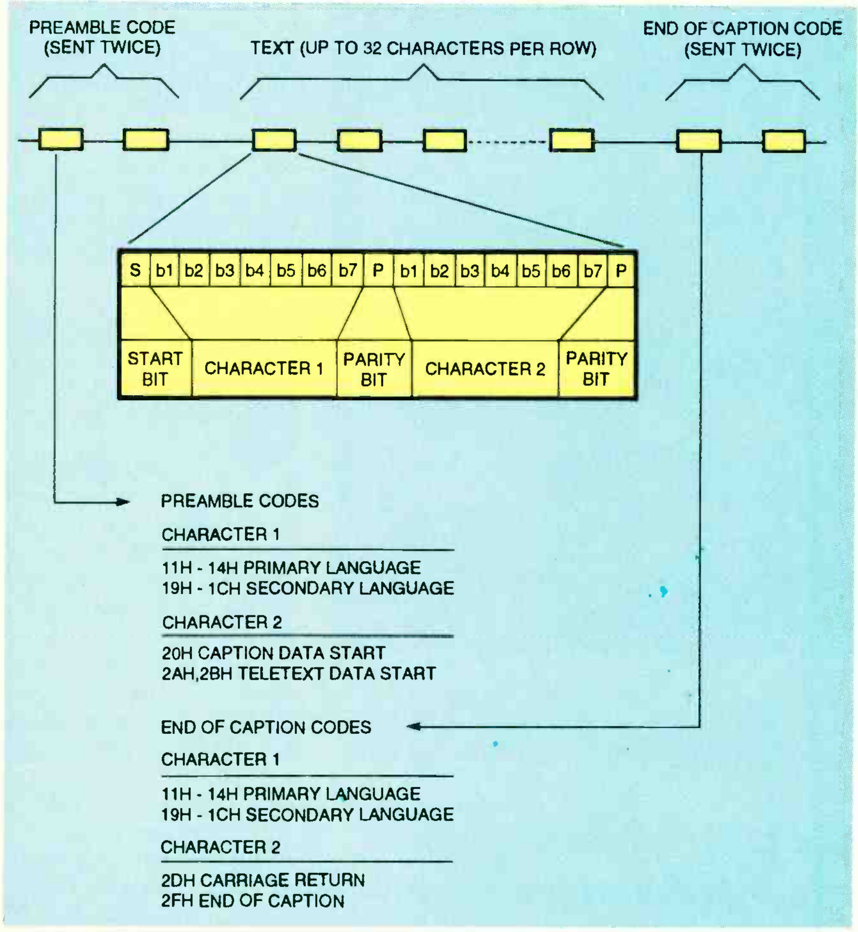


FIG. 2—VBI SERIAL DATA. Each "block" as shown represents a start bit and two seven-bit characters with parity.

TextGrabber hardware

Figure 3 shows a simplified schematic of the TextGrabber. A baseband video source such as a VCR is connected to J1. The video signal is terminated on the TextGrabber, and a buffer drives the video back out to J2. No termination is required if the output jack is left unconnected. Relay RY1 bypasses the buffer when the unit is turned off.

The video buffer and PLL section is shown in Fig. 4. Video is decoupled by capacitor C39 and then buffered by an amplifier formed by Q1 and Q2. Resistors R3 and R4 set the input bias level. The overall gain given by 1+R6/R7 = 2. Amplified video is buffered to J2 by emitter-follower transistor Q3.

Unbuffered video is sent to IC1, an LM1881 sync-separator, which extracts timing information from the video signal. The following signals are extracted: $\overline{\text{CSYNC}}$ (composite sync), $\overline{\text{VSYNC}}$ (vertical sync), $\overline{\text{BURST}}$ (colorburst), and $\overline{\text{EFIELD}}$ (even video field).

$\overline{\text{CSYNC}}$ is applied to one-shot IC2-a, set to around 45 microseconds, and then to IC2-b, set to around 10 microseconds, to filter the serrations out of the composite sync signal and provide a clean horizontal sync signal (HSYNC) for the counters.

The $\overline{\text{BURST}}$ signal from the sync separator momentarily closes analog switch IC7 during the colorburst signal, which applies the video signal to the sample-and-hold circuit formed by R19, C28, and IC8. The time constant of R19 and C28 is slow enough to filter out the 3.58-MHz color subcarrier present during the burst. As a result, C28 maintains a voltage equal to the black level of the video signal. Diode D1 is biased to provide a reference voltage equal to the voltage drop across the diode that tracks the variations in the black level. A voltage divider consisting of R29 and R30 provides a clipping level about 0.3 volt above the black level as a reference to the comparator IC5. Digital data is then extracted from the video and sent to the inputs of the shift registers shown in Fig. 5.

Positive-going HSYNC pulses are applied to the input of IC3, a 74HCT4046 phase-locked loop (PLL) IC. This PLL contains both an edge-triggered phase comparator and voltage-controlled oscillator (VCO). A low-pass filter consisting of R13, R14, C27, and C42 smoothes out the phase error signal and applies it to the input of the VCO at pin 9. The output clock signal is sent to counter IC4, which divides the signal by 32. A reference signal is then fed back to the second phase-comparator input, closing the loop. This response sets the operating frequency of the PLL to 32 times the video's horizontal frequency, or 504 kHz.

The digital data stream from the comparator is sent to a pair of serial-to-parallel shift registers, IC10 and IC11, in Fig. 5. The regenerated 504-kHz clock signal ($\overline{32H}$) drives the SRCLK pin (shift-register clock) of the shift registers, which causes them to sample the data and shift it through the registers.

Programmable array logic (PAL) IC9 decodes the five bits from counter IC4. It also detects a signal from the microcontroller that indicates that line 21 of the video signal is present, and the $\overline{\text{EFIELD}}$ signal that indicates that the odd video field is present. The PAL then asserts the RCLK signal that causes IC10 and IC11 to latch the data in the shift registers on the particular clock cycle when the two bytes from the sampled

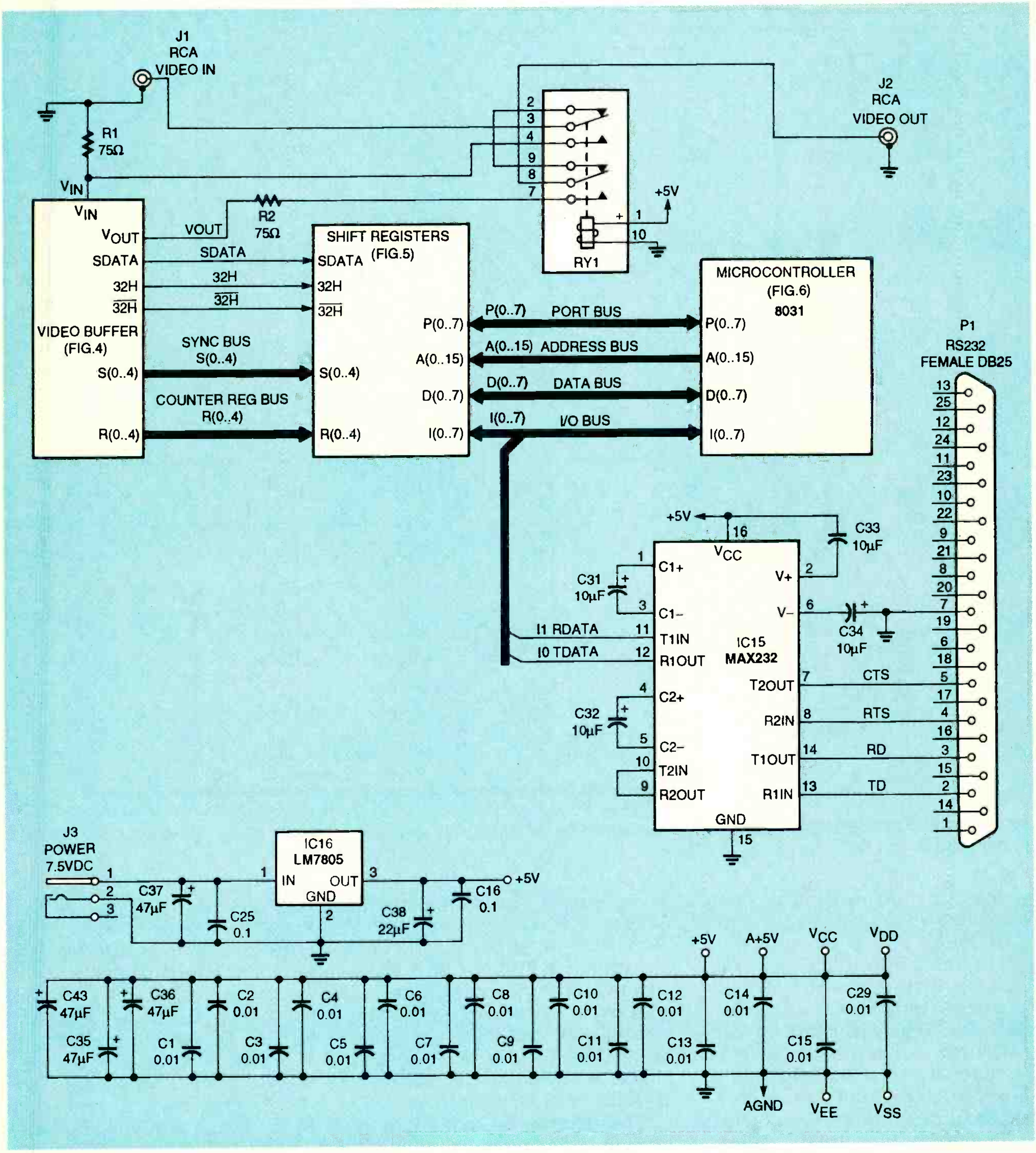


FIG. 3—TEXTGRABBER BLOCK SCHEMATIC. A base-band video source is connected to J1. The video signal is terminated on the TextGrabber, and a buffer drives the video back out to J2.

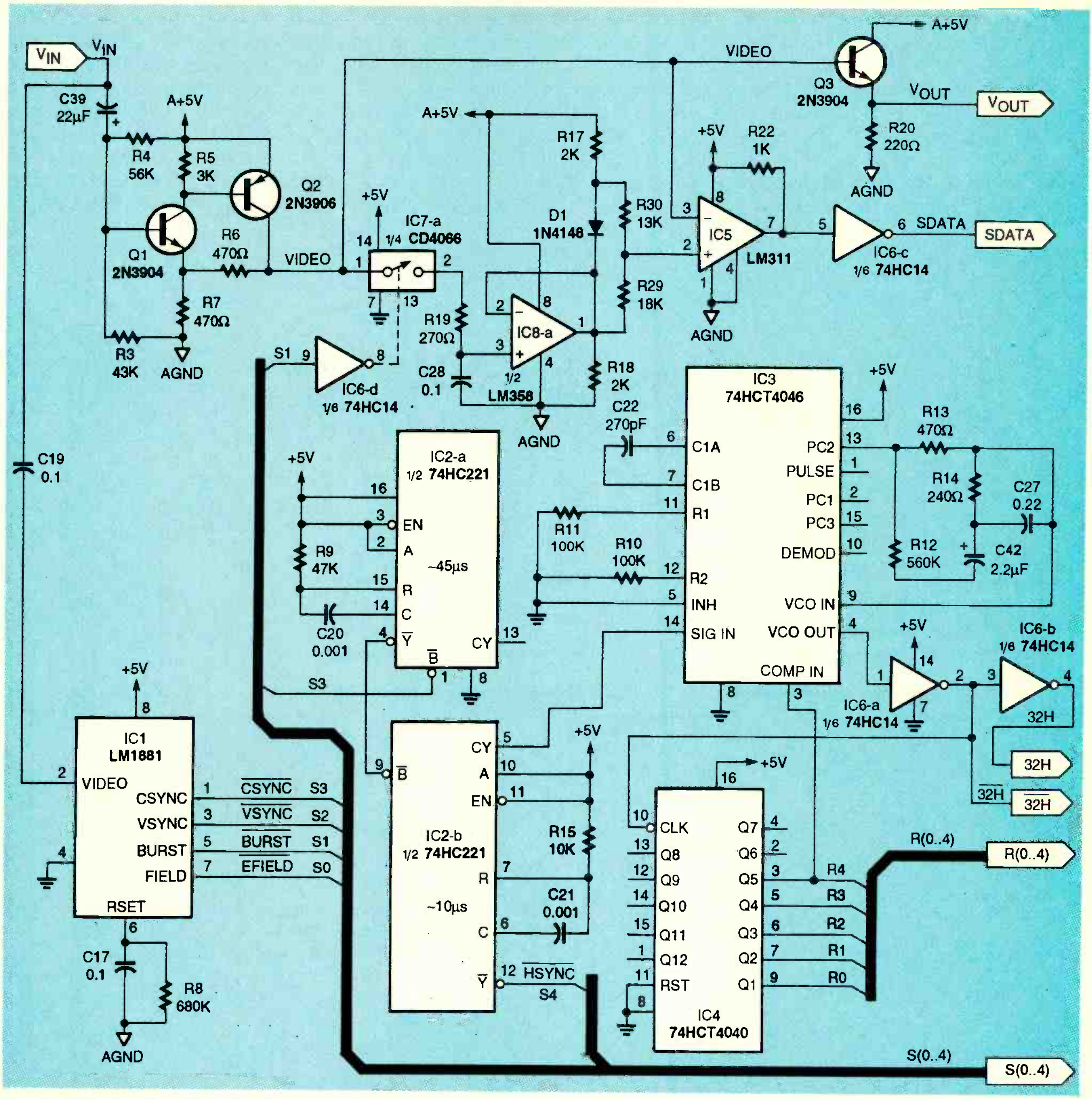


FIG. 4—VIDEO BUFFER AND PLL. Video is decoupled by capacitor C39 and then buffered by Q1 and Q2.

video "line up" with the two-byte wide registers of the 74HC595s.

The microcontroller now has a delay until the next odd field arrives to retrieve the data. The PAL also decodes some of the microcontroller's address lines to map the shift register's read ports into the microcontroller's external memory.

The firmware for the 8031 microcontroller is contained in EPROM IC14 (see Fig. 6). A 2764 has enough memory for the code, but jumper J4 permits larger EPROMs, such as a 27512 to be substituted. Programmed EPROMs and PALs are available from the source given in the Parts List. The source code can be downloaded from the *Electronics Now BBS* (516-293-2283, V.32, V.42bis) as a file called TEXTGRAB.ZIP.

The microcontroller tracks the video timing by monitoring $\overline{\text{VSYNC}}$, which is connected to External Interrupt 0, and $\overline{\text{HSYNC}}$ which is connected to Timer Input 0. When the vertical sync signal is detected, the internal counter starts counting down from 21. When it reaches zero, the processor toggles Port 1, Bit 0 (pin 1) high, so that IC9 latches the shift register data. Firmware running on the 8031 then extracts the captions from the data stream and sends them to the serial port at 9600 baud. A MAX232 chip (designated as IC15 in Fig. 3) provides the proper ±10-volt levels needed for RS-232C.

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AE68

The first alarm system designed to protect you as well as your car...

Revolutionary new vehicle security system is the first of its kind to focus on the safety of the vehicle driver as well as the vehicle itself.

By Charles Anton

Do you wonder why car alarms have countless features to protect your car, but nothing to protect you? After all, what's more important your car or the safety of you and your family?

Now there is a car alarm that *will protect you and your family*. It is the first of its kind to focus on the safety of the vehicle owner as well as the vehicle itself.

Protect yourself. It all begins with the panic button. Imagine you're walking to your car at night and a person approaches. Pushing the panic button on your transmitter lets your car come alive with a shrieking siren and flashing headlights. While the panic alarms of other vehicle security systems have a range of 100 feet, the Smart Alarm's panic alarm lets you call for help or scare away potential attackers from up to 400 feet!

Exclusive feature. Unlike other car alarm systems that begin and end their focus on personal protection with the panic alarm, that's just the beginning of the Smart Alarm. In addition to the panic alarm, the Smart Alarm also has a car finder feature. You'll never again have to wander around a dark and dangerous parking lot searching for your car. You will be able to know where your car is from anywhere within 400 feet by flashing its lights and briefly sounding the siren. You can activate and deactivate your car's headlights by remote control to light your way in a dark driveway or parking lot.

Carjacking. The Smart Alarm also addresses a growing hazard for today's motorists—carjacking. It's alarming how often drivers are hurt in their cars because they refuse to give them up to carjackers. Because of its anti-carjacking device, the Smart Alarm allows you to safely retain your car when confronted by a carjacker. This is made possible by a delayed panic alarm.

What makes Smart Alarm better?

- **Range.** Most car alarm features only work up to 100 feet away—all Smart Alarm features work up to 400 feet away.
- **Panic button.** Smart Alarm lets you call for help or scare away potential troublemakers by controlling a piercing alarm and your car's headlights.
- **Car finder.** Your car will be able to let you know where it is by flashing it's lights and briefly sounding the siren.
- **Carjacking.** Its delayed panic alarm allows you to safely prevent theft of your car when confronted by a carjacker.
- **Easy installation.** Other car alarms are complicated or cost hundreds of dollars to install. Smart Alarm is inexpensive, and you can install it in just minutes.

Smart Alarm is the first car alarm that will protect you and your family.

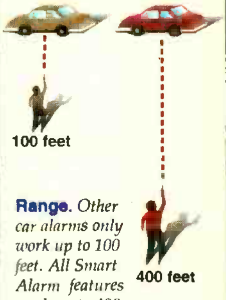
Easy installation. *Installing the Smart Alarm requires no fumbling with wires. Special Plug-In Connectors let you install the Smart Alarm without a single wire-cutter! Simply unplug the headlight connector, plug in the Smart Alarm connector, and then plug the headlight connector to the Smart Alarm. Connect the Smart Alarm to the battery cable with the special clip. In minutes, you and your car can enjoy complete 24-hour protection. Away from your car, you'll feel safer knowing that your car is protected! Near your car, you'll feel safer knowing that you are protected!*

All you do is give up your car and activate the delayed panic alarm. When the assailant has reached a safe distance and is no longer a threat to you, a deafening 120dB siren and flashing lights will force him to flee your car, letting you recover it safely.

Vehicle protection. Smart Alarm's current sensor triggers the siren if the trunk or any of the doors are opened while the alarm is armed. To supplement the current sensor, a shock sensor triggers the siren when it detects a blow to your car. Together, these sensors provide your car with blanket protection.

An adjustable shock sensor prevents the siren from being triggered, eliminating false alarms. You can also adjust the shock sensor and the siren with your remote control at any time you choose. The siren's tone and volume can be adjusted to six separate tones. As a result, you'll never confuse it with any other alarm. You can also customize the siren, making it louder in noisy neighborhoods and quieter in more peaceful neighborhoods.

Compare



Range. *Other car alarms only work up to 100 feet. All Smart Alarm features work up to 400 feet away.*

Risk-free home trial. With the Smart Alarm, you get a complete "No Questions Asked" 30-day money-back guarantee. If it's not everything we say, just return it for a full refund. The Smart Alarm is also backed by a two-year warranty. Your order will be shipped UPS in seven to ten working days.

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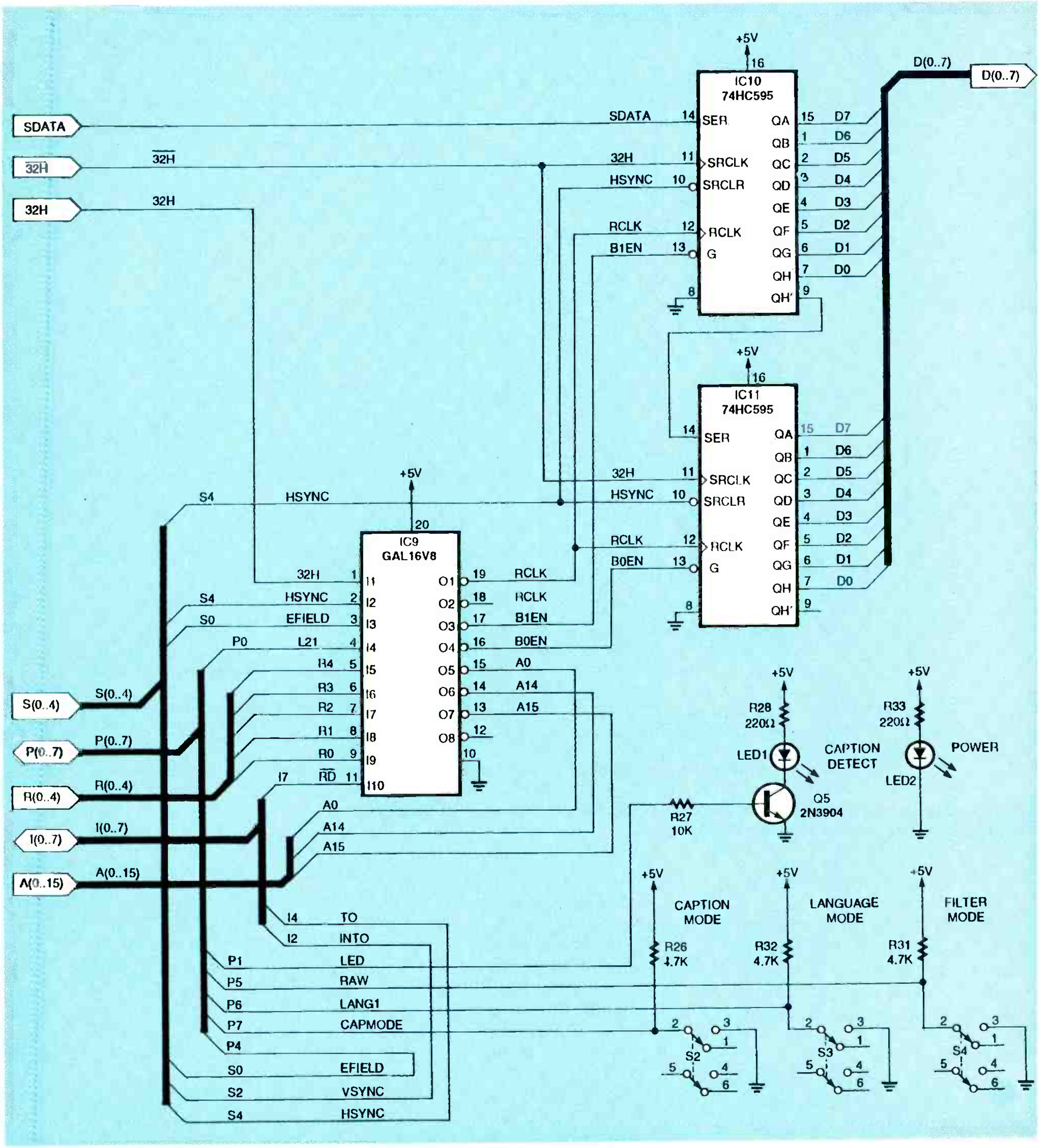


FIG. 5—THE DIGITAL DATA STREAM from the comparator is sent to a pair of serial-to-parallel shift registers, IC10 and IC11. PAL IC9 asserts the RCLK signal that causes IC10 and IC11 to latch the data in the shift registers.

Construction

A printed circuit board is recommendedfor the construction of the TextGrabber. You can fabricate a PC board yourself from the artwork provided in this article, or obtain an etched and drilled board from the source given in the Parts List. If you make your own board, be aware that there are several vias on the board where copper traces must jump from one side of the board to the other. Short lengths of bare copper wire must be inserted and soldered on both sides.

Install the components as shown in the Parts-Placement diagram in Fig. 7. If you have made your own double-sided board, be sure to solder all of the component leads on both sides of the board because many of the traces depend on component pins to provide a connection from one side to the other. Also, install a wire jumper in

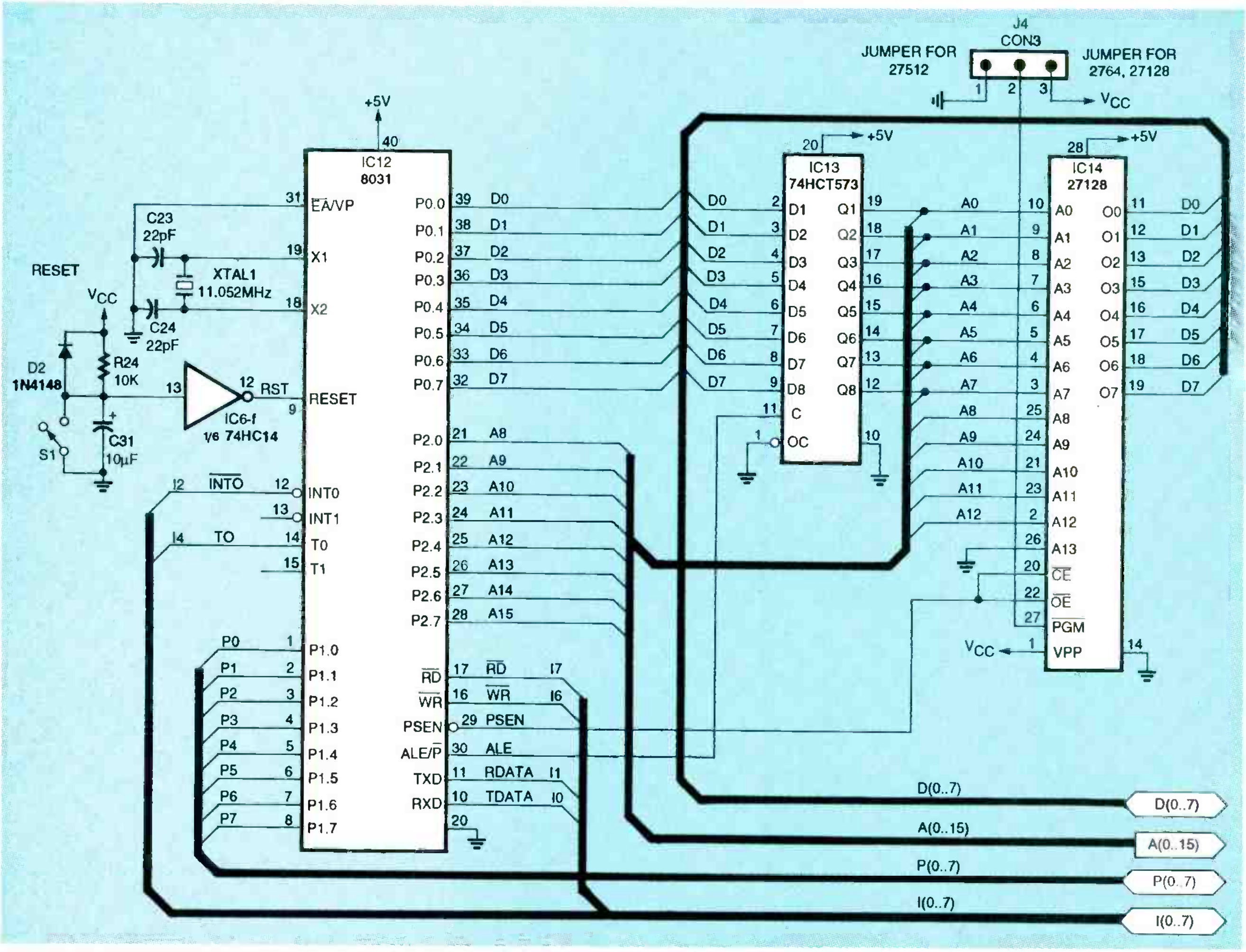


FIG. 6—FIRMWARE FOR THE 8031 MICROCONTROLLER is contained in EPROM IC14. Jumper J4 allows the use of larger EPROMs.

any through holes that don't contain a component lead. (Circuit boards purchased from the source in the Parts List have plated through-holes so that step is unnecessary.) Figure 8 shows the completed PC board.

Checkout

Connect a serial cable between the TextGrabber and a PC that is running a communications program. The software should be set to communicate over a direct connection at 9600 bps. Then connect a "clean" video source to the video input connector. Apply power to the TextGrabber; the message "<READY" will appear on the screen. This indicates that the microcontroller is up and running. If no video source is detected, the TextGrabber will also send "<NO VIDEO SIGNAL" to the terminal.

PARTS LIST

All resistors are ¼watt, 5%.

R1, R2—75 ohms
R3—43,000 ohms
R4—56,000 ohms
R5—3000 ohms
R6, R7, R13—470 ohms
R8—680,000 ohms
R9—47,000 ohms
R10, R11—100,000 ohms
R12—560,000 ohms
R14—240 ohms
R15, R24, R27—10,000 ohms
R17, R18—2000 ohms
R19—270 ohms
R20, R28, R33—220 ohms
R22—1000 ohms
R26, R31, R32—4700 ohms
R29—18,000 ohms
R30—13,000 ohms

Capacitors

C1–C15, C29—0.01 µF, 25 volts, monolithic
C16, C17, C25—0.1 µF, 25 volts, monolithic
C18, C26, C29, C30, C40—not used
C19, C28—0.1 µF, 25 volts, Polyester
C20, C21—0.001 µF, 25 volts, Polyester
C22—270 pF, 25 volts, ceramic NPO
C23, C24—22 pF, 25 volts, ceramic NPO
C27—0.22 µF, 16 volts, tantalum electrolytic
C31–C34, C41—10 µF, 16 volts, Tantalum electrolytic
C35–C36, C43—47 µF, 16 volts, Tantalum electrolytic
C37—220 µF, 25 volts, electrolytic
C38, C39—22 µF, 16 volts, tantalum electrolytic
C42—2.2 µF, 16 volts, tantalum

Semiconductors

D1, D2—1N4148 diode
LED1—green light-emitting diode
LED2—red light-emitting diode
Q1, Q3, Q5—2N3904 NPN transistor
Q2—2N3906 PNP transistor
IC1—LM1881 sync separator
IC2—74HC221 multivibrator

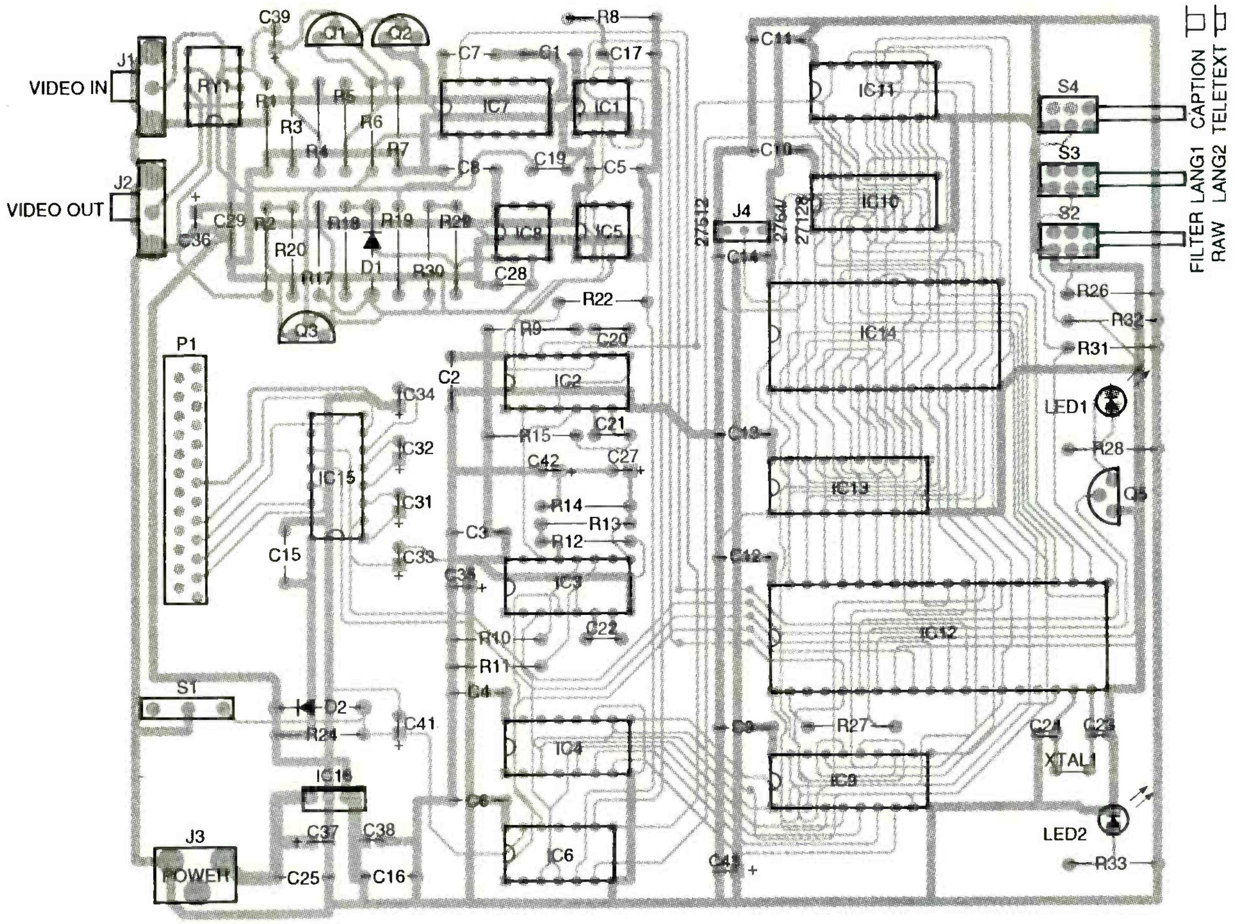


FIG. 7—PARTS PLACEMENT DIAGRAM. If you make your own double-sided board, solder all of the component leads on both sides of the board, and install a wire jumper in any through holes that don't have a component lead in them.

IC3—74HCT4046 PLL
IC4—74HCT4040 counter
IC5—LM311 comparator
IC6—74HC14 hex inverter
IC7—CD4066B quad bilateral switch Harris or equiv.
IC8—LM358 op-amp National or equiv.
IC9—GAL16V8-25 programmable logic device
IC10, IC11—74HC595 shift register
IC12—8031 microcontroller
IC13—74HCT573 latch
IC14—27C64 EPROM
IC15—MAX232 RS232 transceiver
IC16—LM7805 voltage regulator

Other Components

J1, J2—PC-mount RCA connector
J3—PC-mount coaxial power connector
RY1—DPDT—relay, 5-volt coil
P1—PC-mount female DB25 connector
S1—SPST momentary-contact pushbutton switch
S2–S4—PC-mount DPDT switch (push-on, push-off type)
XTAL1—11.0592 MHz crystal

Miscellaneous: PC board, 7.5-volt DC 500 milliampere power supply, project case, cables.

Note: The following items are available from Willamette Designs, 2373 NW 188th Ave. No. 236, Hillsboro, OR, 97124:

- **Complete TextGrabber kit including PC board, and all electrical components (no case or power supply)—$149.95**
- **PC board—$20**
- **Programmed PAL and EPROM—$20**

Please add $5 for shipping and handling on the complete kit, $2 for PC board and PAL/EPROM orders. Check or money order only.

- **A fully assembled and tested TextGrabber with case and power supply is available for $249.95 from Software South Inc., 10010 Abercorn No. 3, Savanah, GA 31406 (800) 899-3950, (912) 925-0082.**

If the microcontroller is working properly, check the video section by first examining the outputs of the sync-separator (IC1) with an oscilloscope to make sure they are active. Then follow the path of $\overline{\text{HSYNC}}$ through to the PLL, and verify that it is oscillating at the proper frequency (504 kHz), and that this clock signal is present at the shift registers (IC10 and IC11). If you have a two-channel oscilloscope, verify that the output of the sample-and-hold circuit (IC8 pin 1) tracks the black level of the buffered video signal, and that the comparator reference at pin 2 of IC5 remains about 0.3-volt above the black level.

Using the TextGrabber

Figure 9 shows a typical operating setup for the TextGrabber. The program being transcribed can be viewed either on a television connected to the VCR's RF

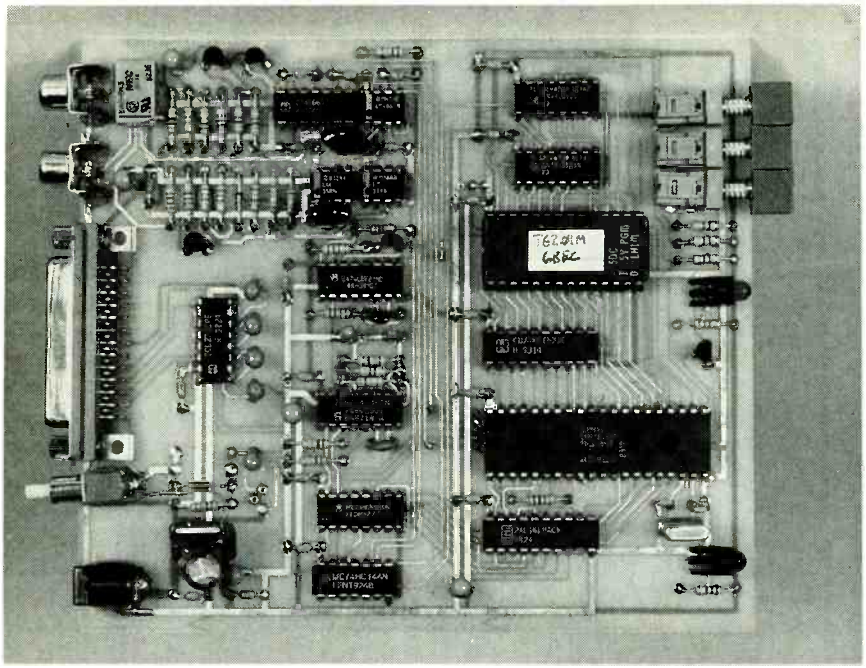


FIG. 8—FINISHED PC BOARD. This is an early prototype, so some of the parts might not be the same as those that you will be installing.

pass-through, or on a video monitor connected to the Text-Grabber's baseband video pass-through.

The computer is running terminal communication software set to 9600 baud, 8 data bits, no parity bit, and one stop bit (8N1). The data from the Text-Grabber is captured on the hard disk drive of the computer with the ASCII download feature of the terminal software being used.

The red LED on the left side of the front panel of the unit will indicate that the unit is powered. The green LED on the right side will indicate a Caption Detect. It lights whenever the unit detects a valid caption data stream, and it stays on while the data is being transmitted.

If the Caption Detect LED is not flashing periodically, then the television program you are watching probably doesn't have closed captions.

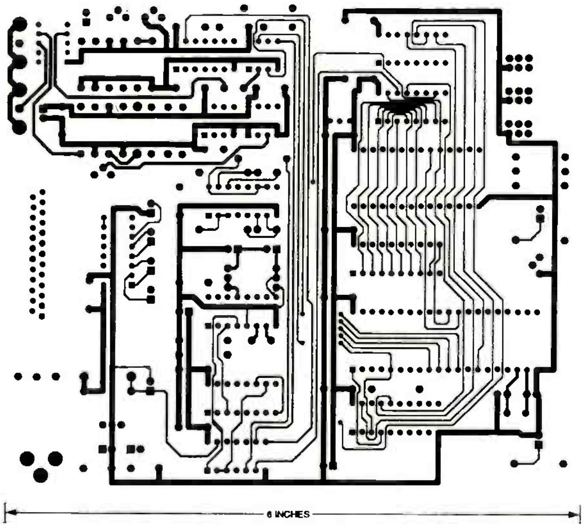
Three front-panel switches control various modes of operation. The FILTER/RAW switch (S4) allows you to select whether the TextGrabber sends just the ASCII captions to the terminal, or raw data which includes a stream of control characters and codes.

Also note that, because captions are generally transmitted in all capital letters, the Filter mode of the TextGrabber will convert all the characters to lower case except those at the start of a sentence.

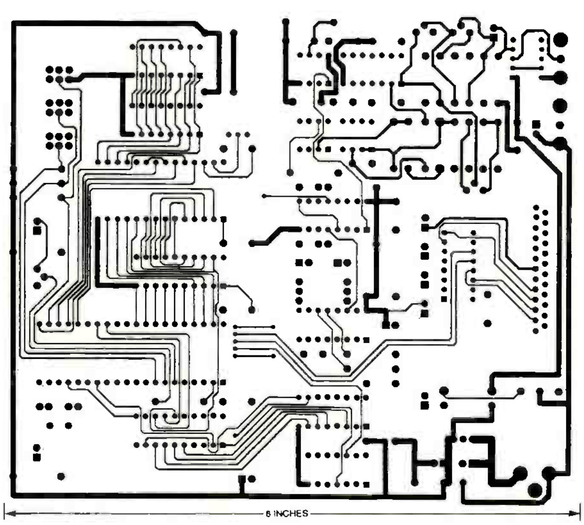
The LANG1/LANG2 switch (S3) selects the multiplexed language data streams to be displayed. At the present time, Language 2 data is not in wide use by any of the American broadcasters.

The CAPTION/TELETEXT switch (S2) selects either the closed caption data stream or the teletext data stream which is multiplexed onto the same channel. Again, Teletext mode is seldom used by American broadcasters, but the ABC television network programming sometimes transmits information on this channel. In general, you will find that the desired setting for each of these switches is in the "out" position.

The microcontroller will be reset by pressing reset button S1 on the back panel, and it will then transmit the "<READY" message. This feature is provided so that you can easily test the serial connection to the PC in the absence of a video signal that contains caption data.



COMPONENT SIDE of the TextGrabber PC board.



SOLDER SIDE of the TextGrabber PC board.

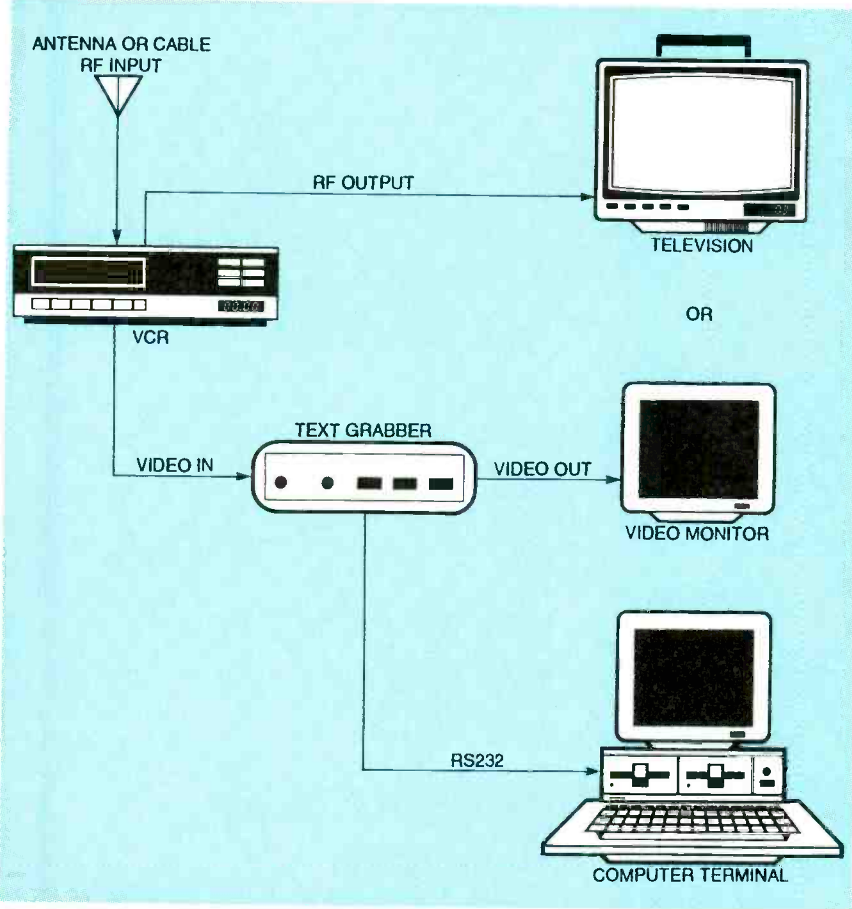


FIG. 9—TYPICAL TEXTGRABBER SETUP. The program being transcribed can be viewed either on a television connected to the VCR's RF pass-through, or on a video monitor connected to the TextGrabber's baseband video pass-through.

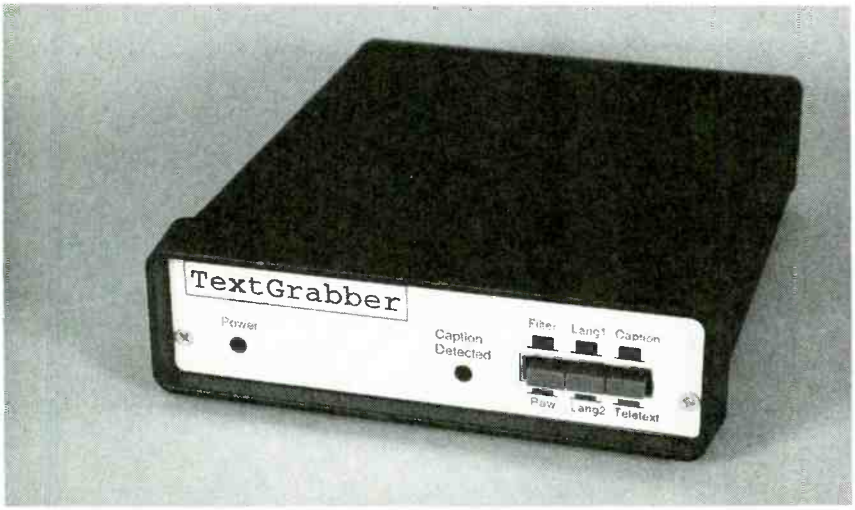
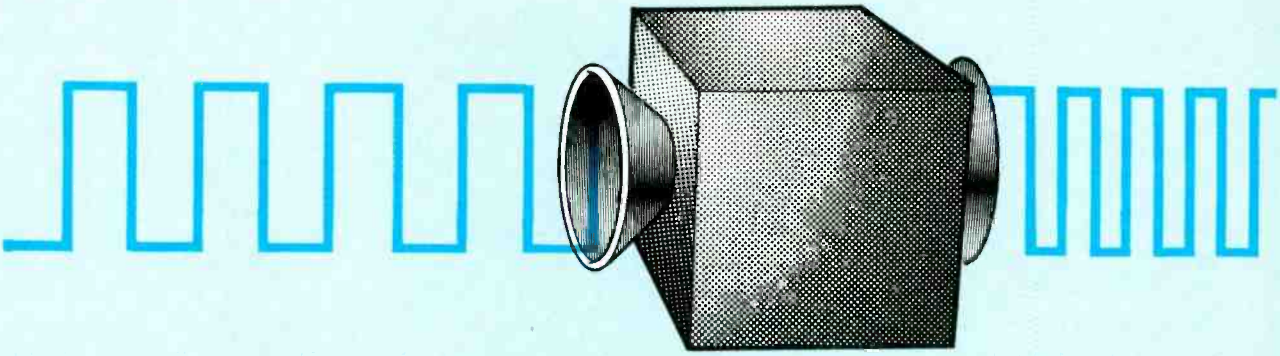


FIG. 10—THE TEXTGRABBER can be built in a compact cabinet.

For best results, the TextGrabber requires a clean video source. Like any other telecaption decoder, characters will be dropped and text will be garbled as the quality of the video signal degrades.

The TextGrabber will work with programs that have been recorded on videocassette tapes. However, be sure that you record tapes intended for use with the TextGrabber at your VCR's fastest tape speed (SP), and be sure that you have high-quality tapes for optimum video viewing and closed-caption decoding quality. Ω



FREQUENCY DOUBLER

Double the frequency of any CMOS or TTL clock signal with this easy-to-build doubler circuit.

JOHN J. YACONO

A UNIVERSAL FREQUENCY-DOUBLING circuit will come in handy in your home shop or on the job. The subject of this article is the construction of a simple circuit that will double the frequency of a digital clock input and be independent of input frequency.

The entire circuit is based on a quad EXCLUSIVE-OR (XOR) gate whose output is 1 (logic high) if any but not more than one of its inputs is 1. The output is 0 if more than one input is 1 or if all inputs are 0. You can make a doubler circuit based on either the CMOS CD4070B or the TTL 74386 because these quad XOR devices are pin-for-pin compatible. A 14-pin socket will permit the devices to be interchanged.

Before discussing construction, some background information on a practical application for the frequency doubler should be helpful, and its theory of operation will be explained.

Consider this situation: You are troubleshooting a digital circuit with a digital logic analyzer and you see that the logic analyzer latches data on the same edge of the clock pulse each time a clock pulse arrives. If you set the analyzer to latch data on the rising edge of a clock pulse, the plot of the clock data will show a constant high. However, if you set the analyzer to latch data on falling transitions, the clock data will appear continuously low. Unfortunately, after you select the desired edge for triggering, you can view only half of the circuit activity and none of the clock transitions.

It is easy to see that under certain circumstances the logic analyzer would be useless. This situation could occur when troubleshooting a microprocessor or microcontroller circuit whose data is latched on one clock transition, processed, and then transmitted on the opposite clock transition.

If you were to view only data collected as it is presented for input or output, it would be impossible to determine if a malfunction were caused by signal-path propagation delays, device propagation delays, settling time, or incorrect processing. Of course, you must distinguish between those three causes to correct them. A digital frequency-doubler that can provide clock pulses for either rising or falling clock pulses (and still remain in-step) would be invaluable.

Operational theory

Propagation delay, a key characteristic of logic gates, is significant in any logic application. It is the time required for a change of logic at the input of a gate to affect the logic at its output. The longer the propagation delays of transistors in a signal path, the longer it takes to produce a usable result. It follows that integrated circuit designers are always trying to minimize propagation delays.

Ironically, a delayed clock signal can be useful in this frequency-doubler circuit. The output of an XOR gate is low when its inputs are equal, and high when its inputs are unequal. Consider what would happen if both a clock pulse and a

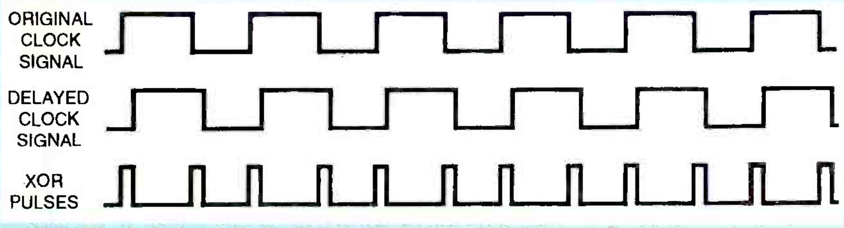


FIG. 1.—IF A PULSE TRAIN (top) is delayed to produce a second pulse train (middle) and both trains are passed into an XOR gate, a pulse train with variable-width pulses will be produced (bottom).

slightly delayed version of the same pulse are applied to the inputs of an XOR gate. The plot of pulses in Fig. 1 shows the original clock pules at the top and a delayed pulse below it.

The output of the XOR gate will appear like the lower waveform in Fig. 1. Thus, the XOR gate generates one pulse for each clock transition. As a result, the gate produces output pulses at twice the clock frequency, but they remain synchronized with the clock, as shown in the upper waveform.

The lower XOR waveform illustrates another important characteristic: the width of the XOR pulses equals the delay introduced to the clock signal or the difference between the rise times of the pules in the top and middle waveforms.

The XOR pulse width will respond to the delay time regardless of frequency with one condition: the delay introduced to the clock signal (the middle waveform) must be shorter than both the high and low times of the clock. Thus, the clock should be delayed by less than 180 electrical degrees if the doubler is to work properly.

This sets the criteria for a circuit that will double clock pulses, but the circuit requires a delayed clock pulse. Because an XOR gate can be configured as a buffer by grounding one of its inputs, and it has an inherent phase delay, the gate will function as delay line to stall clock pulses before they reach a second XOR gate.

The circuit

The frequency doubler circuit is shown in Fig. 2. It is powered by the DUT. This eliminates the need for additional circuitry and also "configures" the doubler to operate at appropriate logic-voltage levels. This is necessary for testing CMOS logic because of the wide range of operating voltages and logic levels.

In Fig. 2, IC1-a is the pulse-producing gate, and IC1-b, IC-c, and IC1-d form a variable-delay network. Each gate in the network adds its phase delay to the signal it receives. Thus, IC1-b delays the clock by one phase delay period, IC1-c delays it for an equal period, and IC1-d adds yet another delay.

The gates are arranged so that both the phase delay and the width of the output pulses can be selected by making wire changes on a header that carries the delayed signal to IC1-a. That feature has two functions: 1) it extends the duration of the output pulses for slower test equipment, and 2) decreases the pulse width for testing very fast circuits.

As stated earlier, you have a choice of quad XOR IC: a CMOS CD4070B or equivalent in a faster CMOS family (HC/HCT, HCS/HCTS, or ACL (FACT)) or a 74386 or its equivalent in faster TTL logic families (AS, LS, ALS, FAST). Your selection will determine the propagation delay of the gates. The delay is important because it determines the maximum input frequency that the circuit can handle and the maximum pulse width it can generate.

Maximum input frequency will limit the circuitry with which the doubler will be effective. Maximum pulse width will permit the circuit to work with the slowest test equipment. (Additional gates can be added to the delay network to increase the output pulse width for the slowest equipment.) To maximize the doubler's versatility, select a quad XOR with the highest maximum frequency that is compatible with your test equipment.

Table 1 provides information to help you select the optimum TTL family for your needs. The propagation delays are typical values obtained from data books, but devices from different manufacturers might have different typical values. The maximum output pulse widths given in the table were obtained by multiplying the

TABLE 1—TTL PROPATATION DELAYS VS. DOUBLER FREQUENCY LIMITS

TTL Family	Typical Delay (ns)	Maxcimum Input Frequency (Hz)	Longest Output Pulse (ns)
Advanced Schottky	1.5	166,667	4.5
Fast Schottky	2	125,000	6
Schottky	3	83,333	9
Advanced Low-power TTL	6	41,667	18
Low-Power Schottky	9	27,778	27
Standard TTL	10	25,000	30
Low-Power TTL	33	7,576	99

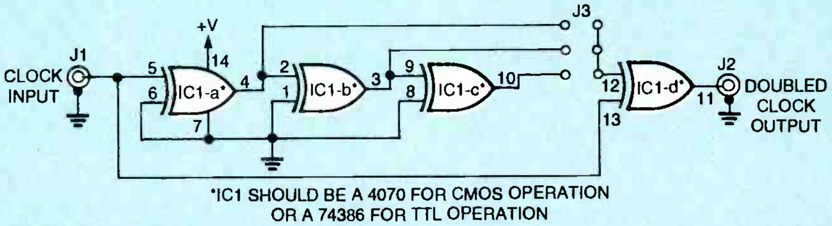


FIG. 2.—THE ACTIVE COMPONENT OF THE FREQUENCY DOUBLER is a quad exclusive-or (XOR) gate.

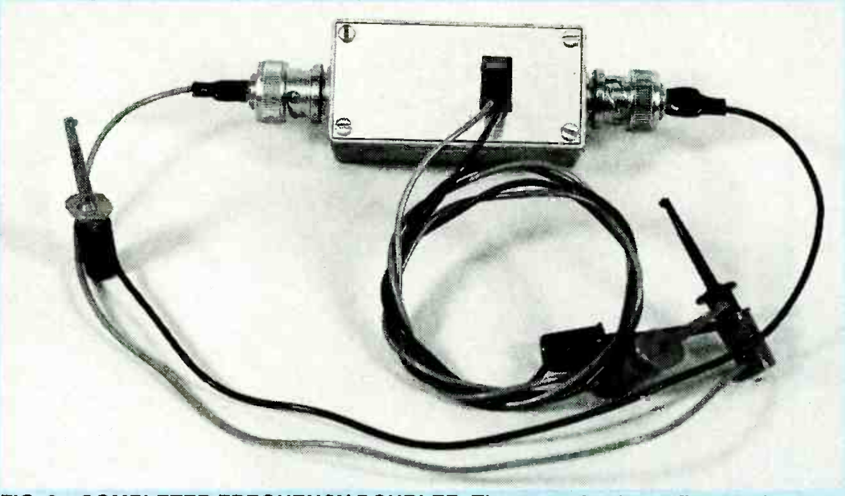
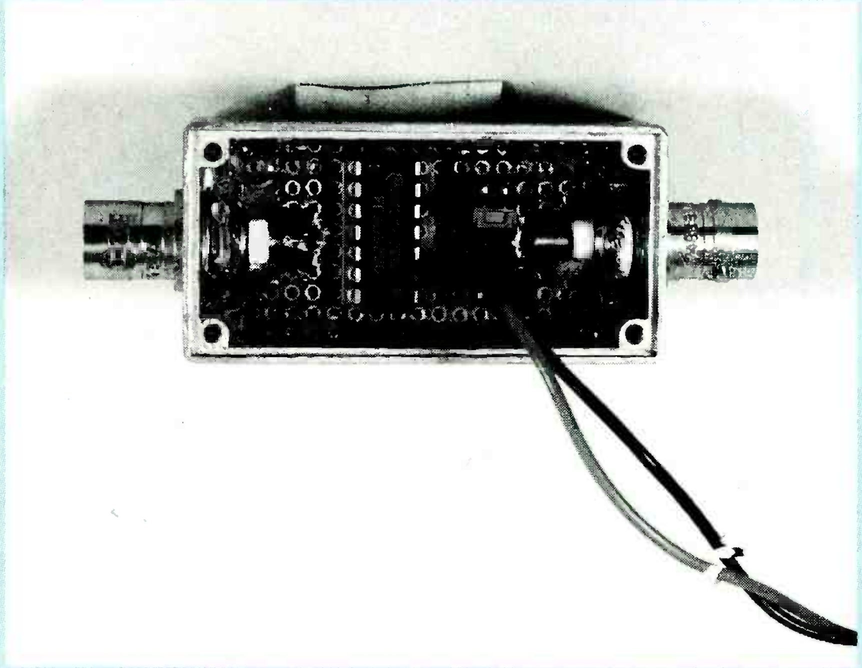


FIG. 3—COMPLETED FREQUENCY DOUBLER. The power leads are fitted with microclips and attached to two extra pins on the jumper block.



A JUMPER BLOCK was substituted for a triple-throw switch to conserve space.

propagation delay by a factor of 3 (the number of delay gates in the delay network).

Deciding on a CMOS IC is easier because even the fastest CMOS ICs are slower than the response times in most test equipment. A device from the high-speed HCT CMOS family is suitable for testing CMOS circuits that are powered by 5 volts, but a standard 4000B series IC will be suitable for testing all other CMOS circuits.

PARTS LIST

Semiconductor

IC1—quad XOR-gate, CMOS or TTL (see text)

Other components

J1, J2—BNC jacks, wall mount

J3 (S1)—four-pin header, PCB mount (or triple-throw switch, see text)

Miscellaneous: Project case (metal, see text), two BNC plugs, two microclips, 14-pin IC socket (see text), perforated construction board, heat-shrink tubing, insulated hookup wire, solder.

Doubler construction

The doubler circuit's 14-pin IC is mounted in a 14-pin DIP socket on a rectangular piece of perforated construction board. (Regardless of assembly method—wire wrapping or point-to-point wiring—keep all wires as short as possible.) If you design your own PC board, design in a ground plane on the reverse side.

Select a metal project case with a metal cover that will provide good shielding. The prototype is housed in an aluminum case measuring 5¼ × 3 × 2⅛inches. Holes are drilled in both ends of the metal case for BNC jacks J1 and J2. Another hole is cut in the case cover to allow the power and ground wires to exit.

In order to fit the circuit in such a small case, a 4×2 shorting header was used in place of a triple-throw switch for S1. The S1 connections are then made by moving a jumper. The two extra pins on the shorting jumper have leads attached to them for obtaining power and ground from the DUT. (You can prevent shorting between the closely-spaced power and ground jumper header pins with heat-shrinkable tubing, if necessary.) If you can find a small triple-throw switch you can use that, or use the header instead (as we did) or use a larger switch and bigger case.

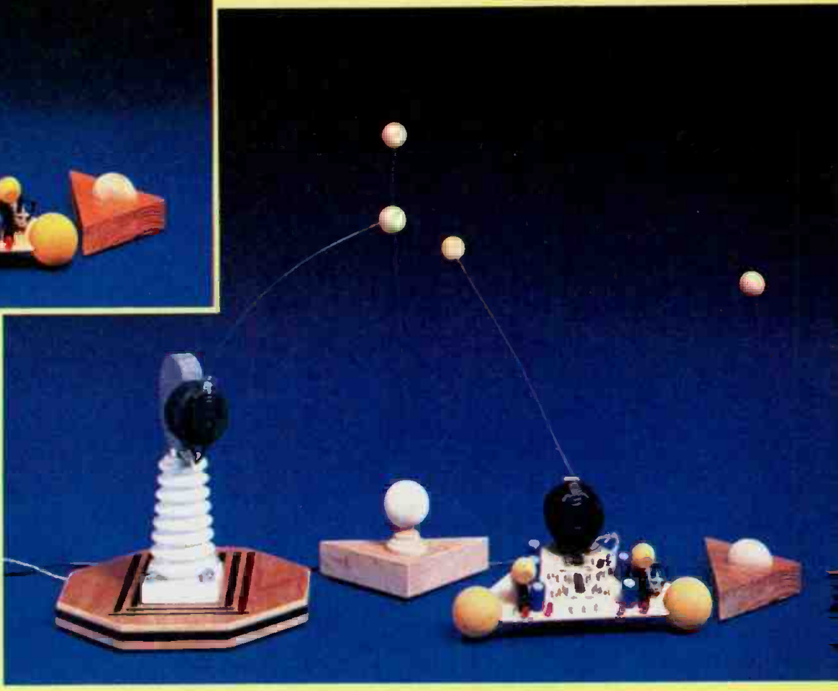
Position the completed circuit board in the bottom of the case and fasten it in place with double-sided tape or RTV silicone. Pass the power leads through the hole in the cover and terminate them with microclips. Figure 3 shows the assembled frequency doubler ready to be put to work.

Testing the doubler

To test out the frequency doubler, feed in a signal of known frequency from a crystal-based reference or function generator and measure the output frequency with a frequency counter or oscilloscope. The doubler will double the input frequency if it is functioning correctly.

The details will not be described in this article, but you can increase the versatility of the frequency doubler by fitting it with an analog front end. An operational amplifier configured as a Schmitt trigger will perform this function. Ω

FIG. 1—WATCH THE DANCING BALL on the end of the spring. An erratically oscillating solenoid on the Bonker sends the ball into unpredictable gyrations captured with time exposure (left). The Bonker at rest (below). Spring-mounted balls on stationary bases add to the chaotic effect.



Build this fascinating device whose moving ball can hypnotize and captivate you with its random (chaotic) motion.

CREATING CHAOS

ROGER SONNTAG

DO YOU WANT RELIEF FROM THE MONOTONY of routine activities that get you down—daily commuting, your job, or those pesky chores that you must do every day? What you need is a little chaos in your life—safe and controlled, of course—at desktop scale. How do you do this? Build the Bonker and go a little crazy watching its bouncing ball whirl and spin in random loops. Then you'll be ready to return to your dull routine.

Unlike a clock pendulum or that executive toy with all its little suspended bearings that clatter back and forth, Bonker's action is completely unpredictable. And you can turn it off when you've had enough chaos for the day. Chaos is defined as extreme confusion or disorder and the kind of formless matter and infinite space that is said to have existed before the universe was ordered. In short, it's the opposite of orderly and predictable.

Figure 1 shows one Bonker setup. Small wooden balls on the end of wire springs are sent into wild gyrations by oscillating solenoids whose motion is controlled by a four-stage pulse generator. It's a fascinating and eye-riveting gadget that will evoke a lot of comments when it's running on your desk.

How does it work?

Figure 2 is a simplified schematic showing only one of the four pulse oscillator circuits that drive the rotary solenoid. Each oscillator is formed from an operational amplifier and a network of external components. Three other circuits similar to that shown on the left side of the diagram all feed the same common bus. The summed output of all four oscillators provides a variable pulsed drive signal for the MOSFET gate.

The MOSFET is in series with the solenoid's coil. When the MOSFET conducts, current flowing in the coil causes the solenoid shaft to oscillate back and forth within a limited angular sweep. Solenoid oscillation is controlled by the summed output of the four oscillator stages.

The op-amp shown in Fig. 2 is IC1-a, one of four op-amp circuits in a quad LM324 shown in Fig. 3, the complete schematic. Each of the four op-amp-based oscillators is identical except for different values of their *charge* and *discharge* resistors. In Fig. 2, R2 in the feedback loop of the op-amp is the charge resistor, and R1 is the discharge resistor.

Diode D2 couples the output of the oscillator to the base of Q1 through resistor R23. Diodes D4, D6 and D8 perform the same functions for the other three oscillator stages formed from op-amps IC1-b, IC1-c, and IC1-d. When the output of any two oscillators is positive, Q1 conducts.

Resistors R4 and R5 divide the 12-volt power from a wall outlet adapter to obtain 6 volts. Positive feedback through resistor R3 cleanly switches the oscillator at each output state. Resistors with identical values in the other three oscillator circuits perform the identical functions.

Figure 3, the complete schematic, shows each of the four oscillator stages that include a LED. The first and fourth stages include a trimmer potentiometer to introduce additional variation in the pulse train.

The differences in the value of resistors R1, R6, R11 and R25 in parallel with grounded aluminum electrolytic capacitors C1, C2, C3 and C4 provide different time constants for each oscillator. The approximately ± 20 % variation in tolerances of those capacitors imparts additional randomness.

The differences in the values of the discharge resistors R1, R6, R11 and R25 (25 to 180 kilohms) determine the pulse duty cycle, and the 1-kilohm values of the charging resistors R2, R7, R12, and R24 determines pulse width.

Bonker action is initiated by closing switch S1. Light-emitting diodes LED1 to LED4 give visual indications of the output from each oscillator. Linear potentiometers R27 and R28 control the swinging of the ball. They can adjust the motion from a gentle swing to a wild, eccentric movement. Electrolytic capacitor C5 shunts any AC transients that might appear on the 12-volt source to ground. Table 1 summarizes the variations in pulse repetition rate that can be be set in each oscillator stage, as well as variations that can be introduced by the capacitor tolerance.

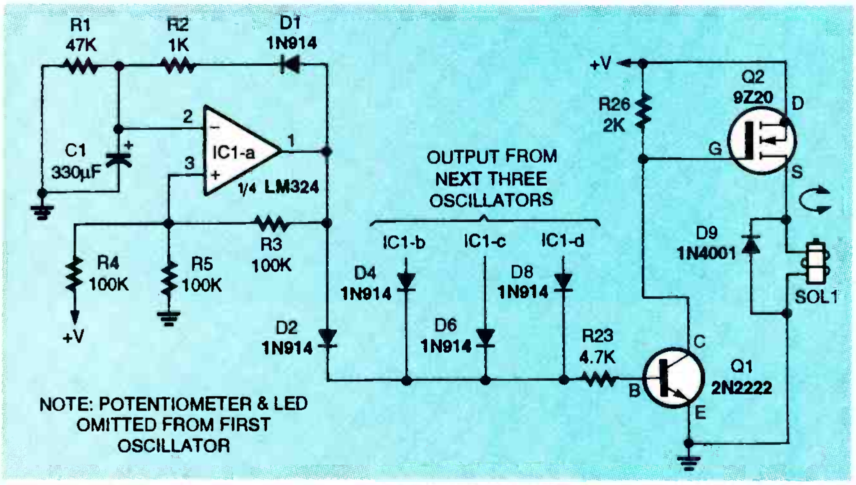


FIG. 2—A SIMPLIFIED SCHEMATIC to explain how the Bonker's solenoid drive circuit works.

Circuit construction

A printed circuit board is available from the source given in the Parts List. However, a foil pattern is included in this article for those who want to make their own circuit boards. There is nothing critical about parts placement in this circuit, so it could made with point-to-point wiring techniques if the parts placement diagram is followed.

Refer to the parts placement diagram Fig. 4. Begin assembly

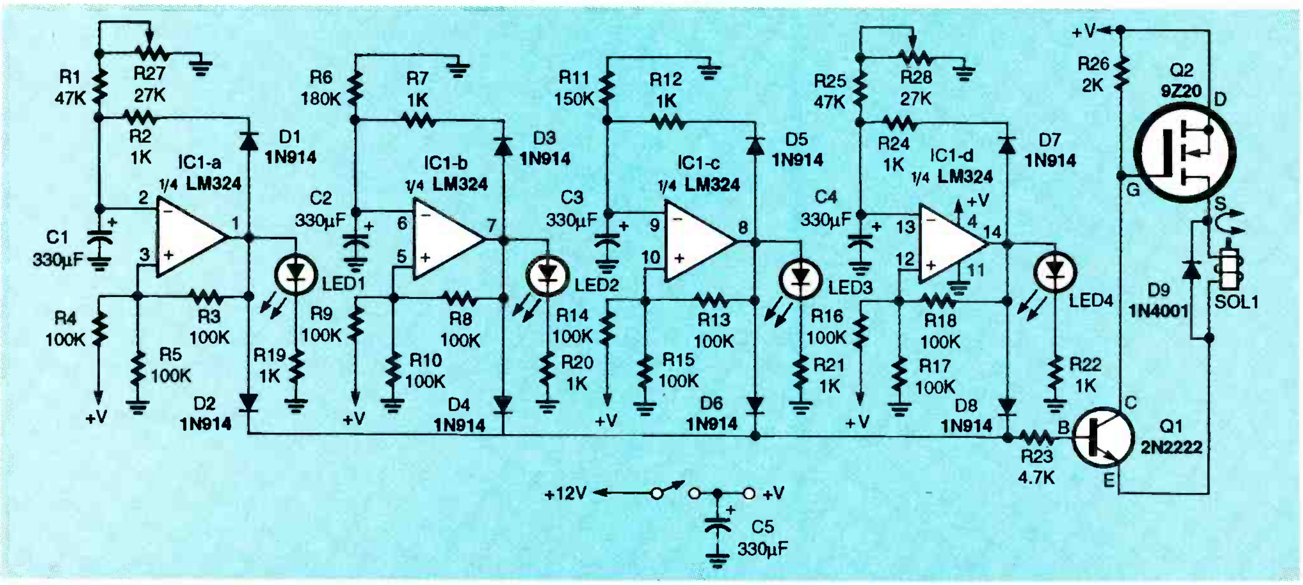


FIG. 3—SCHEMATIC FOR BONKER SOLENOID drive circuit. Four oscillator stages are formed from a quad LM324N op-amp IC. LEDs provide a visual indication of the pulse output of each stage.

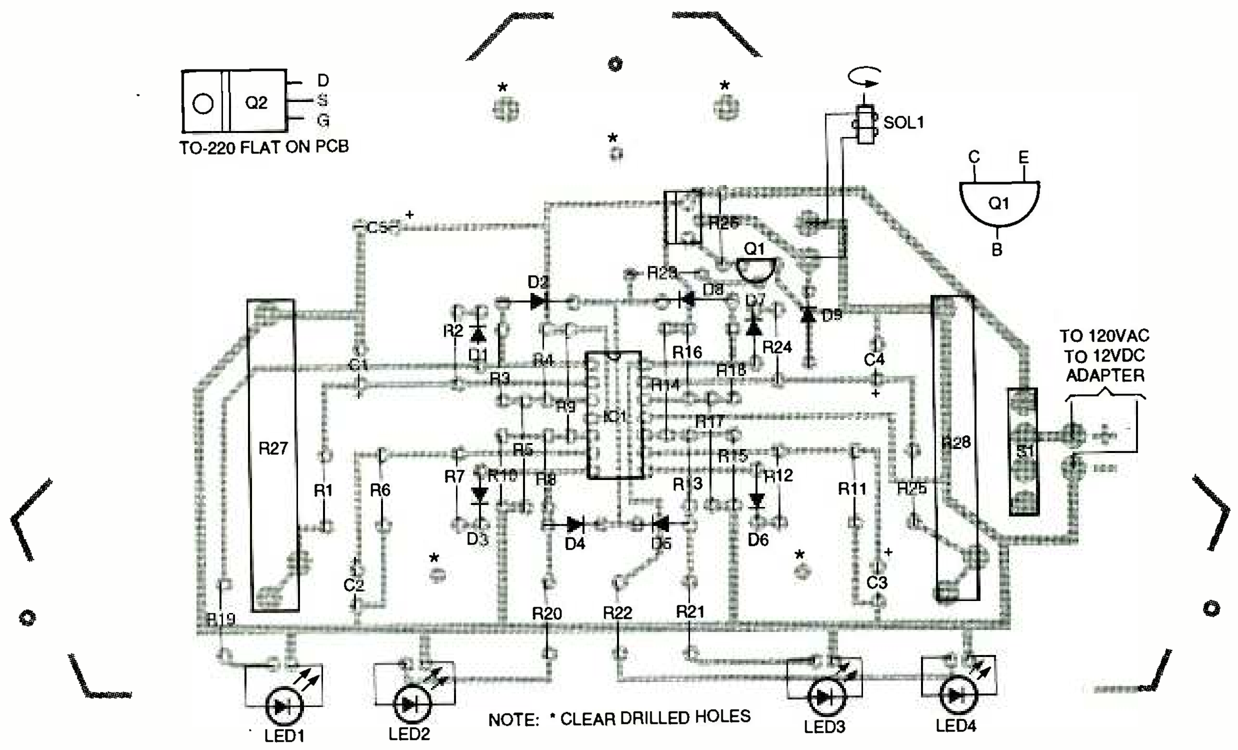
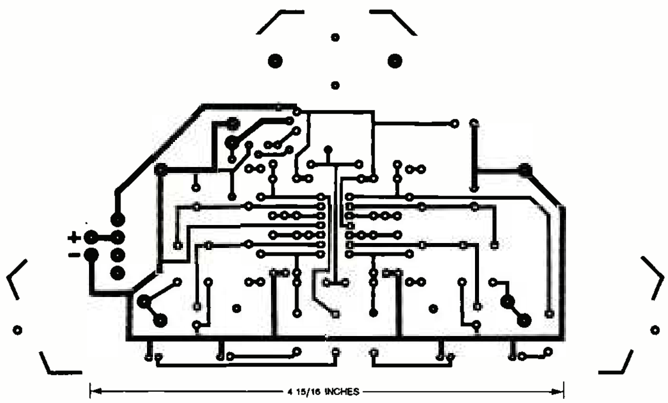


FIG. 4—PARTS PLACEMENT DIAGRAM for Bonker drive circuit. Bend the leads of MOSFET Q2 so it lies flat on circuit board.



FOIL PATTERN for Bonker drive circuit board.

**TABLE 1
OSCILLATOR STAGE
PULSE FREQUENCY**

Oscillator Stage	Pulse Limits (Seconds)
1	4 - 10
2	20 + 20%
3	26 + 20%
4	4 - 10

of the components to the circuit board by inserting all fixed resistors (R1 through R26) in the board as shown. Bend their leads together to clamp them in position close to the board.

Then insert the radial-leaded aluminum electrolytic capacitors (C1 through C5) observing their polarities, as shown in Fig. 4. Bend their leads inwards to clamp them to the board.

Then insert all diodes (D1 through D5), again observing the positions of their anodes, as shown on Fig. 4. Bend their leads to clamp them in position. Solder all of these components to the circuit board, but do not trim the leads at this time.

Next, insert transistor Q1 and bend its leads to clamp it temporarily. Bend the leads of power MOSFET Q2 at right angles so that the heat sink of its TO-220 package will lie flat on the board when the leads are inserted in the proper holes of the board.

Insert trimmer potentiometers R27 and R28 and the four light-emitting diodes (LED1 to LED4) as shown in Fig. 4, but do not twist their leads to clamp them. Now solder the leads of the second group of components inserted.

Carefully file or trim off about one-third of the width of each of the four flat terminals of slide switch S1 uniformly so that they can be press fit in the assigned holes in the circuit board. Insert the switch in the circuit board and solder it.

Identify the plus (+) and (−) wires of the DC output cable of a 120 VAC to 12-volt, 1 ampere, DC-regulated adapter, cut off the coaxial jack, and trim the insulation back on the two wires. Insert them from the component side of the board in the (+) and (−) positions (marked on the foil side of the board), and solder them in position. Trim all excess lead lengths close to the board.

Note: The circuit and solenoid can be run from a battery pack consisting of eight 1.5-volt C or

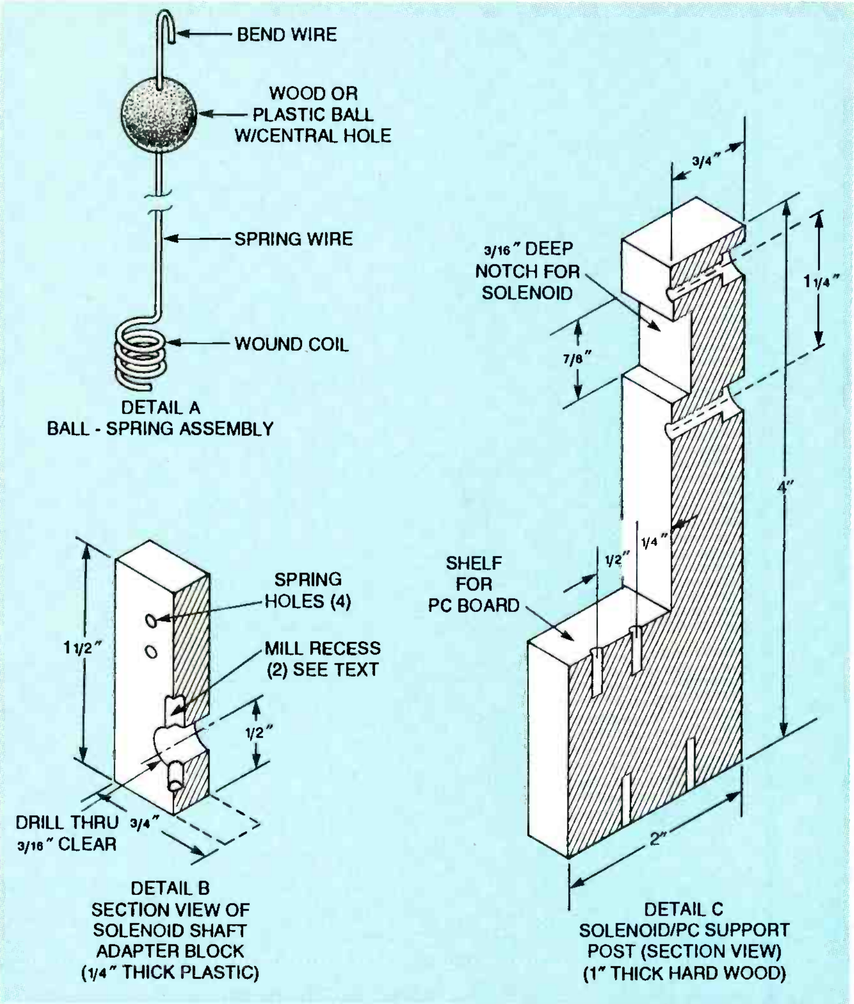


FIG. 5—DETAILS OF MECHANICAL PARTS: ball-spring assembly (Detail A); solenoid shaft adapter block (Detail B); solenoid/PCB support post (Detail C).

D alkaline cells, if you prefer not to run it from an adapter.

Turn on switch S1 to apply power. All of the LEDs should turn on and then go off. Then illumination patterns will be established: LEDs 1 and 4 will turn on every 4 to 10 seconds and continue to repeat that cycle, and LEDs 2 and 3 will turn on every 15 to 25 seconds and repeat that cycle. After you have verified this, turn off switch S1.

Place the rotary solenoid with its shaft side down and find the end of the spring that is coiled around the back end of the shaft within a slotted enclosure. With needle-nose pliers and a small screwdriver, pry up the end of the spring and re-insert it two places to the left (counterclockwise). Releasing the spring tension permits the solenoid to be operated from a 12-volt source.

Strip the insulation back from the ends of the two solenoid wires, insert them in the holes as shown on Fig. 4, and solder them temporarily in position to check the drive circuit's operation.

When S1 is switched back on, the shaft of the solenoid should oscillate back and forth over a limited angular sector. Check to see that a LED lights whenever the shaft oscillates. This response verifies that the circuit is operating properly.

Special mechanical parts

Refer to mechanical detail drawing Fig. 5, Detail A. Securely clamp the ¾-inch diameter wood ball in a vise and carefully drill a hole through its center with a No. 60 drill bit.

Clamp the end of an approximately 15-inch length of 0.028 steel piano wire in a vise and wrap the other end of the wire

PARTS LIST

All resistors are ¼-watt, 10 %
R1, R25—47,000 ohms
R2, R7, R12, R12, R19, R20, R21, R22, R24—1000 ohms
R3, R4, R5, R8, R9, R10. R13, R14, R15, R16, R17, R18—100,000 ohms
R6—180,000 ohms
R11—150,000 ohms
R23—4.700 ohms
R26—2000 ohms
R27, R28—25,000 potentiometer, slide, PC mount, Slide-Trol 112 or equiv.

Capacitors
C1–C5—330µF, 25 VDC, aluminum electrolytic, radial leaded

Semiconductors
D1–D8—1N914/4148 silicon switching diode, 75 PIV
LED1–LED4—light-emitting diode, red, T-1¾ package
Q1—2N2222 silicon transistor, Motorola or equiv.
Q2—IRF9Z20 power MOSFET, N-channel, TO-220 package, International Rectifier or equiv.
IC1—LM324N quad operational amplifier, 14-pin DIP, National Semiconductor or equiv.

Other components:
SOL1—rotary solenoid, Ledex 188687-001 or equivalent.
S1—slide switch, SPST, 5A, PC mount

Miscellaneous: Wood or plastic base (see text); wood ball, ¾ diameter; steel spring wire (0.018 in.), 15 inches long; solenoid/circuit board mounting bracket (see text); 120 VAC to 12 VDC, 1 A, regulated wall-outlet adapter; round or pan head wood screws; insulated hookup wire; solder.

Note: The following options are offered by General Science and Engineering, P.O. Box 447, Rochester, NY 145603, 716-338-7001
- **Printed circuit board—$7.50**
- **Bonker kit including printed circuit board, all electronic components, rotary solenoid, spring wire with coil, and wood sphere—$38**
- **Finished Bonker ready to operate—$89.00**
- **Alternative wood bases and solenoid mounting posts: pine—$9.50; veneer—$12.00; oak—$16.00; ceramic insulator and oak base—$16.00**

Money order, Visa, or Master Card accepted. Add $3.00 S&H. New York State residents add local county sales tax.

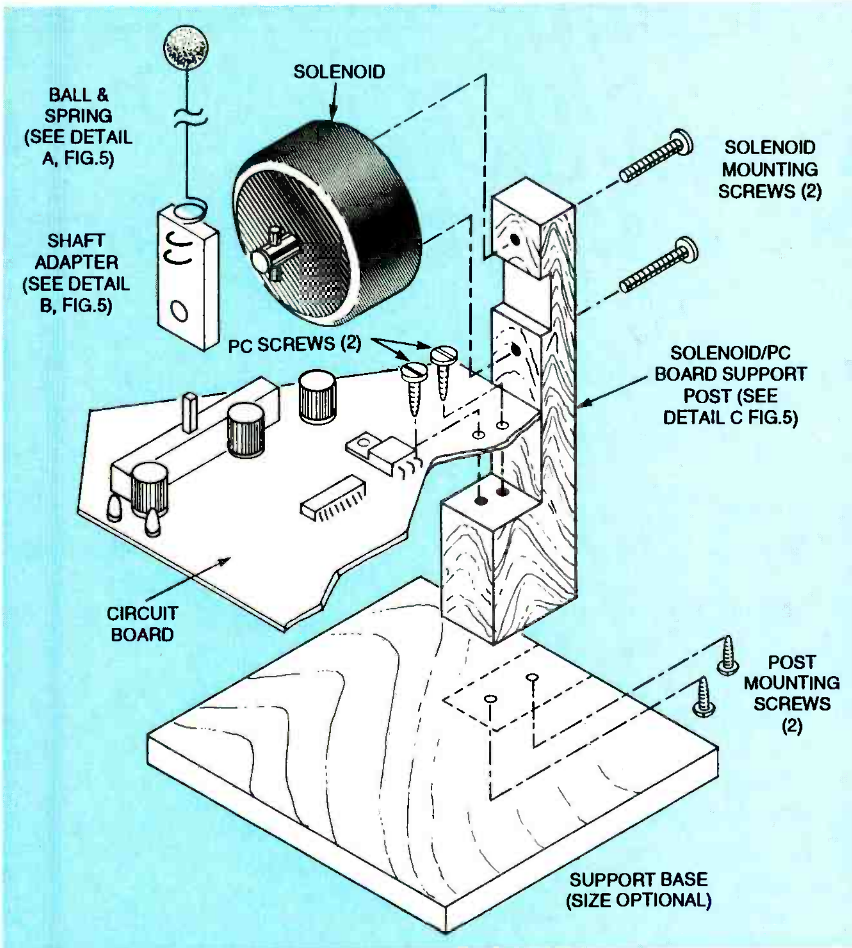


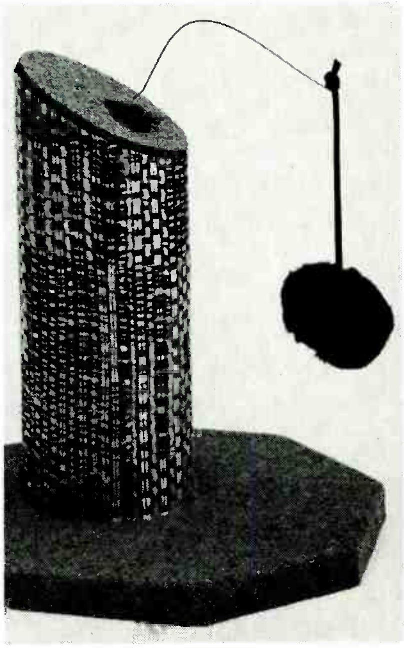
FIG. 6—ASSEMBLY DIAGRAM: The support base can be round or rectangular provided it is thick enough and has an area larger than about 30 square inches so it will be stable.

about eight times around a ⅛-inch dowel to form a coil spring with the aid of pliers. (Expect the diameter of the coil to expand after releasing tension on it.)

Insert the free end of the spring wire in the hole drilled through the ball, and then bend about ¼-inch of the end of the wire back on itself and push the bent end back into the drilled hole to assure a secure press fit.

Note: It is important that the ball be fastened securely to the wire so that it will not fly off when the solenoid is oscillating. If you want to paint or spray the ball with bright red or yellow enamel to make it more conspicuous, this a good time to do it.

Refer to Fig. 5, Detail B. Cut a rectangle measuring 1½ × ¾-inch from ¼-inch thick hard plastic and file the edges smooth. Drill a $^3/_{16}$-inch hole through the block ½-inch in from one end (as shown) so that it can be press fit over the rotary solenoid shaft. Push the block onto the shaft and mark the ends of the cross-pin on the surface of the block.



THE BONKER CAN BE BUILT in many different configurations with a choice of base styles and materials. This one is designed to drive cats wild.

Remove the block and cut or mill out short slots on both sides of the hole so that the cross pin and shaft will seat securely in the block. With a $^1/_{16}$-inch diameter bit, drill four small holes in the block in a square pattern, and set it aside.

Refer to Fig. 5, Detail C. A supporting post that is fastened to a base board is suitable for mounting both the solenoid and the apex of the circuit board. The general dimensions for a post are shown in the detail. It is suggested that it be made of wood that is hard enough so that it will not split when drilling the holes in it and fastening the base and circuit board to it.

The general outline of the post can be changed to suit your taste, but it has some critical dimensions: the size and spacing of the drilled and countersunk holes for mounting the solenoid, the spacing between the drilled holes for mounting the circuit board to the shelf, and the width and depth of the notch for accepting the end of the solenoid. You might want to paint or varnish this post before assembling it to a base.

Bonker Assembly

Refer to the mechanical assembly drawing Fig. 6. The bonker must have a suitable, sturdy base. This can be cut from wood or plastic in a round square, or rectangular shape but should be large and heavy enough to provide a secure support for the solenoid and circuit board. (A minimum of 40 square inches of material that is at least ¾-inch thick is recommended.) Again, you might want to paint or varnish the base before proceeding.

Drill and countersink two holes near the edge of the base with the same spacing as the matching holes in the base of the support post (Detail C, Fig. 5). Fasten the post to the base

(Continued on page 60)

READERS: TELL US WHAT YOU THINK ABOUT THIS ISSUE

Are you interested in helping us make this magazine as good for you as it can be? Then be one of the first to join the 1994 *Electronics Now Reader Council*. Twice a year you'll be asked to complete a detailed questionnaire. It will tell us about the things in this magazine that are important to you and give us the information we need to make this your best possible reading.

If you would like to be considered for this special *Electronics Now* project, take a few minutes to answer the questions on this page and return it to us.

While we cannot accept everyone, we will randomly select our participants, giving each one of you an equal chance of being selected.

Please mail the completed questionnaire no later than November 30, 1994, to:

Total Recall Research Group
Box 4079
Farmingdale, NY 11735-9622

Thank you, and I am looking forward to hearing from you!

Larry Steckler,
Editor-in-Chief

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2. **Are you:**
   Male ☐ Female ☐

3. **How old are you:**
   I am ______ years old

4a. **Highest education achieved?**
   Attended technical school ☐
   Graduated technical school ☐
   Attended College ☐
   Graduated College ☐
   Earned PhD ☐

4b. **Do you**
   Hold FCC license ☐
   Hold other license, Certif. ☐

5. **What is your total household income?**
   Total household income, before taxes is $ ______________

6. **Name the article in this issue that you liked the best.**
   ____

7. **Name the article in this issue that you liked the least.**
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8. **Name the department or regular column in this issue that you liked the best.**
   ____

8a. **Name the department or regular column in this issue that you liked the least.**
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9. **Do you earn your living working in the electronics industry?**
   Yes ☐ No ☐

10. **If you were the editor, would you make the articles:**
   More complex ☐
   Simpler ☐

   Longer ☐
   Shorter ☐

   More build it ☐
   Less build it ☐
   More how to ☐
   Less how to ☐

11. **What articles would you publish?**
   ____
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12. **What new columns would you add?**
   ____
   ____
   ____
   ____

13. **What else would you change?**
   Use a separate sheet for your comments. Please give as much detail as possible.

Name ______________
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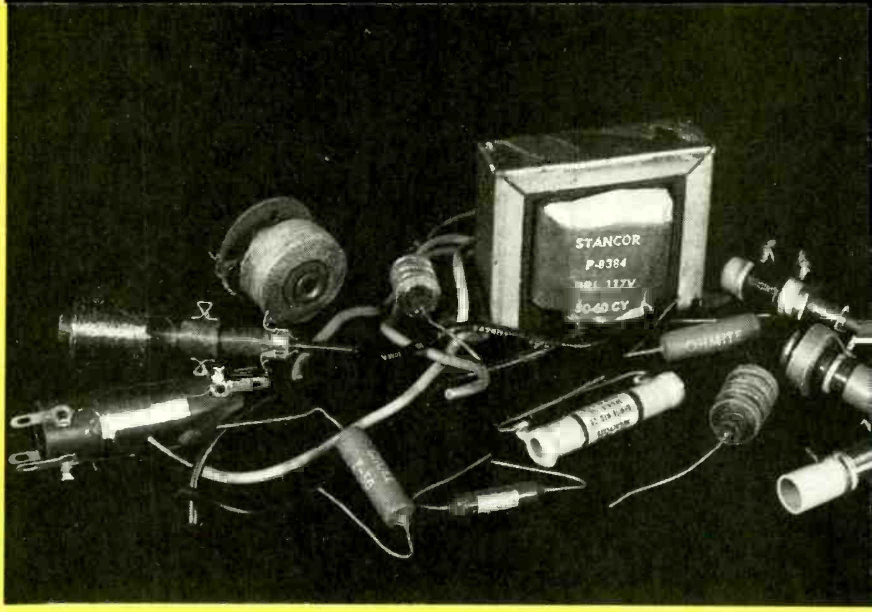
Here's an easy way to test transformer windings, coils, chokes, and motors—almost any device containing a winding.



JUD WILLIAMS, CET

SIMPLE TEST FOR TRANSFORMERS

ONE COMPONENT THAT PRESENTS perplexing troubleshooting problems is the ordinary power transformer. It is particularly difficult to tell if the windings are short-circuited because ohmmeter readouts are rather ambiguous when measuring resistance values less than 1 ohm. When I first started to repair power supplies, I got the idea of bucking an ordinary 6.8-volt filament transformer against the winding of a suspect transformer. (Transformers called *filament* transformer were used to power the heating elements of vacuum receiving tubes known as filaments. These transformers are still widely available.)

I found that when I connected the 6.8-volt secondary of the transformer across (or parallel to) the winding of a transformer under test, the output voltage was approximately the same as the open-circuit voltage of the unloaded filament transformer. If the suspect transformer had a short-circuited winding in it, the voltage would drop to 50% or more. Thus, by placing an AC voltmeter across the winding, I could identify a defective transformer with no trouble. Figure 1 shows my test setup.

I found that a continuity check with an ohmmeter is also necessary to ensure that the winding is not open. When making a continuity test with an ohmmeter, I looked for a very low resistance reading, and made sure that the meter was set to its lowest range. Transformer winding resistance is typically several ohms, depending on the number of turns in the winding. This value depends on the length of wire in the winding, its diameter, and its DC resistance.

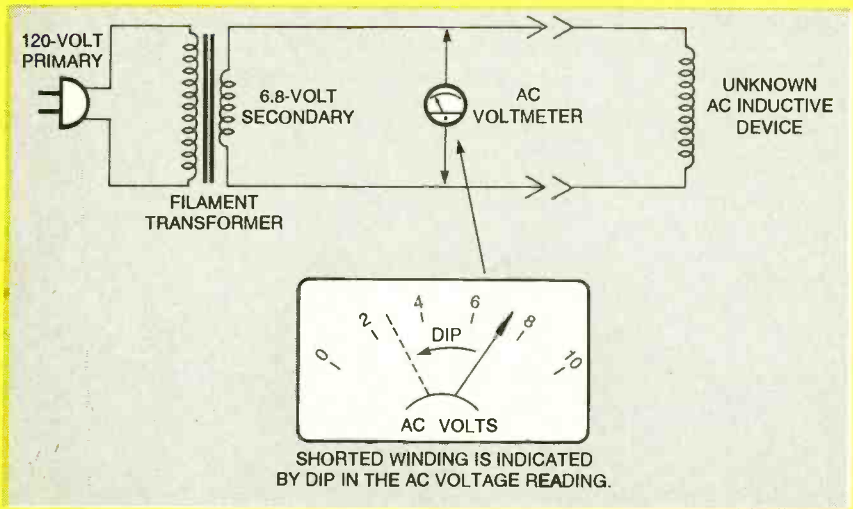


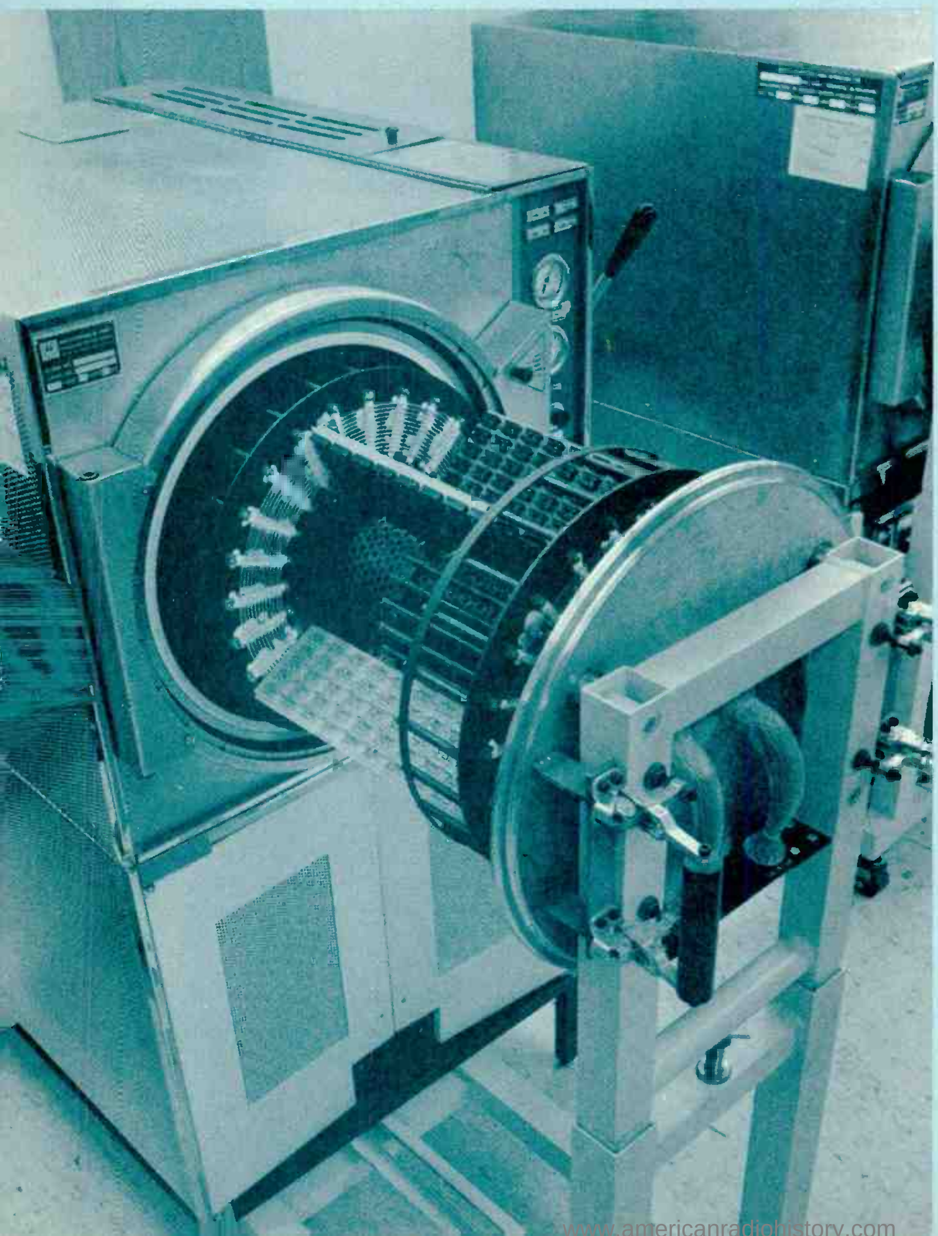
FIG. 1—**THIS SIMPLE TEST SETUP** makes the testing of any kind of coil or winding easy.

Why does this work? An AC inductive impedance is parallel to an unknown reactive element such as a coil or winding. Because the secondary winding of the filament transformer has a relatively low impedance, it should, in most cases, be in parallel with a higher impedance, so the filament transformer will not be loaded down. If the transformer being tested has shorted windings, the impedance will usually be less than the filament transformer impedance. This will result in a lower-than-normal voltage reading.

This test will work for power transformers, as well as relay coils, solenoid coils, chokes, ferroresonant transformers, AC adapters, inverter transformers, electric motors, and fans. Almost any product containing a winding can be tested. Ω

ENVIRONMENTAL SEMICONDUCTOR TESTING

Learn about the testing performed on semiconductor devices to ensure that they work as intended under environmental stresses.



TJ BYERS

A SEMICONDUCTOR DEVICE CAN function perfectly under optimum conditions at room temperature, sea-level air pressure, and low relative humidity but fail when operated in a hostile environment, which can present any combination of physical, chemical and electrical challenges. *Physically hostile* environments exhibit extremes of temperature, air pressure, acceleration, humidity, and radiation. *Chemically hostile* environments include exposure to salt spray, biological fluids, noxious atmospheres, dirt, and chemically active fluids and gases. *Electrically hostile* environments include destructively high voltages and magnetic fields as well as AC, DC, and transient interference over the whole spectrum.

Semiconductor device manufacturers can go a long way in protecting their products from hostile environments by packaging them in hermetically sealed cans or ceramic packages. There is a choice of ceramic DIP (CERDIP) hermetic packages and even more expensive solder-sealed (side-brazed) ceramic packages. But this premium-priced packaging increases the number of manufacturing steps required and raises the unit price of the device.

Military and aerospace standards have long specified metal or ceramic device packaging because it is known that these products will be exposed to greater stresses than comparable consumer or commercial devices. This applies to diodes, transistors, and thyristors as well as logic, memory and microprocessors. In certain instances, semiconductor device failure could result in loss of life in applications such as life support equipment, emergency radios, navigation equipment, and weapons control systems.

Therefore, reliability has been more important than unit price in these applications, and devices intended for those purposes are still more rigorously tested and they receive tests not specified for other devices.

However, as a result of improvements in manufacturing techniques, and favorable indications from years of accumulated reliability data, plastic packaged devices are now performing satisfactorily in applications previously reserved for metal and ceramic-packaged devices. The Department of Defense is trying to reduce the cost of electronics without compromising reliability by turning to the documented internal practices of semiconductor manufacturers for many non-critical applications.

For years U.S. military contracts for electronics equipment of all kinds routinely called for military-spec-semiconductors, regardless of end-use—combat aircraft, ships, or vehicles as well non-combat activities in military bases and depots. However, the NATO-pact countries have generally been more relaxed on this issue when procuring military electronics.

Today, however, the DOD is accepting more commercial equipment for base and depot activities such as telecommunications, electronic test and checkout, and data processing. Commercial equipment such as radios, radar and navigational equipment is purchased for non-combat aircraft, ships and vehicles. While that equipment might have more rugged, military-style packaging and be subjected to relaxed environmental tests, the semiconductors will be commercial products.

Nevertheless, when you buy any semiconductor device these days, you are purchasing a survivor—only the fittest have made it out of the factory. The device might represent only a fraction of its mates that were grown on the same wafer. Regardless of its intended end use, only the healthy products have made it out of the factory door.

If you are an electronics hobbyist or design and build circuits intended to work only under controlled environmental (indoor) conditions, you might not be concerned with environmental testing. However, if you have responsibilities for the design, manufacture, maintainance, or specification of military and aerospace electronics, you are probably familiar with MIL-STD-883, the Military Standard Test Methods and Procedures for Microelectronics.

The "Bible" for all semiconductor device testing, MIL-STD-883 includes 18 different environmental tests. Table 1 lists the environmental tests by method number, and Table 2 lists method numbers for mechanical tests.

Not every semiconductor device manufactured is 100 % tested because its cost would be prohibitive. A sampling of parts "stands in" for its mates; that lot shares the fate of the samples. There is no reason to believe that 100 % testing would yield products that are more reliable than those screened by statistical quality control.

Preliminary electrical tests are performed on special test circuits designed into the wafer. A failure to pass these built-in tests could lead to the rejection of the complete wafer containing hundreds of active discrete or integrated devices.

Dies or chips that will become military-qualified parts are sorted from those that will become commercial parts at the wafer level. Both classes can be further sorted by performance characteristics (such as speed in memories). The slowest devices in any lot sell for less than the fastest devices.

TABLE 1
MIL-STD-883 ENVIRONMENTAL TESTS FOR SEMICONDUCTORS

Method Number	Test Name
1001	Barometric pressure (altitude operation)
1002	Immersion
1003	Insulation resistance
1004	Moisture resistance
1005	Steady state life
1006	Intermittent life
1007	Accelerated life
1008	High-temperature storage
1009	Salt atmosphere (corrosion)
1010	Temperature cycling
1011	Thermal shock
1012	Thermal characteristics
1013	Dew point
1014	Seal
1015	Burn-in test
1016	Life/reliability charaterization tests
1017	Neutron irradiation
1018	Internal water-vapor content

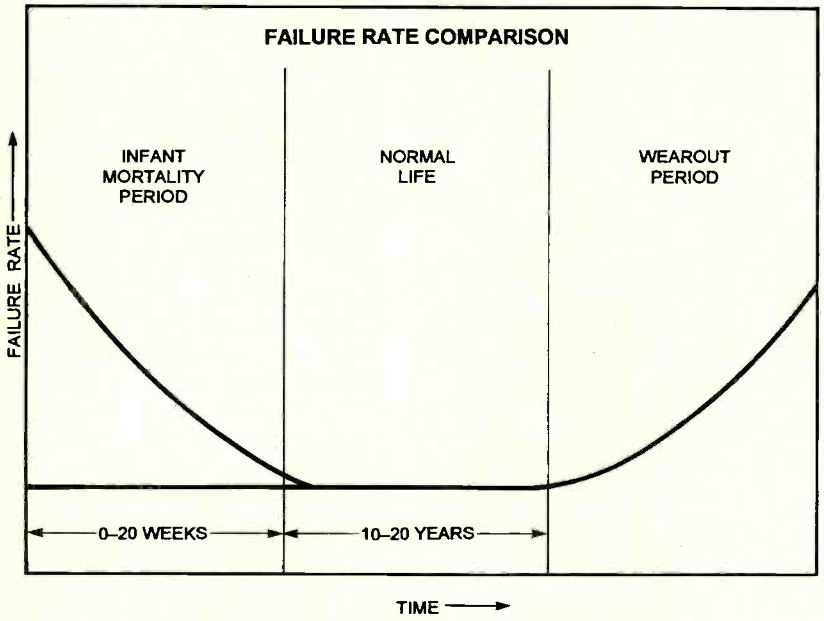


Fig. 1—BATHTUB HAZARD RATE CURVE for failure rate comparison in reliability testing of semiconductor devices

Dies or chips packaged in plastic are not be subjected to the same environmental stresses (particularly temperature extremes) as those packaged in hermetically sealed metal cans or ceramic packages. Regardless of the device's eventual application or packaging, its electrical parameters are measured and recorded for reference before it is subjected to the rigors of environmental testing.

At the completion of the environmental testing steps, the electrical parameters are measured again, and any changes in characteristics are noted. That data determines whether the device is acceptable for sale in any category or must be rejected as a failure.

AMBIENT TEMPERATURES inside a chamber at Motorola Semiconductor typically range from -65°C to 150°C.

Classes of environmental tests

The environmental tests given to any device depend on its type and application. Most of the world's semiconductor manufacturers subject their products to tests based directly or indirectly on the methods specified in MIL-STD-883. Semiconductor devices procured by the Department of Defense must be tested in accordance with those provisions, but commercial/consumer products might be given tests that are relaxed versions of those tests.

Many people assume that the military standard tests for semiconductors are prepared by Pentagon bureaucrats and imposed upon the semiconductor manufacturers. But they are actually the result of a joint efforts between the Department of Defense and the manufacturers who have an opportunity to express their views on what is feasible and wht is not.

The military standards are the result of considerable investment of time and money over many years by all participants. Those standards and specifications were far more important years ago when the DOD was the largest semiconductor customer. However, the standards have survived the massive shift in customer base from defense to commercial over the past 20 years, due more to the rapid growth in the commercial spending rather than a decline in defense spending.

As Table 1 shows, the range of environmental and mechanical tests based on MIL-STD-883 is wide and varied. Most testing is done on a sampled basis. Some tests are so potentially destructive that even if the device passed, it might be fatally weakened by the test.

It is common industry practice to select a random sample of devices from a larger lot, usually from about seven to a hundred, for testing. These devices are then divided into groups of one device or more, and each group is subjected to a different test routine. At the end of the test program, the parts are evaluated for performance. From these results, the general health of the untested devices in the lot is determined by statistical analysis.

Chambers of horrors

Most environmental tests take place in chambers that are capable of testing semiconductors under environmental conditions that exceed those that would normally be encounterd in the laboratory. Temperature, humidity, and air pressure, for example, can be cycled over wide limits and controlled within chambers.

Most test chambers are designed for a specific test such as temperature or pressure cycling. A temperature chamber with a humidifier permits the simulation of tropical conditions, and one with a salt mist injector can reproduce conditions on or near the ocean. A pressure chamber permits the simulation of air pressures many times normal that would be encountered in the depths of sea as well as those near zero to simulate outer space.

Thermal stress

Thermal stress is the most damaging environmental influence on semiconductor devices. Extremes in operating and ambient storage temperatures place more strain on an electronic component than all of the other environmental factors combined.

Thermal stress testing is classified into three basic categories: high-temperature storage, temperature cycling, and thermal shock. Within each category there are subsets of test conditions that can be tailored for different kinds of devices.

High-temperature storage

The high-temperature storage test (stabilization bake) (Method 1008) tests the effect of elevated temperature on a semiconductor device with no power applied. A temperature-controlled oven is the only equipment required to perform this test. The parts to be tested are placed in the chamber, and the temperature is increased to the required storage temperature.

The actual storage temperature depends on the intended application of the part being tested. Temperatures range from 75°C to 400°C (167°F to 752°F). Military and aerospace devices are, as you might expect, tested at higher temperatures than their commercial counterparts. Devices with plastic packages are generally tested at 150°C (302°F).

The samples are kept at the storage temperature for a specified time period that can range from 24 to 1000 hours. The parts are then removed from the chamber, allowed to cool to room temperature, and tested for electrical performance.

Some form of high-temperature storage is frequently imposed as preconditioning treatment for other tests. Solvents left over from plastic injection molding and subsequent cleaning can cause erratic performance. Even brief high-temperature cycling can drive off those contaminants, stabilizing the device parameters.

Temperature cycling

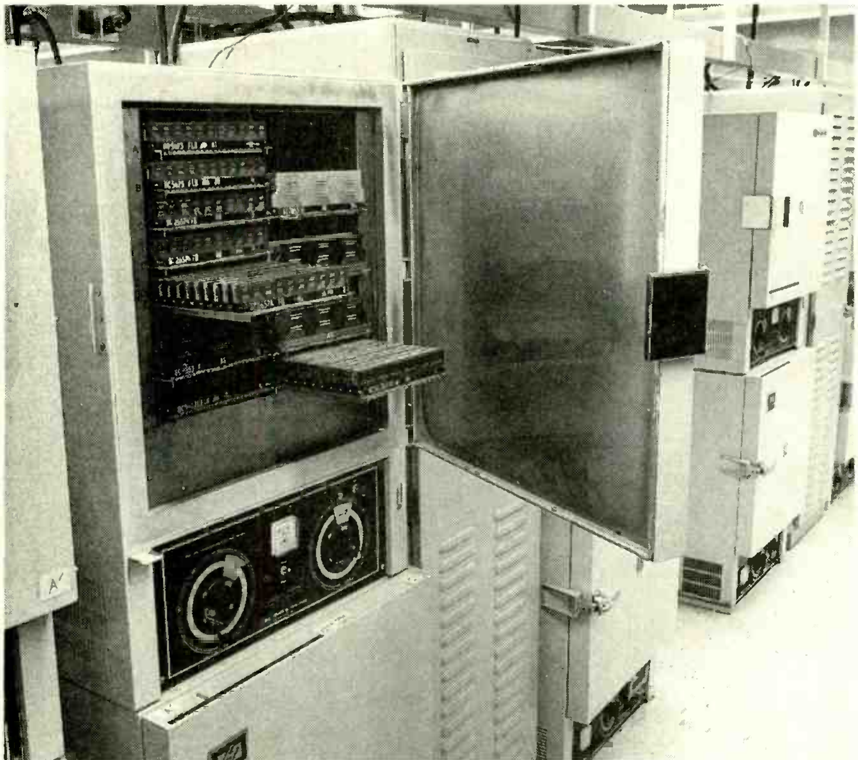
Temperature cycling (Method 1010) also tests the ability of a component to withstand alternate exposure to extremes of heat and cold. Devices intended for automotive applications, for example, must survive repeated cycles of high and low temperature extremes.

Any permanent changes in a semiconductor device's operating characteristics caused by temperature cycling are usually the result of mechanical strains set up between materials. This damage can take many forms: cracking and crazing of the molding compounds, opened seams and seals, insulation failure, and the separation of the lead wires from the semiconductor die or chip.

Temperature cycling is done in a chamber or oven whose temperature can be cycled and controlled between specified temperature extremes. Alternatively, the test can be performed in two separate chambers: one to obtain the high temperature and the other to obtain the low temperature.

For military-qualified devices, these extremes are typically −65°C to 150deC, (-85°F to 302°F) air-to-air for 10 cycles. For commercial/consumer (including automotive) devices, they are typically 0°C to 100°C (32°F to 212°F. Forced air circulated within the chamber minimizes the thermal layering within chambers that could invalidate the results.

In the standard procedure, the devices to be tested are put in the cold chamber first and allowed to stabilize for a minimum of 15 minutes. Then they are transferred to the hot chamber for 15 minutes. Together, these exposures make up one temperature cycle, and ten cycles are required. No more than a five minutes delay at room temperature (25°C) is permitted between the time the parts are transitioned from one extreme to the other.



BURN-IN CHAMBER at Motorola Semiconductor exposes test devices to thermal stress under power.

Thermal shock

Thermal shock (Method 1011) is the most demanding thermal stress test. It is a more severe version of temperature cycling. A liquid replaces the air as the heat transfer medium for temperature cycling in this test. Because a liquid transfers heat more efficiently than a gas (air), the internal temperature of the device being tested is changed more rapidly.

A temperature-controlled bath containing a liquid, typically water, suitable for heat transfer over the specified range is required for this test. The temperature limits for thermal shock are often the same as those for temperature cycling.

Chlorofluorocarbon (CFC) compounds (e.g., Freon) have been used for mil spec testing, but substitutes may be required because of possible damage to the ozone layer caused by the release of those compounds to atmosphere.

Unlike temperature cycling, a thermal shock cycle begins with the immersion of the sample in the heated liquid. After five minutes at that temperature, the component is quickly transferred to the cold solution. Then after another five minutes at low temperature, the cycle is complete and another cycle is started immediately. Fifteen complete cycles are required to complete the test, and the time taken to transfer the part from the hot to the cold bath must not exceed 10 seconds.

Moisture resistance

The moisture resistance test (Method 1004) is similar to the thermal shock test (Method 1011). It is performed to evaluate the ability of a device to withstand the deteriorative effects of high humidity and heat. The damage caused by moisture includes absorption of moisture by insulating materials, surface wetting, and metal corrosion.

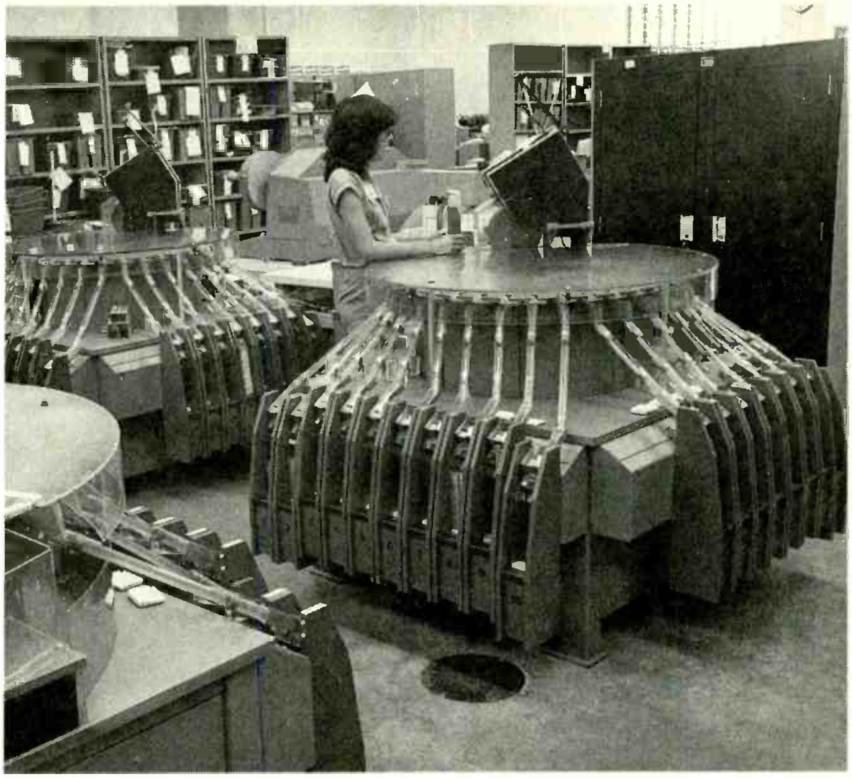
This test is performed in a temperature-controlled chamber with a humidifier capable of creating relative humidity conditions of 85 % or more. Prior to the test, a bias voltage equal to the maximum operating voltage of the device is applied between its power terminals.

A reverse bias voltage equal to their breakdown voltages is applied to diodes, transistors, and thyristors, and a voltage equal to the normal supply voltage is applied to digital and analog integrated circuits.

Salt atmosphere

The salt atmosphere (corrosion) or salt spray test (Method 1009) determine the device's resistance to the ingress of salt solution and to corrosion on exposed and interior surfaces. More rigorous than the moisture resistance test, it simulates conditions found at the shore or aboard a ship at sea.

The devices to be tested are suspended for 24 hours in a mist of 20% sodium chloride solution at 35°C so that liquid cannot collect on them. Air flow within the chamber is adjusted so that salt deposits accumulate at the rate of 10,000 to 50,000 milligrams per square meter per day.



POST BURN-IN TEST and evaluation with automated test equipment.

At the conclusion of the test, the samples are rinsed in warm water and gently scrubbed to remove salt deposits. The devices are then given a visual examination under a magnifying lens for signs of deteriorization such as lead metal corrosion or surface contamination.

Hazard rate curve

High infant mortality has been an ongoing problem for the semiconductor industry since the early days of transistors. A device might pass all of its electrical, environmental and mechanical tests and for various reasons fail after hours or days of service.

Theory and experience have shown that the failure rate for semiconductor devices normally follows a predictable curve—the famous *bathtub hazard rate curve* (see Fig.1). This curve is normally split into three regions for reliability analysis:

1. *Infant mortality period* is a region of high early life failures normally related to manufacturing defects.
2. *Normal life* is a region of relatively stable performance representing the useful life of the device. A low level of random failures can occur in this region of the curve.
3. *Wearout period* is the region following normal life where failure rate will increase rapidly due to wear out.

The infant mortality period is typically a few weeks while stable or normal life could be 20 years or more. Most semiconductor circuits will have been replaced with new designs and technologies before the wearout period is reached.

Many reasons have been advanced to account for infant mortality. Typical reasons advanced include materials and assembly defects, marginal design of the device, or faulty setting of test guardbands. Many of these failures can be detected during the manufacturer's quality testing process.

However, device mortality after it has been operating for weeks in a circuit is generally caused by deviations in the manufacturing process or the inadvertent application of overvoltages. These failures cost the industry millions of dollars in lost production and reflect poorly on the manufacturer, who must bear the burden of replacements.

Static burn-in

There is ample evidence that infant mortality can be reduced to less than 1% with a test procedure called *burn-in* (Method 1015). The device is placed in an chamber that stresses both the device's electrical and thermal limits. Only those components that survive this ordeal live to become useful products.

Burn-in is performed on the test device at a minimum ambient temperature of 125°C (257°F) with power applied. For military compliant products, a 100 % test is given for 160 hours. However, for commercial products the duration of that test might only be 16 hours—if it is done at all. The high ambient temperature is maintained during burn-in by thermostatic control of the chamber. A means is provided for transmitting power to the devices inside the chamber.

The power simulates electrical and signal conditions that the device is expected to experience in normal operation. Five methods for applying the power are in common use. The first three methods, known as *static burn-in*, call for the application of DC power only.

Dynamic burn-in

Dynamic burn-in is specified when simple steady-state test conditions are insufficient to guarantee the reliability of the device for critical applications, such as those that would be encountered in spacecraft. In this test, AC signals are applied to the inputs of the device under test to simulate actual circuit operating conditions.

After burn-in, all sample devices receive a 100% functional screening at 100° C. Because failures among burned-in devices can be catastrophic, a continuity check is usually given to the parts before testing to prevent short-circuited devices from damaging the test circuit.

Mechanical tests

The MIL-STD 883 includes the mechanical tests listed in Table 2. These include methods for testing constant acceleration, mechanical shock, and vibration fatigue, noise, and variable frequency. A constant acceleration test might require that the device be subjected to 30 kg for 1 minute on each axis to test the internal connections of the device.

ELECTRICAL TESTS are made on a semiconductor device wafer to eliminate faulty units prior to environmental testing.

TABLE 2
MIL-STD-883 MECHANICAL TESTS FOR SEMICONDUCTORS

Method Number	Test Name
2001	Constant acceleration
2002	Mechanical shock
2005	Vibration fatigue
2006	Vibration noise
2007	Vibration, variable frequency
2013	Radiography
2020	Particle impact noise detection test

Other tests

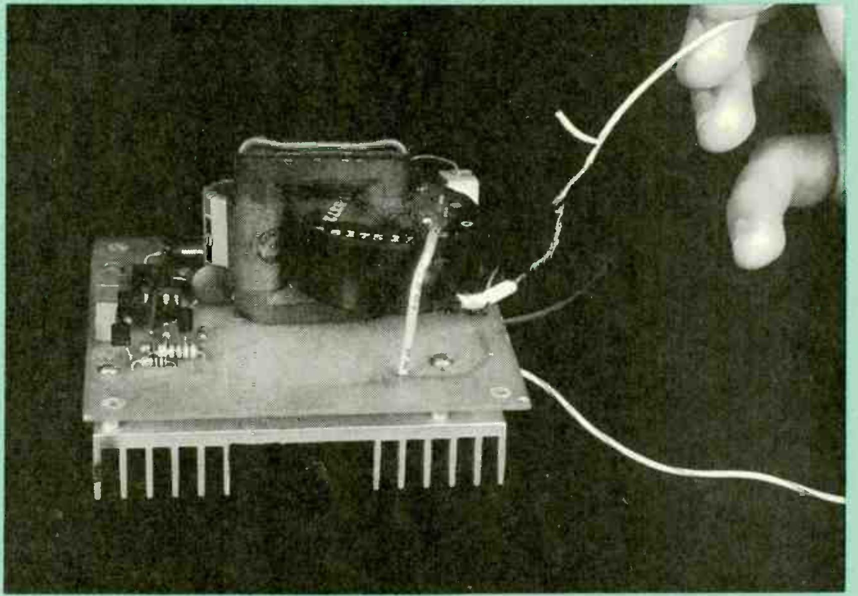
The procedure for obtaining qualification for a semiconductor device in compliance with MIL-M-38510 is costly and time consuming. When complete, a so-called JAN (Joint Army Navy) "slash sheet" is issued by the Defense Electronics Supply Center (DESC). There are two product assurance classes available for M38510 products (Class S and B). The IC manufacturers qualified to supply product to a particular M38510 slash sheet are identified in the Qualified Products List (QPL) issued by DESC.

However, if a military/aerospace contractor wishes to use a part that does not have a JAN slash sheet, the product can be processed to MIL-STD-883, Class B, Method 5004, and it will be electrically tested 100% to the manufacturer's data sheets. These products are identified by the /883 suffix on the part number.

Continued on page 89

BRENT C. TURNER

BUILD A SOLID STATE TESLA COIL



Build a solid-state version of Tesla's famous coil. It is easier to build and safer to operate.

NICOLA TESLA'S COIL IS ALIVE AND well today, living in school labs and hobbyist's workshops as a tool for learning and experimentation. The classical air-core transformer with a spark gap and capacitor produces a high voltage at high frequencies. However, new designs of that concept based on solid-state components and improved transformers make the construction of a Tesla coil easier and safer.

When Tesla devised his coil, the spark gap oscillator was the only practical method for generating the necessary radio frequency current across a transformer primary that would result in high-voltage at the secondary winding. However, the drawback of the classical Tesla coil is the ability of its high-voltage transformer to impart a life-threatening electrical shock to anyone experimenting with it.

Fortunately, high-voltage power transistors designed and built to meet the demand from switchmode power supply manufacturers are now readily available. Some power MOSFETs are capable of switching up to 1500 volts safely. Moreover, the task of building a suitable transformer has been simplified with the development of ferrite core materials that permit transformers to be made smaller and lighter and confine their magnetic fields.

How the Tesla coil works

The voltage output of a classical Tesla coil's secondary, a series-resonant circuit, is produced by oscillations in the secondary winding, as shown in Fig. 1. The Q or figure of merit for a resonant circuit and the applied frequency determine the voltage developed across the inductor.

If a voltage generated at the resonant frequency of the Tesla coil is coupled to its secondary, a high voltage will be produced. In the classical Tesla coil, the primary side of the transformer is fed by a spark-gap oscillator. The capacitor and primary inductance determine its operating frequency. An electromagnetic field from the primary winding couples the energy into the secondary system.

This original design works well, but it is inefficient; only a fraction of the primary winding's magnetic field is effective in inducing energy into the secondary. This inefficiency is caused, in part, by the expansion of the primary magnetic field. It was seen that if this field could be confined to a smaller volume, the system would be more efficient.

Ferrite transformer core materials make it possible to confine magnetic fields. Various

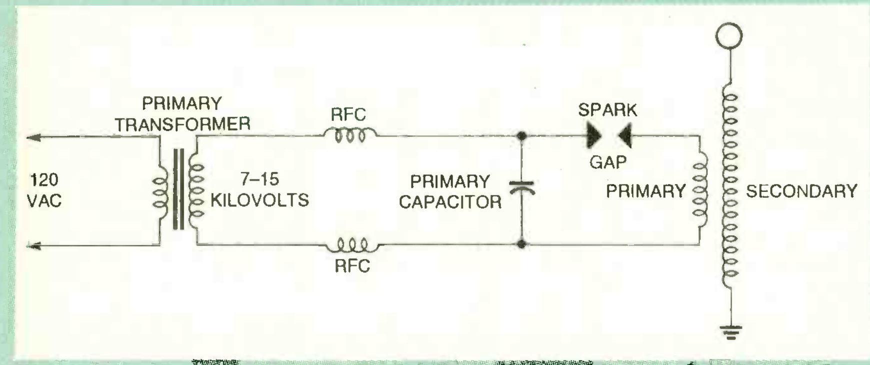


FIG. 1—IN A TESLA COIL, the voltage is produced by resonant oscillations created in a secondary winding.

powdered compositions of ferric oxide and other metals such as nickel or cobalt are compressed and sintered to form solid cores. Their high resistance makes eddy current losses very low at high frequencies, and coupling efficiency is improved.

The operating principle of the primary system in the solid-state coil design discussed in this article differs from the principle of the classical spark-gap design. If a spike of energy is applied, the coil responds with an oscillating burst that decays with time, analogous to the ringing of a bell when struck by the clapper.

If there is no instant damping of the ringing, it will occur at the natural resonant frequency of the coil. A higher voltage output will be produced by a phenomenon known as *Q factor multiplication*.

The solid-state Tesla coil includes a stock, off-the-shelf, high-frequency pulse transformer. It is essentially the same as the transformer that you will find in the high-voltage generation circuit of a standard television set.

The coil circuit

Refer to Fig. 2. The Tesla circuit consists of a pulse generator, a driver circuit, and a high-voltage transformer. The pulse generator, a 555 timer (IC1), is organized to run in its astable mode to generate a continuous pulse train. Resistors R1 and R2 determine the time duration that the output at pin 3 is off, while R3 and R4 along with R1 and R2 determine the on time. Inductor L1 and regulator IC2 provide a clean, stable power source for the timer.

Transistor Q1 acts as a buffer, effectively isolating IC1 from the highly capacitive load present on the gate of Q3. Resistor R6 determines the rise time based on the time constant developed by R6 and the inherent gate capacitance of Q3. Resistor R8 limits current so that excessive current will not damage T1's primary winding. Capacitor C5 absorbs some of the back EMF generated in T1's primary. Another function of C5 is to provide an extra kick to drive Q3 to an on state.

The pulse waveform from IC1 is applied to Q1, which provides the high current necessary to offset the high capacitance of Q3. When Q3 starts to conduct, current flows through T1's primary, building a magnetic field in the core. After a short time interval, the core saturates, preventing any further generation of magnetic flux. Prior to this, Q3 is switched off, causing the magnetic field to collapse and producing a sharp voltage spike in both windings.

Capacitor C5 partially absorbs the primary EMF, reducing the stress on Q3. The spike produced in the secondary creates a ringing oscillation. When this oscillation begins to decay, Q3 is once again switched into its on state. This dumps the energy stored in C5, and builds the magnetic field in T1. If the timing of both the on and off states of the pulse train are adjusted correctly, the secondary of T1 produces a nearly constant, high-frequency, high-voltage current.

(Continued on page 68)

PARTS LIST

All resistors are ¼-watt, 5%, unless noted.
R1—7500 ohms
R2—10,000 ohms, potentiometer
R3, R6, R9—10 ohms
R4—5000 ohms, potentiometer
R5—180 ohms
R7—180 ohms
R8—150 ohms, ½-watt
R10—1 ohm, 5 watts

Capacitors
C1—220 µF, 25 volts, electrolytic
C2—0.0047 µF, 50 volts, Polyester
C3—0.05 µF, 50 volts, Polyester
C4—0.01 µF, 1200 volts, Polyester

Semiconductors
IC1—NE555 timer
IC2—LM7809, +9-volt regulator
Q1, Q2—2N2222 NPN transistor
Q3—SSM5N55 FET transistor (Samsung or equivalent)

Other components
L1—100 µH choke (Radio Shack No. 273-102 or equivalent)
T1—Flyback transformer (Penn-Tran No. 1-017-5372—or equivalent, provided that the high-voltage rectifier is not embedded within the transformer)

Miscellaneous: Heatsink for Q3, eight-pin socket for IC1, wire, high-voltage wire, perforated construction board.

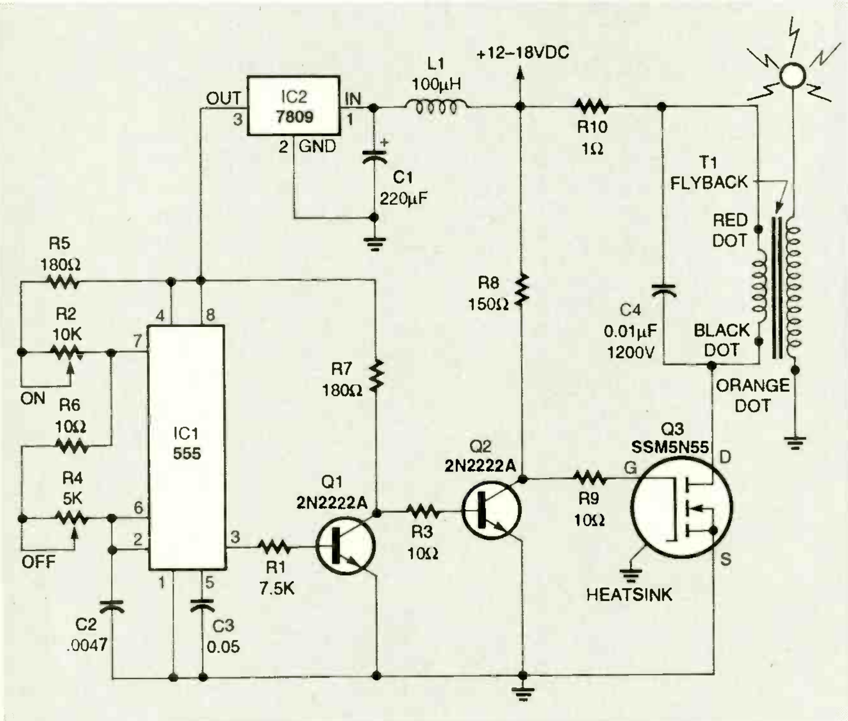
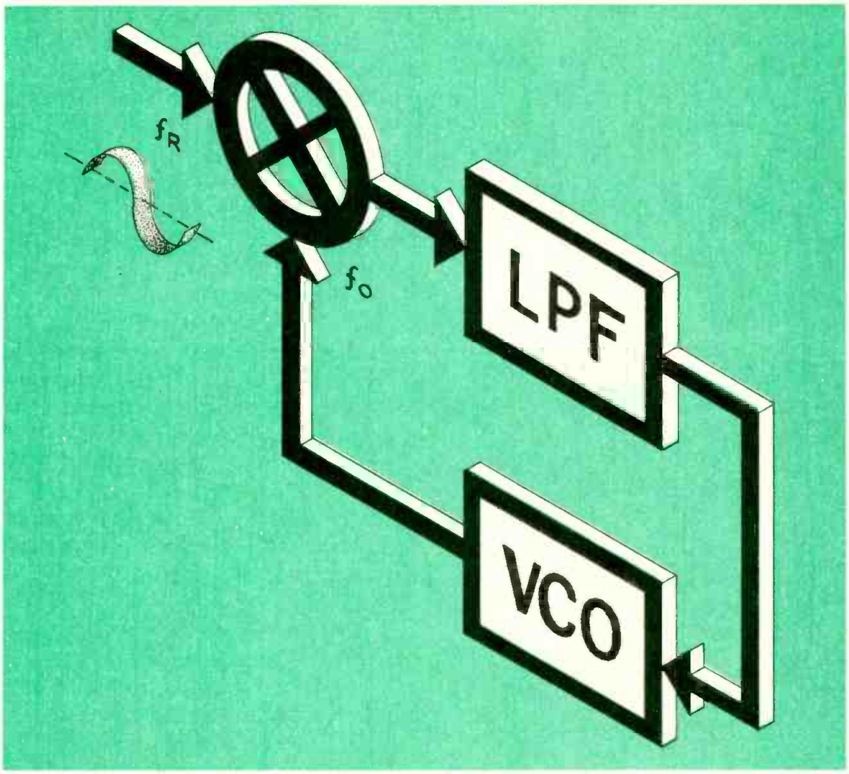


FIG. 2—THE SOLID-STATE TESLA CIRCUIT consists of a pulse generator, a driver circuit, and a high-voltage transformer. The 555 timer (IC1) runs in its astable mode, producing a continuous pulse train.

RAY MARSTON



PHASE-LOCKED LOOPS

Learn more about designing with phase-locked loop circuits in this continuation of last month's article

THIS IS THE THIRD ARTICLE IN A SERies on phase-locked loop and related circuits. It focuses on the monolithic NE565 phase-locked loop and the NE566 function generator, both prime sourced by Philips (Signetics) but alternate sourced by at least four other multinational suppliers. The electrical characteristics of these two PLL ICs are described, and their block diagrams are presented. Circuit schematics based on these devices are included for learning and experimentation.

The last two articles in this series explained the basic operating principles of the phase-locked loop and examined applications for the popular CD4046B PLL IC.

The NE565 PLL IC

The NE565 is a general purpose monolithic PLL used in circuits for frequency-shift keying (FSK), telemetry receivers, tone decoders, and FM discriminators, to mention just a few. Figure 1 shows the principal functional blocks of the NE565: phase detector (comparator), amplifier, stable voltage control oscillator (VCO), and low-pass filter. The self-contained adaptable filter and demodulator cover a frequency range of 0.001 Hz to 500 kHz.

The center frequency of the NE565 is determined by the free-running frequency of the VCO. This frequency can be adjusted externally with a resistor or capacitor. The low-pass filter, which determines the capture characteristics of the loop, is formed by an internal resistor and an external capacitor. Figure 2 is the pinout diagram of the most popular plastic, 14-pin DIP package for the NE565.

The NE565 is not as versatile as the CD4046B because the voltage control input pin of its VCO section is permanently tied to the amplifier output through the internal 3.6-kilohm filter resistor (see Fig. 1). As a result, its VCO can't function separately from the rest of the device. While the NE565 works well in many of the same applications as the CD4046B, unlike that PLL device, it is not recommended as a general-purpose signal generator.

Figure 3 is the the schematic for an NE565 with external components organized as a signal tracker or FM demodulator. The PLL is powered by a split 12-

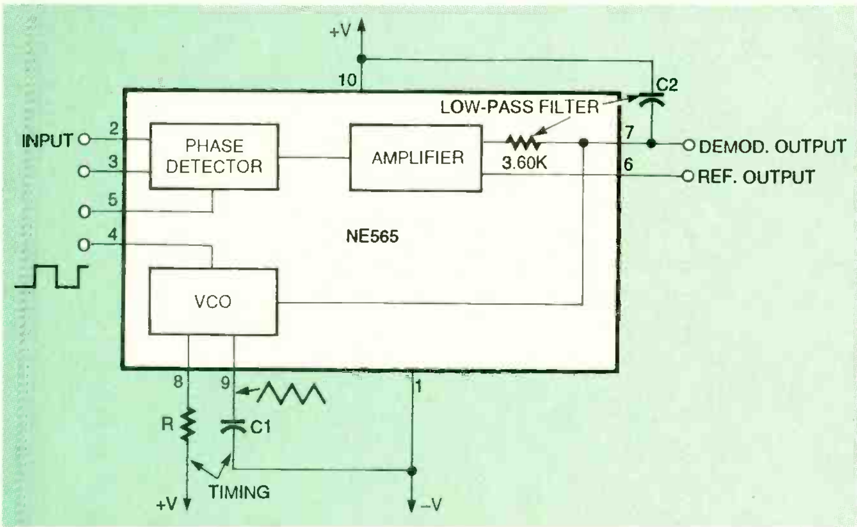


FIG. 1—BLOCK DIAGRAM OF THE NE565 phase-locked loop IC.

volt (+6-volt and −6-volt) power supply. The external signal input to be tracked or demodulated is typically connected to input pin 2 of the phase detector of the PLL, while unused pin 3 is grounded.

Output pin 4 of the VCO is tied to pin 5, the phase detector's input terminal, to complete the phase-locked loop. The free-running frequency (f_O) of the VCO can be adjusted with the RC network connected to pins 8 and 9 so that it corresponds to the mid-range value of the external input signal.

Under those conditions, the VCO's frequency can "lock" to the input signal. This frequency lock condition occurs because the mean DC level of the phase detector's amplified output is directly proportional to the difference between the input and VCO frequencies, and it can act to voltage control the VCO input.

As a consequence, if the input frequency rises above that of the VCO, the detector's output also rises and automatically drives the VCO's frequency toward that of the input until locking occurs.

The single-pole loop filter formed by capacitor C3 (between pins 7 and 10) and the internal 3.6-kilohm resistor at pin 7 causes a short time delay. Therefore, if the input signal is noisy, has jitter, or is frequency modulated (FM), the VCO locks to the *mean* frequency of the input signal and generates a "clean" output at pin 4 or 5. This produces a demodulated FM output at pin 7. The 0.001 µF capacitor (C2) connected between pins 7 and 8 assures circuit stability.

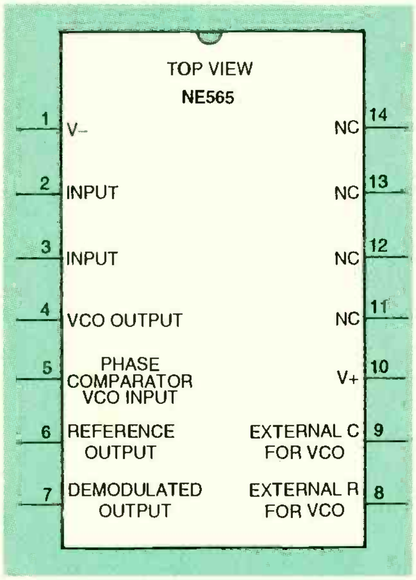


FIG. 2—PINOUT DIAGRAM of the NE565.

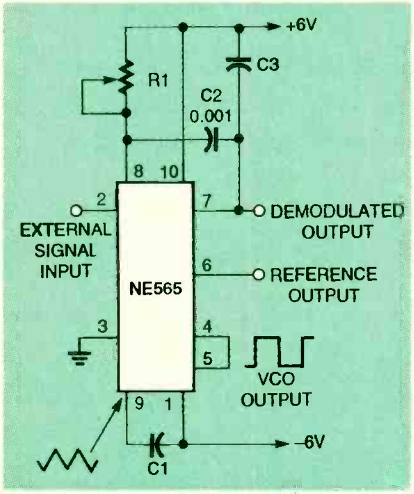


FIG. 3—EXTERIOR COMPONENTS for a signal trackerand FM-demodulator.

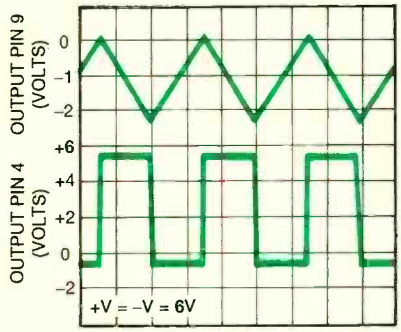


FIG. 4—VCO OUTPUT WAVEFORMS for the NE565 with a plus and minus 6-volt power supply.

NE565 characteristics

Table 1 summarizes the leading characteristics of the NE565. The IC is normally configured with a split (positive and negative) power supply, which must be between ± 6 and ± 12 volts, but it can also be powered by a single-ended +12 to +24-volt supply.

The phase detector section of the IC has a typical input impedance of 10 kilohms on each terminal. The IC can lock and track to input impedance of 10 kilohms on each terminal, and lock and track to input signals with amplitudes as low as 1 mil-

TABLE 1—ELECTRICAL CHARACTERISTICS OF THE NE565

Parameter	Min	Typ	Max	Unit
Supply voltage	±6		±12	V
Input impedance	5	10		kΩ
Input level for tracking	10			mVRMS
VCO Characteristics				
Center frequency		500		kHz
Drift with temperature		300		ppm/°C
Drift with supply voltage		0.2	1.5	%/V
Triangle wave				
Output voltage level	1.9	2.4	3	Vp-p
Linearity		0.5		%
Square wave				
Logic "1" output voltage	+4.9	+5.2		V
Logic "0" output voltage		-0.2	+0.2	V
Rise time		20		ns
Fall time		50		ns
Output current (sink)	0.6	1		mA
Output current (source)	5	10		mA
Demodulated output				
Output voltage level	4.0	4.5	5.0	V
Maximum voltage swing		2		Vp-p
Output voltage swing		200	300	mVp-p
Total harmonic distortion		0.4	1.5	%
Output impedance		3.6		kΩ
Offset voltage (pins 6 to 7)		50	200	mV
AM rejection			40	dB

livolt RMS. Normally, input signals should be AC coupled, but they can be DC coupled if the DC resistances seen from pins 2 and 3 are equal and there is no DC voltage difference between those pins.

The high stability of the NE565's VCO can be seen in its typical drift with temperature specification of 300 ppm/°C and its typical drift with supply voltage specification is 0.2% per volt when the supply voltage is ± 6 to ± 7 volts. Both of these values are measured at f_o.

The VCO provides well formed, TTL-compatible square waves and triangle waves, as shown in Fig. 4. Those waveforms were obtained with the IC powered by a split 12-volt supply. The square waves, with typical rise and fall times of 20 and 50 nanoseconds, respectively, appear at pin 4, and highly linear triangle waves appear at pin 9 of the VCO.

The VCO's free-running frequency (f_o) is set by trimmer potentiometer R3 in series with the +6-volt power source between pins 8 and 10 and by capacitor C1 in series with the −6-volt power source between pins 9 and 1. That frequency in kilohertz can be calculated as:

$f_o = 1.2/(4\ RC)$

where R is in kilohms and C is in micofarads.

Resistor R3 can have any value between 2 and 20 kilohms, but the optimum value is about 5 kilohms. Capacitor C1 can have any value. Normally, the NE565 will phase-lock to any input signal frequency that is within the range of plus or minus 60% of the f_o value. This is known as the circuit's *lock range*.

The output section of the IC yields a demodulated output at pin 7, and pin 6 gives a DC reference voltage that is close to the DC potential of pin 7. If a resistor is placed between pins 6 and 7, the gain of the IC's output stage can be reduced with with little change in the DC voltage level of the output. This allows the lock range to be decreased to a value as low as 20% of f_o, with little change in the f_o value.

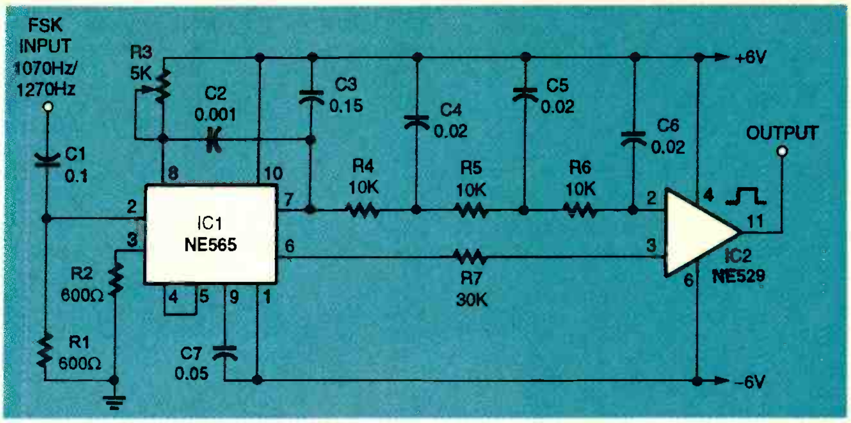


FIG. 5—FREQUENCY SHIFT KEYING (FSK) demodulator circuit.

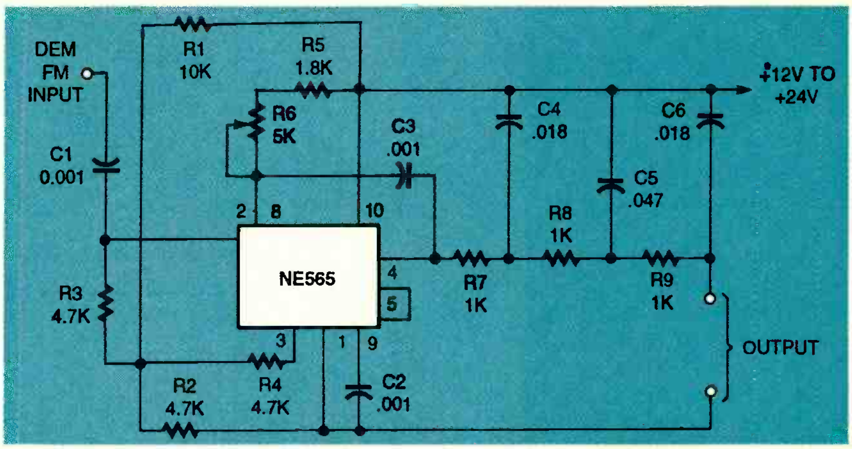


FIG. 6—60 kHz FM DEMODULATOR with a single-ended power supply.

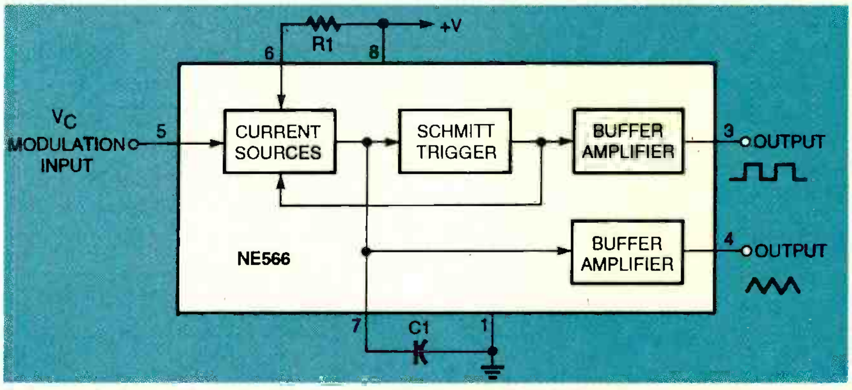


FIG. 7—FUNCTIONAL BLOCK DIAGRAM OF THE NE566 function generator.

FSK demodulator

Frequency shift keying (FSK) is widely accepted in digital communications systems. The transmitter generates a continuous two-tone carrier signal from binary signals with a *mark* or logic 1 state represented by one tone and the *space* or logic 0 state represented by another tone. An FSK decoder in the receiver converts the two-tone carrier back to a binary signal.

Figure 5 shows the NE565 (IC1) organized as an FSK de-

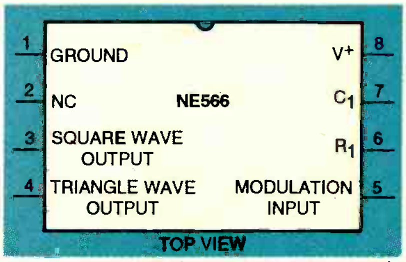


FIG. 8—PINOUT DIAGRAM of the NE566 function generator.

coder of a 1070-Hz to 1270-Hz input waveform. When the signal appears at the input, the loop locks to it and tracks it be-

TABLE 2—ELECTRICAL CHARACTERISTICS OF THE NE566

Parameter	Min	Typ	Max	Unit
Supply voltage	±6		±24	V
VCO Characteristics				
Maximum operating frequency		1		MHz
Drift with temperature		300		ppm/°C
Drift with supply voltage		0.2	2.0	%/V
Control terminal input impedance		1		MΩ
FM distortion(±% deviation)		0.4	1.5	%
Maximum sweep rate		1.0		mHz
Sweep range		10:1		
Triangle wave output				
Impedance		50		Ω
Output voltage level	1.9	2.4		Vp-p
Linearity		0.5		%
Square wave input				
Impedance		50		Ω
Voltage	5.0	5.4		Vp-p
Duty cycle	40	50	60	%
Rise time		20		ns
Fall time		50		ns

tween the two frequencies, with a corresponding DC shift at the output.

Loop filter C2 has a small value to eliminate overshoot on the output pulse, and a three-stage RC ladder filter removes carrier components from the output. This filter has a band edge that is approximately half way between the maximum FSK keying rate (300 baud or 150 Hz) and twice the input frequency (about 2200 Hz).

The NE529 (IC2) is a high-speed analog voltage comparator that combines a Schottky diode with two high-speed TTL gates and a precision amplifier on a monolithic chip. It is useful in analog to digital conversion and can act as an interface between TTL and ECL circuitry.

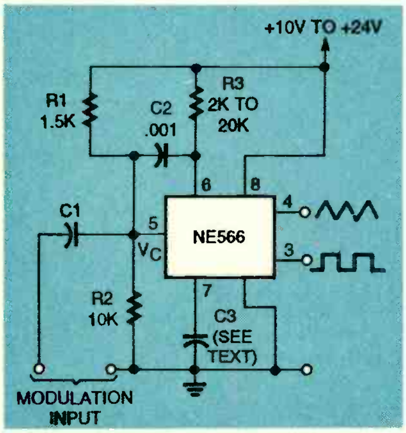


FIG. 9—FIXED FREQUENCY GENERATOR circuit based on the NE566 function generator.

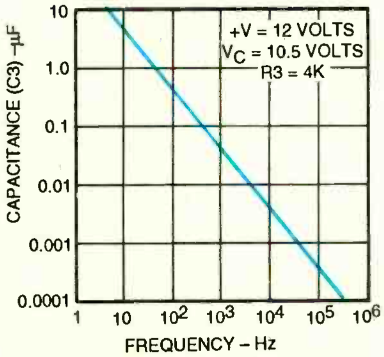


FIG. 10—GRAPH OF FREQUENCY as a function of capacitance for an NE566 when R3 = 4 kilohms.

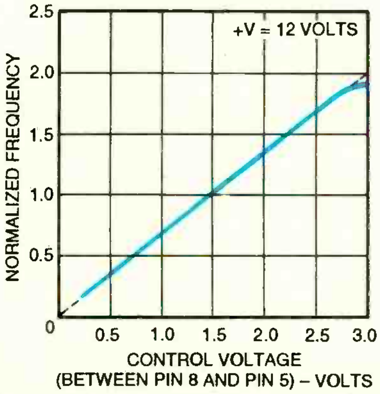


FIG. 11—GRAPH OF NORMALIZED frequency of the Fig. 9 circuit as a function of control voltage.

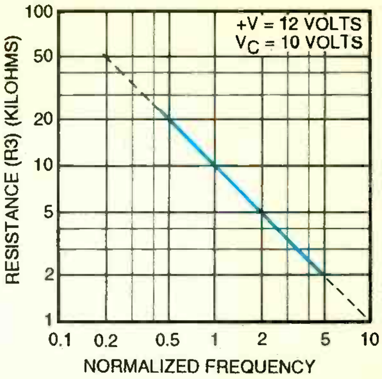


FIG. 12—GRAPH OF NORMALIZED frequency of the Fig. 9 circuit as a function of resistance R3.

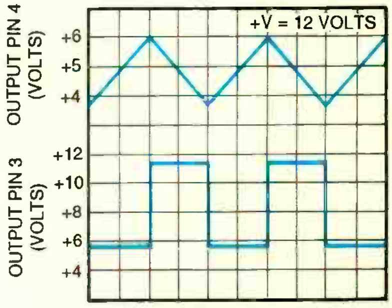


FIG. 13—GRAPH OF VCO OUTPUT waveforms for the generator circuit of Fig. 9.

An NE529 between pin 6 of IC1, the NE565, and the output of the circuit makes the output of the filter CMOS logic compatible. Adjusting trimmer potentiometer R3 sets the free-running frequency of the VCO to give a slightly positive output voltage when a 1070-Hz input signal is applied.

The input connection of the circuit shown in Fig. 5 is typical for applications where a DC voltage is present at the source, preventing a direct connection. Both input terminals are returned to ground with identical resistors. In this circuit, the values of resistors R1 and R2 were selected to give a 600-ohm input impedance.

Single-ended power

Figure 6 shows the NE565 configured as a 60-kHz FM demodulator that is powered from a single-ended 12- to 24-volt supply.

A resistive voltage divider (R1 and R2) and R3 and R4 apply a balanced bias voltage to input pins 2 and 3 of the NE565. The

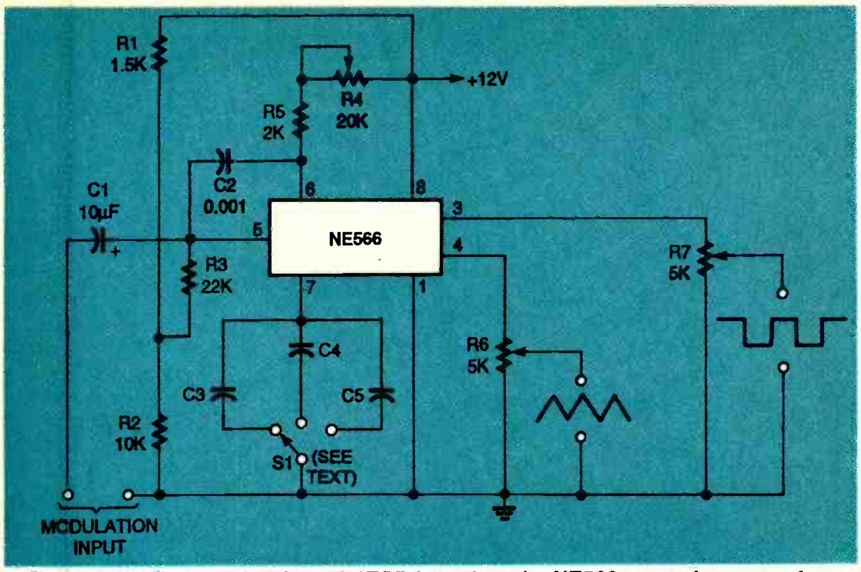


FIG. 14—THREE-BAND FM GENERATOR based on the NE566 general-purpose function generator.

60-kHz FM input signal is AC-coupled to pin 2. The VCO's free-running frequency is set to 60 kHz with R6, C2 and trimmer potentiometer R5. The decoded output signals are fed through a three-stage, low-pass filter to minimize the effects of unwanted noise on the signals.

NE566 fundamentals

The NE566, a general-purpose function generator, is a linear voltage-controlled oscillator capable of producing buffered squarewave and triangle-wave outputs, at fixed and variable frequwncies, up to a maximum of about 1 MHz. Its frequency of oscillation is determined by an external resistor and capacitor and the voltage applied to the control pin.

The oscillator can be programmed over a ten to one frequency range by the appropriate selection of an external resistance. It can also be modulated over a ten to one range by a control voltage. The NE566 finds applications in tone, signal, and clock generators, as well as FM modulators.

Figure 7 is a block diagram of the NE566. The principal blocks are current sources, a Schmitt trigger, and two buffer amplifiers. Two essential external components, R1 and C1, are shown. The VCO section consists of the pair of voltage-controlled current sources that linearly charge or discharge an external timing capacitor.

A linear triangle wave is generated across the capacitor and appears at pin 3, and a square wave generated at the Schmitt trigger switches the current sources when the capacitor voltage reaches preset levels. These waveforms are available at the output pins of the buffer amplifiers.

Figure 8 is the pinout diagram for the popular 8-pin plastic DIP package. The NE566 is, however, also packaged in a 14-pin DIP package. Table 2 lists selected electrical characteristics of the NE566. It can be seen that the impedance values for both the triangle-wave and squarewave outputs are a low 50 ohms.

Figure 9, a schematic showing the NE566 configured as a fixed-frequency FM waveform generator, shows the locations of the external components required for its functioning. Frequency is determined by resistor R3 with capacitor C3 and by the voltage applied to its control terminal.

Resistor R3 must have a value between 2 and 20 kilohms but capacitor C3 can have any value. The control voltage must be between ¾ and the full supply voltage.

The output frequency can varied or modulated over a ten to one range by variation of the control voltage. Capacitor C2, connected between pins 5 and 6, has a value of 0.001µF to stabilize the circuit.

The operating frequency of the NE566 is:

$$f_o = \approx (+V - V_C)/R3 \times C3 \times +V$$

Resistor R3 should be in the range of 2 to 20 kilohms.

Figure 10 is a graph of output frequency as a function of the values of capacitor C3 when R3 has a value of 4 kilohms. The frequency can be varied from 5 Hz with a C3 of 10µF to about 200 kHz with a C3 of 0.0001µF. Figure 11 is a graph of normalized frequency as a function of control voltage, and Fig. 12 is a graph of normalized frequency as a function of resistance R3. Figure 13 is a graph of VCO outputs of the circuit in Fig. 9 when the power supply is 12 volts.

Figure 14 shows a modification that can be made to the Fig. 9 schematic to convert it into a wide-range, three-band FM generator. The frequency can be altered by trimmer potentiometer R4, and three different frequencies can be obtained with selector switch S1 in series with C3, C4, and C5 in parallel and connected to pin 7 of the NE566. As stated earlier about Fig. 9, capacitor C3 can have any value, so C3, C4, and C5 can have values to give three different frequencies.

The voltage levels of the triangle-wave and squarewave outputs can be varied by trimmer potentiometers R6 and R7. Those waveforms can be frequency modulated by applying the modulation waveform to pin 5 through input capacitor C1. Resistor R3 raises the circuit's input impedance to its value of 22 kilohms.

The NE565 PLL and associated NE566 function generator are useful intergrated circuits to be familiar with. The circuits presented here should give you a working knowledge of the ICs' applications.

The final article in this series about PLL devices will describe the NE567, a highly stable phase-locked loop device. Although it is primarily used as a tone decoder, the IC has additional applications as well. Ω

TESLA COIL

continued from page 62

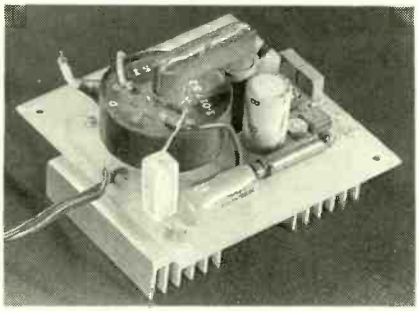
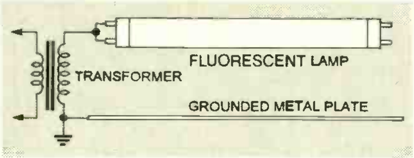


FIG. 3—THE PULSE GENERATOR can be built on a small piece of perforated construction board.



4—SUFFICIENT RF ENERGY is radiated to light small fluorescent lamps up to several inches away, without wires.

Construction and adjustment

Begin construction with the pulse generator. It can be built on a small piece of perforated construction board. After installing all components, verify all connections, and apply 12 volts to the circuit. Verify that a pulse train is present at pin 3 of IC1 with an oscilloscope. While examining the waveform at pin 3, determine that both potentiometers (R2 and R4) function correctly by changing both the on and off time periods.

If that circuit works satisfactorily, turn off the power, insert the components, and wire the remainder of the circuit. Leave the connections to the primary winding of T1 open. Apply power and examine the waveform on the collector of Q1 with an oscilloscope. Verify that the waveform is the same as that present at pin 3 of IC1, but inverted. (There might be slight rounding of the leading edges due to the capacitive effects of Q3.) Temporarily connect a 10-ohm, 10-watt resistor in place of the primary of T1. Verify that Q3 is switching the current on and off in sync with the signal at pin 3 of IC1.

If the circuit appears to be operating correctly, adjust R4 to produce an off time of about 10 microseconds (μs), and adjust R2 for an on time of 60 to 70 μs. Remove power and the temporary 10-ohm resistor. Connect T1 to the circuit and apply power, observing the current that the circuit draws. With all circuitry operating correctly, some corona should be visible on the high-voltage lead of T1, accompanied by a slight hissing noise. (There might also be a faint whistle from T1.)

Attempt to create an arc from the high-voltage lead of T1 with a grounded lead. The voltage should be high enough to strike an arc of over ½ inch inch. By adjusting R4, maximum voltage output can be obtained. Similarly, small adjustments to R2 will also affect output power. Figure 3 is a photograph of the author's prototype.

Applications

Many interesting experiments can be performed with this circuit. By attaching a small brass drawer knob to the high-voltage lead, sufficient RF energy will be radiated to light low-wattage fluorescent lamps up to several inches away, without wires (see Figs. 4 and 5).

The solid-state Tesla coil has enough power to drive decorative plasma lamps. By adjusting R2 and R4, various discharge patterns can be obtained. A modulating voltage on pin 5 of IC1 will modulate the output and create more interesting visual effects.

The low-current output of the solid-state Telsa coil is not an extreme hazard to healthy adults. However, the high-voltage output should still be treated with respect. The shock can be dangerous to people with heart problems. and the arc can easily start a fire. Ω

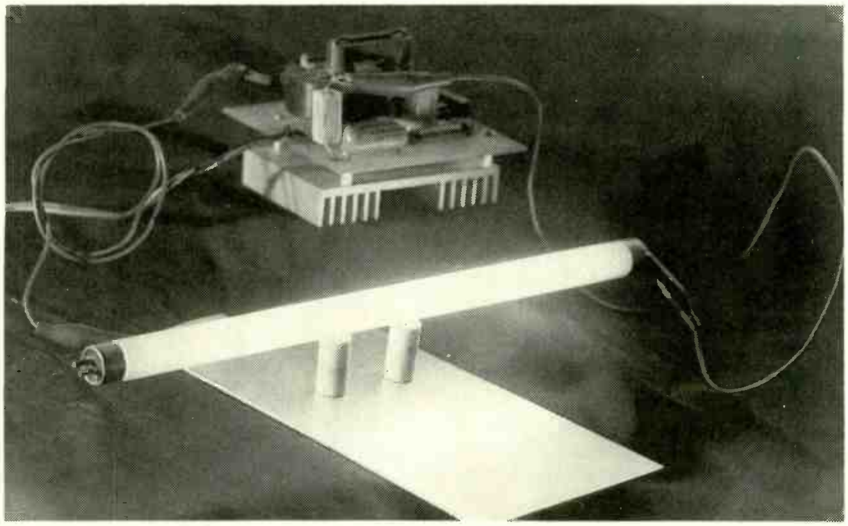


FIG. 5—THE FLUORESCENT LAMP lights above a grounded metal plate.

HARDWARE HACKER

More on dowsing, reprints and standards, using helical resonators, a scientific method review, and a new laser service manual.

DON LANCASTER

There sure were a lot of readers who responded to our recent dowsing contest. Several revealed detailed information on new controlled studies, all with highly negative results. Several others genuinely and truly believed in dowsing, but presented their cases on blind faith alone.

Check the *Skeptical Enquirer* issue 4-1 pages 16–20; 6-4 pages 34–37; 8-1 pages 138–140; and 15-3 pages 386–397 for a lot more negative evidence. Or see the *Untapped Technology in Review*, Spring 1994, pages 4–7, for a bizarre sampling of current pro-dowsing thought.

I thank all readers who sent me mountains of information on dowsing—virtually all of it is totally devastating to the dowsing cause. The Skeptical Enquirer will pay $10,000.00 cash to anyone who can use a dowsing rod to detect any buried flowing pipe in a properly controlled test.

There's also a dead wrong popular myth about finding water wells. As a spelunker, I can assure you that rapidly flowing underground rivers are *extremely* rare. A well simply taps into a *permeable* (or porous) layer above an *impermeable* (or solid) layer—something like a straw in a bowl of oatmeal.

Except near the *cone of depression* of an existing and flowing well, the water pretty much just sits there. *The usual flow rate is zero. Any* device (scientific *or* pseudoscientific) that searches for flowing water will be of no use in finding new wells.

Over the years, I've had lots of questions about those long distance electrostatic treasure finders. One industry expert dissected a $2500 unit and discovered less than $6 worth of surplus parts haphazardly arranged in a very simple and highly questionable circuit. Apparently they are nothing but high-tech coat hangers.

The intent is to make a dowsing rod look like an induction balance treasure finder. Their "unconditional guarantee" is simply to ward off the Federal Trade Commission.

Although I am a believer in the *scientific method*, this is *only* a belief system. With *any* belief system, some things are unknown and others stay inherently unknowable. Thus, you can *not* use the scientific method to disprove dowsing. All you can do is show that repeated tests fail, making any dowsing credibility more and more unlikely.

The scientific method

The scientific method is a belief system in which observed effects have underlying physical causes, and the relationship between cause and effect has rational mathematical *and* experimental bases to support it.

Typically, something has happened and you want to know *why*. Or you want to cause something to happen and you want to know *how*. In either case, you'll make an educated guess called a *theory* or a *premise*. You'll then attempt to perform the simplest possible lab experiment or else work out the simplest possible mathematical

HP MANUAL	HP PRINTER	APPLE PRINTER	QMS PRINTER
02686-90920 (CX Engine)	LaserJet I	LaserWriter LaserWriter Plus	PS800 Smartwriter 80+
33449-90906 (SX Engine)	LaserJet II LaserJet III	LaserWriter NT LaserWriter NTX LaserWriter F LaserWriter G	PS810 & Turbo PS820 & Turbo PS815-MR PS825-MR
33459-90906 (SX Engine)	LaserJet IID LaserJet IIID	----	----
33481-90951 (LX Engine)	LaserJet IIP	Personal LW NT Personal LW NTR	PS410 PS420
C2010-90939 (NX Engine)	LaserJet IIIsi LaserJet IVsi	----	----
C2001-90940 (EX Engine)	LaserJet 4 LaserJet 4M+	LaserWriter 600 LaserWriter 630	----
C2005-90988 (PX Engine)	LaserJet 4ML LaserJet 4MP	----	----
---- (BX Engine)	----	(Fall 1994)	Hammerhead 860

FIG. 1—HEWLETT-PACKARD MANUALS are helpful in repairing most popular laser printers from dozens of manufacturers. Here's the latest update.

analysis that will test your theory for accuracy. This is known as a *model*. The purpose of your model is to get the intended effect to show up consistently.

Then you tell others about your results, and invite them to duplicate them. Should enough independent outsiders duplicate the results repeatedly, the theory is upgraded to "law" status. A law is just some theory that nobody has been able to disprove.

For the scientific method to work, there has to be a *balance* between lab experiments and math theory. Too much of either will *always* be suspect. Underlying *hidden variables* or *alternate causes* must be eliminated. All of the observed effects also must obey the statistical laws. Just because something happens once is not proof. It has to be repeated many times until the results are beyond a shadow of a doubt.

One of the things that pops up over and over again when using the scientific method is that many effects obey a *square law*—that is, they drop off rapidly with respect to distance. In most radar detection or treasure-finding situations, both the illuminator and the target emissions drop off in accordance with a square law. The sensitivity of these systems drops off as the *fourth power* of distance.

Another unavoidable aspect of the scientific method is the *noise floor*. There is a certain limit below which events are unobservable. It is caused by inherent sources of interfering signals that are stronger than those one is trying to measure. One example is the thermal emission noise inherent in anything that's not at a temperature of absolute zero.

Certain techniques can be performed to reach well down into noise, such as filtering, integration, or correlation. But the noise floor will *always* set an ultimate limit.

Enter Heisenberg and Company

The bane of the scientific method is an even more fundamental "gotcha" known as the *Heisenberg Uncertainty Principle*. This principle states that *you cannot measure something without disturbing it*. At the lowest level, if you try to extract information from a system, you alter its condition.

Let's look at two wildly different examples. Say you want to verify Ohm's law by measuring the current through a 2.2K resistor. It seems simple enough—just apply a one-volt source and then look for a value like a 455-microampere current. But even with this "pure physics," you can easily get into lots of trouble. Why? Any current-measuring device has a voltage drop across it, and any voltmeter draws current. They cause inherent instrumentation errors.

Dissimilar contacts generate thermocouple voltages. The resistor might be photosensitive. Power line hum or the local radio signals might be getting into the measurement. You might have forgotten to calibrate or ground your oscilloscope probe. Or other energy sources might cause transient currents. Even your test current can cause a *self-heating* effect that shifts values. Somebody might have painted the wrong stripes on the resistor, or you might be color blind.

Thinking "positive psychic thoughts" about your resistor is unlikely to change the results. But trying to please your boss just might—as might trying to get through your school lab report or daydreaming about a giant clockwork armadillo instead. But all this is largely manageable, one way or another..

Suppose, instead, that you want to prove that *L-Carnitine* is a cheap and safe cure for heart disease. Now the uncertainties and the hidden variables get ugly in a big hurry.

Most psychic effects tend to be highly controversial. But one psychic phenomenon that has strong proof of its validity is the *placebo effect*. It has been observed time and time again that a patient who wants to get well and who feels that he or she is taking positive steps toward that goal is significantly more likely to do so. But just watching someone taking L-Carnitine won't work. Chances are the patients are taking other stuff too, or they are doing other things that'll make their problem better or worse.

So, for the scientific method to work here, you have to do *double blind testing* of thousands of patients in which neither the patient nor the doctor knows whether the real medicine or a placebo is being used. Actual selection has to be done on a totally random basis by a third party. Otherwise, unavoidable visual clues and other hidden variables will trash the test results.

Similarly, the only credible way to raise or lower the apparent validity of dowsing or any other psychic effect is by large-scale double-blind testing. All of the dowsing tests I know about seemed to have failed.

Once again, it is not fair to discredit anything you know nothing about. But from all of my research to date and from what you've told me, dowsing appears to be an outright scam. The "dowsing reaction" appears to be something the dowser wants to see happen, or else it is a chaotic effect.

A correction or two

Whoops. I apparently said some things that were just plain wrong two issues ago in my transmission line story. Here are the correct statements. A *shorted* transmission line will appear as a short circuit at zero length, as an open at *one quarter* wavelength, and back to a short at *one half* of a wavelength, neglecting losses. The line will appear to be inductive at *less* than one-quarter wavelength and capacitive at *more* than one-quarter—but less than one-half—wavelength.

Note that a round trip on a quarter wavelength stub is actually one half of a wavelength long, and that any short circuit inverts reflections.

An *open* transmission line appears as an open at zero length, as a short circuit at *one quarter* wavelength, and back to open again at *one half* of a wavelength. The line should appear capacitive at *less* than one-quarter wavelength and inductive at *more* than one-quarter wavelength. These changes have been picked up in HACK79.PS on *GEnie* PSRT.

New laser training manual

Don Thompson has just released his new volume on *Mastering Laser Printer Service*. It contains detailed step-by-step technical information on repairing all of the *Canon* series "engines" used in the most popular printers from *Apple*, *Hewlett-Packard*, *QMS*, and others.

You'll find hundreds of pages of proprietary "from the trenches" information in Thompson's book that's not available elsewhere. It includes such insider secrets as the zero cost cure for those flaky connectors on the SX engine, rapid repair shortcuts, and much more. There is also information on running your own repair service.

I particularly like the dozens of printouts of the actual page problems and his unique pie-chart method of breaking down probable causes. All of it is based on thousands of real-world case histories.

As a small sample of its contents, Fig. 1 shows a listing of the little known Hewlett-Packard manuals that are handy for repairing most laser printers from any source. Any and all of these can be ordered from *Hewlett-Packard Manuals*.

Don Thompson's book is not cheap, but his company has set up a special offer for *Hardware Hacker* readers. Contact him directly for further details.

Helical resonators

Above 100 megahertz, conventional coils and capacitors create design problems. Stray capacitance and inductance often dominate, and unwanted coupling occurs. The Q values tend to drop off and stability degrades.

The usual solution is to go to some *distributed* network in which the inductance and capacitance is "spread out" rather then being concentrated in distinct lumps. If the network can be self-shielding, so much the better.

A *cavity* is the stock solution at microwave frequencies. A cavity is simply any *conductive enclosure*. A cavity can resonate at many possible frequencies. Field equations explain cavities in any situtation in which an E-field is *across* a conductor or an H-field is directed *into* it, a conductor will resonate.

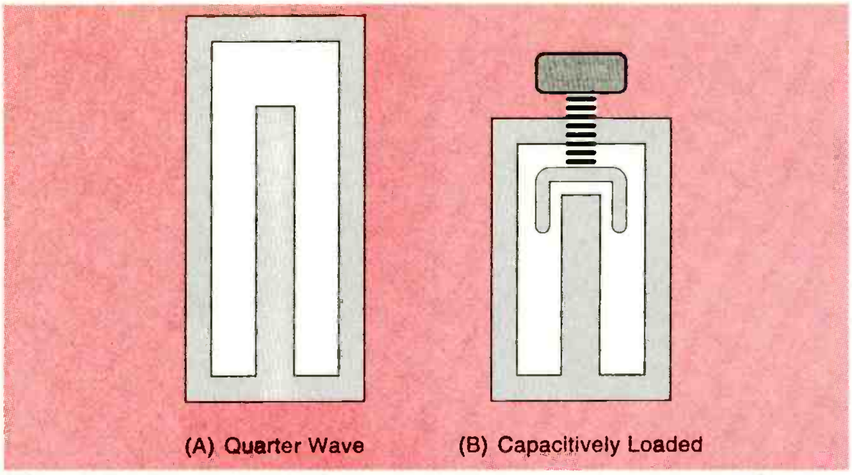


FIG. 2—A CAVITY is any conductive enclosure that can support resonance. These are common at microwave frequencies. Energy can be coupled in or out with magnetic loops, electric probes, or electron beams. Here are cross sections of two examples of simple coaxial cavities.

Normally, you use the simplest and most obvious solutions to the field equations. These are called *low order resonance modes*.

Figure 2-*a* shows a *coaxial* cavity. It is a sealed cylinder that has coaxial rod inside it. If the rod is precisely a quarter wavelength long, it can support resonant energy, with resonant current at a maximum at the shorted bottom and resonant voltage at a maximum at the open top.

The resonant frequency depends on the length of the rod. The Q is determined by surface conductivity and the diameter ratios. In general, the larger the cavity and the better its surface conductivity, the higher its Q. One-piece cavities machined from solid blocks are usually better than built-up ones.

In Fig. 2-*b*, the cavity is *capacitively loaded.* That results in a more compact size and a tuning option. Sometimes a plain old machine screw or two is all you need for tuning. Other times, a variable capacitor or varactor diode will be used.

Energy can be coupled into or out of a cavity in several ways. A wire loop can be used for *magnetic* or "H-field" coupling, or a wire probe can be used for *electric* or "E-field" coupling. Simply leaving a hole in the side of the cavity will also let energy in or out. Carried to an extreme, a very long cavity intended to move energy is called a *waveguide*.

The position of the probe or the size of the hole defines the ratio of unloaded versus loaded Q and thus the bandwidth of the resonator. The low-frequency equivalent would be a tap on a coil.

Cavities are temperature- and humidity-sensitive. Temperature can be compensated by the choice of the cavity base metal, and the addition of a small bellows, or by purposely adding components whose temperature drifts are in the opposite direction. Active automatic frequency control feedback is another temperature compensation solution. The best base material is *Invar*, which has a near-zero temperature coefficient. One way to avoid humidity problems is to hermetically seal the cavity in a vacuum or dry nitrogen.

The Q of a cavity is very sensitive

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to the conductivity of its walls. While hardware hackers might get by with soldered printed circuit boards, the highest Q cavities should be gold- or silver-plated. Q values of several thousand are easily met.

Microwave oven magnetron RF oscillators have a cavity, as do many radar speed detectors. In fact, just about all microwave applications include one or more cavities. But for VHF and UHF frequency operation, cavities are big and expensive.

Enter the *helical resonator*, stage left. It's a cross between cavities and discrete L-C circuits. It is a cheap and effective device for everything from improved FM reception to ham television and wireless cellular phones.

Figure 3 shows a helical resonator. All you do is take an ordinary coaxial cavity and twist its center conductor, making a helix out of it. The final size is a lot smaller this way, and tuning can still be done with a variable capacitor.

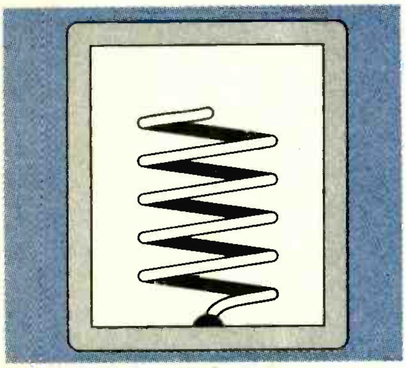

FIG. 3—THE HELICAL RESONATOR is a cavity variation that is more suitable for VHF and UHF. They can be easily made from wire and printed circuit board stock.

You do *not* just have a plain old series inductive capacitive circuit here. Most of the resonating capacitance is obtained from coil to wall spacing in a distributed and time-sensitive transmission network.

Figure 4 shows a two-stage helical filter. Energy is coupled into the first stage from a suitable tap, something like an impedance step-up transformer. A "hole in the wall" can provide interstage coupling, and energy is finally tapped out of the second stage. The size and the other details vary according to what you want the filter to accomplish.

You could easily make your own helical resonators from soldered printed circuit boards and heavy wire. Avoid any supports on the "hot" end of the helix as they will dramatically lower the Q. Fancy math might be needed for the design, and some experimentation.

More information on cavities in general appears in *Reference Data for Radio Engineers*, the *Radio Engineer's Handbook*, and in most microwave texts. One source for surplus cavities is *Fair Radio*.

The "horses mouth" paper on the helical resonators showed up in the December 1959 *Proceedings of the IRE*. Reasonably priced helical filters are manufactured by *Toko* and stocked by *Digi-Key*.

Please let me know if you find any newer and readable papers on helical filter and resonator designs. A free *Incredible Secret Money Machine II* for your trouble.

Resource resources

I just got a new UMI (formerly *University Microfilms*) catalog, so I decided it is high time to gather the most significant of my fundamental research tools into one sidebar. UMI is *the* place to go for hard copies of almost any magazine story or journal paper. Sadly, the free *Interlibrary Loan* services of many libraries are being discontinued, and others seem to be slower and unreliable. UMI is now associated with *The Information Store*, and it sells all the "hard to get" information such as standards or conference records.

Major standards associations were listed in *Hardware Hacker II* and in HACK47.PS on *GEnie* PSRT. Another place to pick up standards is *Global Engineering Documents*.

I have mentioned the *Ulrich's Periodicals Dictionary* before as the single most important Hacker resource ever. Its competition is the *International Standard Periodicals Dictionary*.

Other library resources include the *Encyclopedia of Associations*,

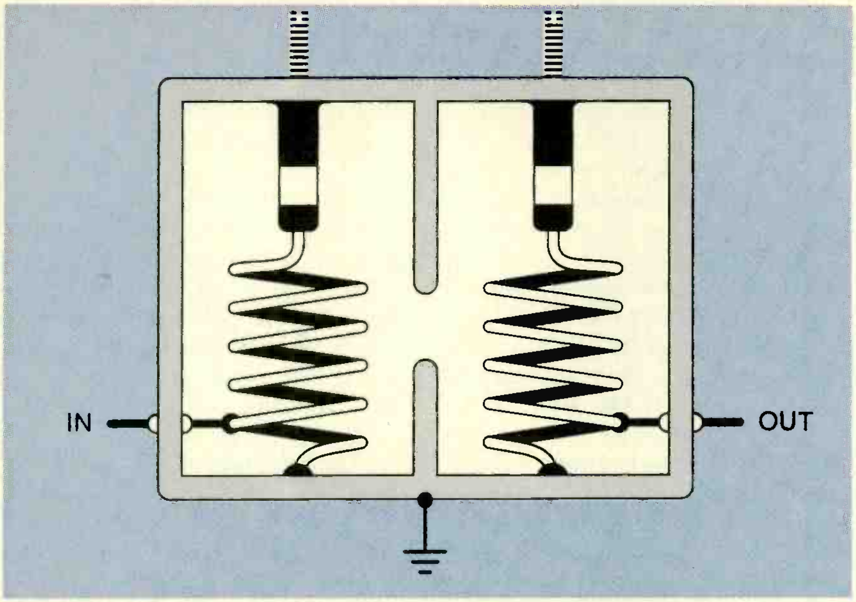

FIG. 4—A TWO-STAGE FILTER made from helical resonators. Energy is coupled between resonators by the hole in the wall. The input and output taps serve as impedance step-up and step-down transformers.

the *Thomas Registry of Manufacturers*, *Books in Print*, and the *Science Citation Index*. That index lets you move *forward* through time, finding newer and newer material as you go.

The major publishers of reference directories are *Gale*, *Oxbridge*, and *Bowker*. Check any library.

My favorite online resource to find out *anything* from *anywhere* is the *Dialog Information Service*. It is now available 24 hours a day as a *GEnie* service. It has a surcharge-free Dialog practice area. Dialog is the broker for hundreds of information sources. Three sources of major interest to hardware hackers are INSPEC, MATHSCI, and COMPENDEX.

And then there is the Internet—all zillion terabytes of it. Chances are you can instantly talk to an expert, once you figure out *which* of those zillion terabytes to access. Lots of very informative Internet guides are now available.

Of the alternative resources, my two favorites are *Rex Research* for pseudoscience stuff, and *Factsheet Five* for little-known reviews. The *KeelyNet BBS* is another weird and wondrous pseudoscience resource. If you have any research favorites of your own that I haven't mentioned, please be sure to let me know about them, so that I can let others know about them.

New tech lit

Philips has a fat and free new *80C51 Application Notes* manual. *Samsung* has free samples of its new *microMOSFETs*. These are very small high-current switches.

New lasers that literally could be *painted* onto almost any substrate are detailed in the *Photonics Spectra* for August 1994, pages 119–124. A good bibliography is included in it.

Computer Video is a brand new trade journal from the *Radio News* folks. It's free, and has a surprisingly good mix of technical information. Two leading sources for most video products are *B&H* and *Markertek Video Supply*.

Loose Change is a magazine for slot-machine restorers and rebuilders from the *Mead Publishing Company*. It also has lots of *Pictorial*

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Guide repair manuals for popular vintage slot machines. Most states now allow private ownership of classic slot machines as antique collectibles. But check first.

Stupendously major breakthrough! I finally found out where to go for *real* steam calliopes! Check out the *Rough and Tumble Engineers Historical Association* in Kinzers, PA. They have year-round events. Meanwhile, modern replica air calliopes remain available from *Ragtime*.

The *Neon News* is a newsletter for the neon sign trade. Many thanks to Steve Hansen for this information. As I've said before, Steve publishes the *Bell Jar*, a superb labor-of-love newsletter on homebrew high vacuum.

For the insider secrets on forming your own technical venture, check into my *Incredible Secret Money Machine II*. It's also available as part of my *Lancaster Classics Library*.

A reminder that electronic reprints of all my columns, along with instant technical help, are now offered on *GEnie* PSRT. I've managed to arrange ten free *GEnie* hours for your use as indicated in the help box. Free catalog requests and technical questions you want answered here or on PSRT can also be sent to me via E-mail at my SYNERGETICS@GENIE.GEIS.COM Internet address.

As usual, most of the resources I've mentioned appear in the *Names & Numbers* or the *Resource Resources* sidebar. Be sure to check those two sidebars first before you decide to call our no-charge technical helpline. Ω

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Electronics Paperback Books

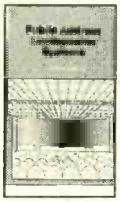
☐ **#226—How to Build Advanced Short Wave Receivers...$5.75.** Practical construction details of a number of shortwave receivers which should have levels of performance at least equal to that of commercially built sets of similar complexity. Also included are a number of add-on circuits, such as, Q-multiplier, S-meter, noise limiter, etc., which can be used to aid and improve the listener's shortwave reception.

☐ **BP321—Circuit Source-Book 1...$6.50.** A collection of over 150 analog-signal circuits on audio signal and power amplifiers, DC amplifiers, signal filters (high-pass, low-pass, band-pass and notch), tone controls, voltage-controlled amplifiers and filters, triggers and voltage comparators, gates and electronic switching, bar graphs, mixers, phase shifters, sensors, digital circuits, etc. (See BP322 at right)

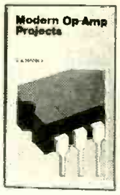
☐ **BP322—Circuit Source-Book 2...$6.50.** Contains over 170 circuits on signal generation, power supplies and digital electronics. A continuation of BP321. Topics are: 555 oscillators, sinewave and function generators, CMOS oscillators, voltage-controlled and RF oscillators, (555, TTL and CMOS) monostables, precision long timers, power supply and regulator circuits and many other useful circuits. (See BP321 at left.)

☐ **PCP108—Computers and Music...$9.95.** The text leads you through the topics on computers and music software. Learn how to choose the right components for a system to suit your personal needs and fully equip yourself to exploit that system.

☐ **PCP109—Everyday Electronics Data Book...$10.00.** An invaluable source of electronics information—the text contains many sections that deal with the underlying theory of electronic circuits and a wide range of practical electronic applications.



☐ **BP292—Public Address Loudspeaker Systems...$6.95.** Covers the moving-coil loudspeaker, baffles, the basic requirements of a PA system, sound patterns, line-source, horn loudspeakers, low-impedance matching and much more.

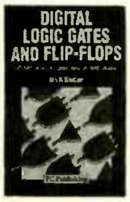


☐ **BP106—Modern OpAmp Projects...$5.75.** Various projects that make use of operational amplifiers available to hobbyists. Text includes low-noise, low-distortion, ultra-high input impedance, low slew-rate and high current types.

☐ **BP245—Digital Audio Projects...$5.95.** Practical details of how to construct a number of practical projects. All should be of interest to most audio and electronic music enthusiasts. Some of the projects are: oscilloscope storage circuit, A/D converter, negative supply, input amplifier, low-noise microphone preamp, compressor and expander circuits, input mixer, echo effect circuit, and others.

☐ **BP301—Antennas for VHF and UHF...$6.00.** From installing a TV or FM antenna to setting up a multi-antenna array for shortwave listening or amateur radio, this book explains the essential basics of antenna operation and installation. The text describes in easy-to-understand terms the necessary information about how antennas work, the advantages of different types, and how to get the best performance.

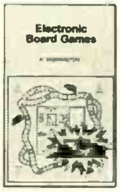
☐ **PCP105—Make Money from Home Recording...$10.00.** Start earning money after you spent a "fortune" on all that professional recording gear, MIDI and all. Here's the book that tells you how! Whether you have a fully fledged recording studio at home, or just a couple of stereo cassette recorders and a microphone, you'll be able to put the ideas presented in this book into immediate practice and make money.



☐ **PCP107—Digital Logic Gates and Flip-flops...$10.00.** Establishes a firm foundation in digital electronics by covering gates and flip-flops thoroughly. Topics such as Boolean algebra and Karnaugh mapping are explained, demonstrated and used.

☐ **BP277—High Power Audio Amplifier Construction...$6.25.** Practical construction details of how to build a number of useful audio power amplifiers ranging from about 50 to 400 watts rms. Text includes MOSFET and bipolar transistor designs.

☐ **BP176...TV-DXers Handbook...$7.95.** The text includes many units and devices that have been designed and used by active enthusiasts, and often, considerable ingenuity and thought have gone into the development of such units to overcome problems.



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☐ **BP310—Acoustic Feedback—How to Avoid it...$6.25.** Feedback is the bane of all PA systems. Much of the trouble is often the hall itself, not the equipment, but there is a simple and practical way of greatly improving the acoustics. Determine which microphone to use. Select the correct loudspeaker system. Includes info on equalizers, frequency-shifters and notch- and twin-notch filters.

☐ **PCP106—Synthesizers for Musicians...$10.00.** Written especially for musicians, the book explains all current popular forms of synthesis, covering LA, additive, phase distortion, FM and sampling. The theoretical side of synthesis is treated in an easy to understand way; the technical information being restricted to what you need to know to use your instrument effectively. Ideal for beginners and muscians.

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WHAT'S NEWS

continued from page 4

more efficient use of silicon than in conventional programmable logic device (PLD) fabrication and promises higher gate counts per unit area.

The more efficient use of silicon is expected to permit Xilinx to sell FPGAs at half the price of comparable conventional PLDs because less silicon is used. Alternatively, the new process will permit more than twice the number of gates to be placed on a die than is possible with existing SRAM- and EPROM-based fabrication methods.

The Xilinx MicroVia antifuse layer of amorphous silicon sandwiched between two metal conductive layers can be added to the standard CMOS logic wafer with only a few additional processing steps. An antifuse forms a permanent conductive connection to organize the gates for a specific application in contrast to a *fuse* in programmable PROMs which is opened or "burned" to break existing connections between gates to achieve the same circuit.

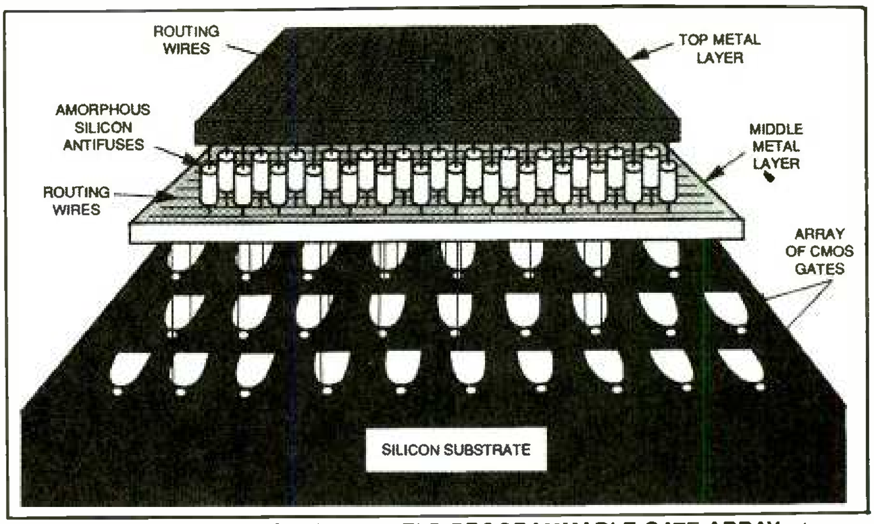


FIG. 2. A THREE-LAYER, STACKED, FIELD-PROGRAMMABLE GATE ARRAY economizes on silicon. Current programmed to flow through the amorphous silicon antifuse layer forms permanent connections that dedicate the array of CMOS gates for a specific application.

Xilinx reports that it has made test memories and other structures with its MicroVia metal-to-metal antifuse structure, three-layer-metal CMOS process, and sea-of-gates technologies. For example, a 6000-gate FPGA based on the new technology has been undergoing evaluation

Continued on page 92

AUDIO UPDATE

Directional hearing: New data indicate that sensing the source of a sound isn't a psychoacoustically simple exercise

LARRY KLEIN

I think we can credit Darwin's natural-selection process for our sense of aural directionality. The ability of our remote ancestors to detect the precise direction from which a saber-toothed tiger was coming (as a guide to the direction they should be going) contributed significantly to our species' survival. The ability to localize sound contributed to the survival of many other species as well.

Human sound localization has been under study since about the middle of the 19th century. Ultimately, it became clear that we use the differences between the sounds reaching our two ears to derive our perception of directionality. English physicist Lord Rayleigh (1842–1919) was the first to determine that a sound coming from the far right or left is significantly more intense in the ear closest to the sound source. ("Significant" means that the sound pressure level, or SPL, difference provides sufficient raw material for the brain to work with.)

The SPL difference is easy to explain: The listener's head partially deflects and/or blocks the impinging sound wave from reaching the far ear. This holds true mostly for the high-frequency sounds. As the frequencies of the oncoming sound waves become lower, and their wavelengths become longer, the shadowing effect of the head diminishes.

At very low frequencies the wavelengths are long enough so that head blockage is no longer a factor, and the intensity differences disappear. For the higher frequencies, however, the intensity difference—Rayleigh called it the "binaural ratio"—continues to provide a basic clue for localization. For this and other work in the physics of sound, Rayleigh won a 1904 Nobel Prize.

Time vs. intensity

Rayleigh subsequently determined that aural localization does not depend on intensity alone. Sounds whose source is "off-axis" are not only stronger at the closer ear, but also arrive earlier. The significance of sonic-arrival time was investigated in another series of ingenious experiments using precisely calibrated tuning forks—a favorite laboratory instrument of the early psychophysicists. Rayleigh concluded that interaural phase differences—or arrival-time differences—also contribute significantly to localization.

It wasn't until the 1930s that things finally got fully sorted out. Present understanding is that localization is achieved by differences in both time of arrival and sound pressure. (There is some evidence that interaural frequency-response differences caused by head diffraction and external-ear shape assist the localization process, but the present view is that the contribution is small, no matter how large the head or misshapen the ears.)

The ear/brain's arrival-time sensitivity begins to roll off at about 1,200 Hz. However, SPL localization doesn't appear to be fully operable until 4 kHz or so, which leaves an ambiguity gap centered at about 3 kHz. This should not be cause for concern, however, because predatory muggers (and performing musicians) can be localized by the wide sonic spectrum they generate.

Two cues

There's a good reason why your

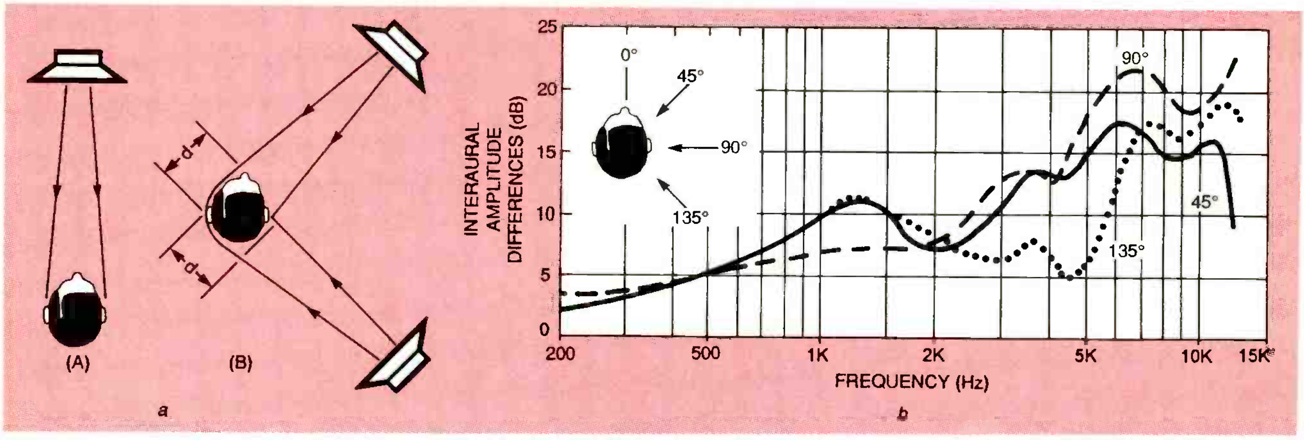


FIG. 1. THE IDENTICAL PATH LENGTHS TO THE EARS are shown at left (a). This localizes the sound source as either directly in front of or directly behind the listener. The brain uses interaural differences (d) shown at (b) to localize off-axis sound sources. At right, interaural differences in signal strength are charted for three off-axis sound sources over the range 200 to 12,000 Hz.

ear/brain mechanism uses (actually, needs) at least two different cuing mechanisms for localization. In general, differences in arrival times are used to localize the lower frequency sound sources, and differences in level are used to localize the higher frequencies. For wavelengths of high- to mid-frequencies, where your head is an acoustic barrier, the difference between the ears is something like 30 dB at 10 kHz, 16 dB at 5 kHz, falling to about 7 dB at 1 kHz.

When the frequency is low enough (i.e., the wavelengths are long enough), the head no longer runs interference and essentially the same signal level is heard by both ears. However, you still sense the arrival time differences, or phase, between the signals reaching your two ears—which is about 0.6 millisecond from a source that is located fully on one side of the head or the other. This information provides the data that is needed for localization.

Below 200 Hz or so, when the wavelengths get very long, arrival-time differences also begin to disappear and directionality begins to disappear as well. That, by the way, explains why the sound from subwoofers is nondirectional.

We generaly understand what happens to sound-pressure waves as they travel through the ear. However, once the "sound" signals reach the cochlea, the spiral-shaped organ lined with hair cells, things get really complicated. Those hair cells are complex mechanical-electrical transducers that convert sound vibrations into microvolt-level electrical signals. Those signals are sent to the mid-brain via the axons in the eighth cranial nerve. (I previously discussed the signal-generating hair cells—and their susceptibility to noise damage—in the December 1992 column.) This description of the hearing-localization process is accepted by psychoacousticians, albeit with certain cavils and reservations.

Aural potentials

Historically, research into the hearing process has always consisted of providing auditory stimuli and then asking subjects what they did or didn't hear. (Hearing aids, for example, are fitted by that process.) But things are changing rapidly. Today's psychoacoustic researchers have a new and sophisticated group of investigative tools. The ability to tap into the microvolt potentials in the inner ear and brain has opened up vast new areas of investigation and discovery.

Dr. John C. Middlebrooks from the University of Florida's Brain Institute recently published his new findings in *Science* magazine. He showed that the auditory system has evolved "coding strategies" that work differently from our other sensory systems. Moreover, the auditory cortex of the brain, where sounds are interpreted, contains a population of cells unlike any others in our nervous system. The special cells in the cortex working on the auditory information processed and forwarded by our right and left inner ears can differentiate and respond specifically to sounds arriving anywhere in the 360° of space around the body!

By placing electrodes in the brains of anesthetized cats, Dr. Middlebrooks found cells that fire differently when sounds arrive from different directions. If a sound comes from a given distance, say 10 feet to the left, the cell will fire in one pattern. As Dr. Middlebrooks put it, "It might go dit, dit, ditty, dit." Sounds originating from a different direction might produce a "ditty, ditty, dit" response. In effect, the research indicates that single neurons can encode sounds from every direction. None of the other brain cells that respond to sensory input from the external world operate in precisely that way.

Does Dr. Middlebrooks' work represent a breakthrough in our understanding of the sound localization process? Perhaps, but I suspect that it simply adds another (if somewhat surprising) bit of data to our still limited understanding of the complexities of aural perception. In any case, we can thank Mother Nature that the stereo hearing facility of our simian ancestors contributed to their survival in a world of long-toothed predators—even if they didn't know how it worked. Ω

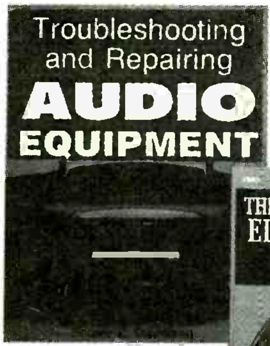
VIDEO NEWS

continued from page 6

gramming is in letterbox proportions. Europe's proposed analog HDTV system has already flopped—broadcasters opposed it and governments refused to subsidize it. Although there is much talk about developing a digital HDTV system there, it's noteworthy that a new battleground is developing over widescreen broadcast technology—not high definition. As reported in this column, broadcasting in PALPlus has already started and PALPlus receivers are on sale. The PALPlus system restores letterboxed transmissions to full definition (but not high definition) when received on specially equipped sets.

However, the BBC has now adopted a program to develop digital widescreen broadcasting, with tests due next year and regular service to begin in 1997. The BBC system isn't expected to be high-definition—just widescreen. Meanwhile, a British commercial network has been granted a contract by the European Commission and a TV set manufacturer to broadcast at least 500 hours of widescreen PALPlus by the end of 1995. The arguments on PALPlus vs. digital widescreen are increasing in the U.K. In favor of PALPlus is the fact that the broadcasts are compatible with existing television—conventional sets display the picture with a black band above and below—as opposed to the BBC's planned digital broadcasts. The BBC says, in rebuttal, "We do not wish to impose letterbox viewing on unwilling viewers, as is necessary with PALPlus." Ω

You're right—that's the most powerful TV projector I've ever seen!



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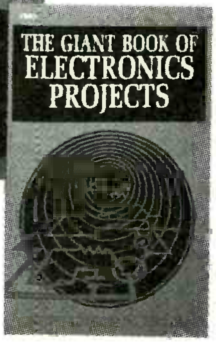

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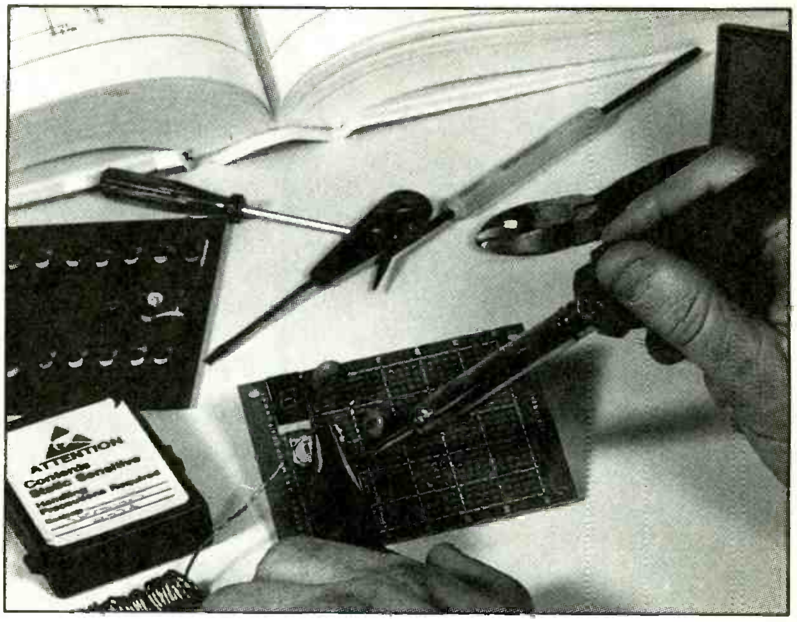

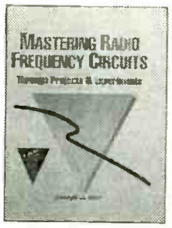

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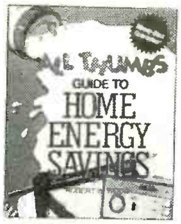

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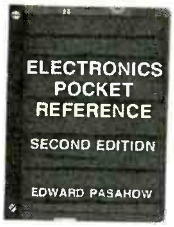

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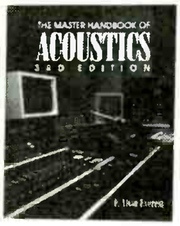

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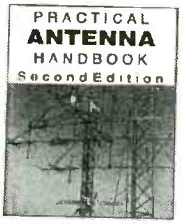

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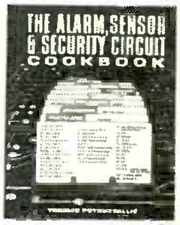

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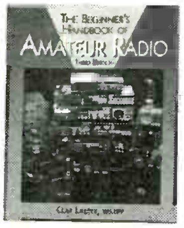

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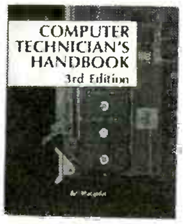

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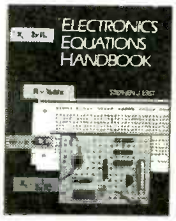

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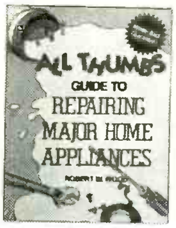

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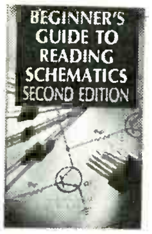

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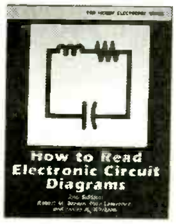

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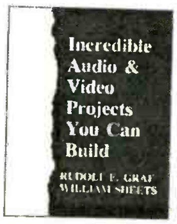

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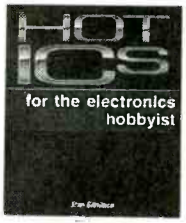

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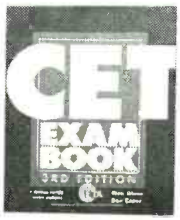

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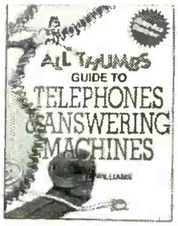

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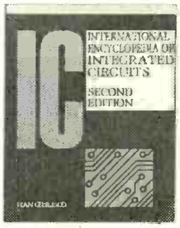

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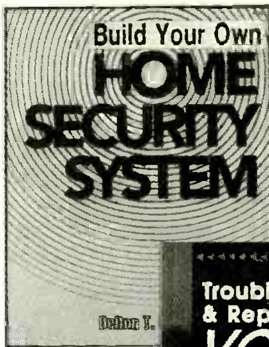

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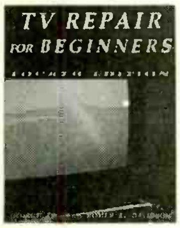

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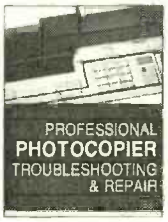

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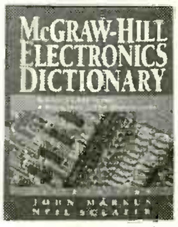

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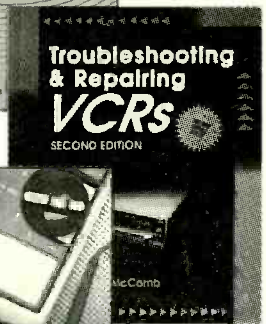

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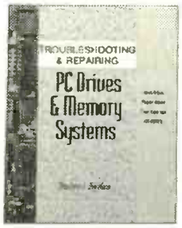

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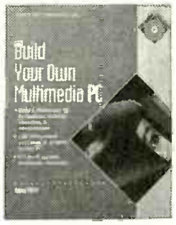
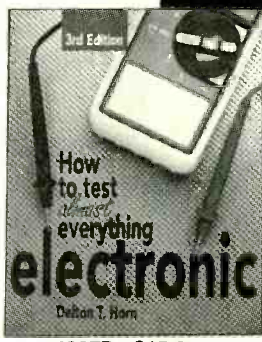


4503P-XX $36.95
Counts as 2



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DRAWING BOARD

Completing the tachometer's spark-counter section.

ROBERT GROSSBLATT

You always have to make compromises between theoretical circuit performance and practical circuit construction. That's what happened last month when I was working out the details of the spark counters. While more bits mean more accuracy, they also mean greater circuit complexity. However, the tachometer's accuracy and stability is a function not only of the number of bits, but also the size of the sample. The larger the sampling period, the less significant will be the loss of the bottom three bits. After all, starting the spark count after eight pulses have passed isn't much of a problem if the counter is going to count at least ten times that number.

The best solution is to enlarge the statistical universe by adding more pulse counters—that's the solution I chose last month. If you absolutely refuse to make any compromises in the range of the tachometer, you'll need more pulse counters, but you'll also get greater accuracy and greater range. You can make these decisions yourself when I finish the design.

The complexity of the design has been dropped to a manageable level by cutting the bit width of the counters. Unfortunately, since the total width of the expected maximum counts is still eleven bits, a convenient synchronous dual binary up-counter like the 4520B can't be used. Although the 4520 is an eight-bit counter and we're only using eight bits, the 4520 doesn't have the eight bits we need. We have to use bits 2 through 10. Without a lot of extra devices, the 4520 can provide only bits 0 through 7.

The circuit will use a long-chain ripple-carry binary counter to add up the spark pulses. That's better than using one in the timing section. In the case of the spark counters, no critical timing operations are performed—all we want to know is how many events have happened in a particular period of time.

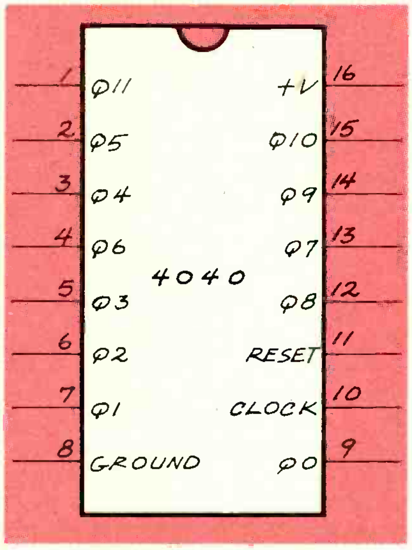


FIG. 1—4040 PINOUTS. The only control pins the chip has are the clock input (pin 10) and an active-high reset (pin 11).

There are several long-chain ripple counters available, but the best one here is the 4040B because it gives a continuous count from bit 0 through bit 11 (a total possible count of 4096). The pinouts for the 4040 are shown in Fig. 1, and you can see that the compromise for a long counter in a small package is a scarcity of control pins. Only a standard clock input (pin 10) and an active-high reset (pin 11) are available.

Getting back to the original problem presented last month of how the counter outputs could be three-stated, a simple octal buffer like the Philips 40240B would do the job, but a better choice would be the 4508B dual four-bit latch. It has three-state outputs and can also store the spark counter output state. This is convenient because it means stable data will be available for the rest of the circuit for a half-second period during which the device can translate the spark count into rpm and then send it on to the display.

The spark counter section is shown in Fig. 2. I've indicated the connections that go to the timing, arithmetic, and display sections. The 4508 is a good choice because both the STORE ($\overline{S1}$ and $\overline{S2}$) and ENABLE ($\overline{E1}$ and $\overline{E2}$) control lines are active-low. When STORE is low, the 4508 will latch the state of its inputs and ignore any further changes. A low on the ENABLE line will make the stored latch data available at the IC's output pins. This means that a common signal can latch the spark counter output and put it on the bus going to the rest of the circuit for further processing.

The next block is for sequence control. This section of the circuit decides which spark counter is read next. It issues the control signals needed to grab that counter's output, get it into the latch, enable the latch outputs, and also reset that spark counter to zero so it can start a fresh count and be ready for the next time it is accessed.

The main "muscle" in the sequence control section is the 4017B. Because the tachometer is designed to update every half a second, the spark counters have to be sequenced and sampled at that rate. The 4017, therefore, has to be clocked at an update rate of half a second, or 2 hertz. The schematic for this section of the tachometer is shown in Fig. 3.

Just about the only drawback here is that active-low signals are needed to control the spark counters, but the 4017 outputs are active-high. The problem is solved by adding some inverters to the outputs. Every half second, the 4017 will select the next spark counter in sequence and cause its count to be

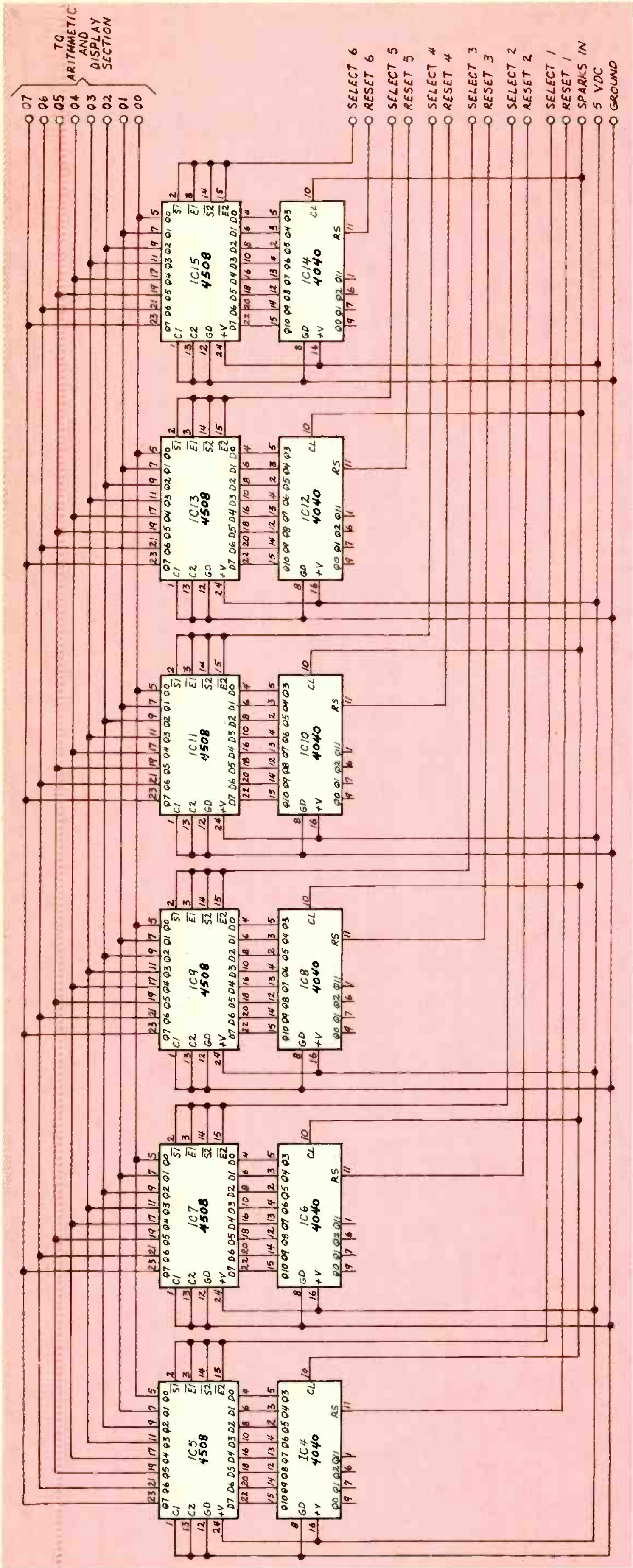


FIG. 2—SPARK COUNTER SECTION. The connections that go to the timing, arithmetic, and display sections are shown.

latched to determine engine rpm.

The seventh output of the 4017 controls the chip's reset pin. After the sixth spark counter is selected, the 4017 will reset, select the first spark counter again, and the sequence will start all over. The capacitor between the reset pin and the positive rail of the power supply gives a power-on reset pulse and makes sure that the 4017 starts its count with the first output.

The 4017 can handle a maximum of ten spark counters, but if you want more than that, you can increase the range by adding another 4017. However, note that the 4017 does not have an output enable control, so there's no easy way to turn off the outputs. The 4017 will always have one high output, and it is difficult to come up with a design that will let two or more 4017s sequence logically across their outputs.

The last subject to cover is the half monostables on the outputs of the inverters that control the spark counter latches. To explain this, I have to go back to the spark counters. Whenever a spark counter is selected by the sequence control, events have to happen in a certain order for every function to work properly. First the latch has to be directed to store the current count in the spark counter. This is accomplished with the inverted signal from the sequence control. Once the count is safely stored in the latch, the spark counter has to be reset to zero so it can begin totaling spark pulses for the next three seconds.

It's extremely important for these events to happen in the right order, so we have to guarantee that the count is stored in the latch before the counter is reset. By using a half monostable circuit to trigger the counter reset, there will be enough time for the latch to grab the count before the counter is reset. The width of the half monostable circuits output pulse need only match the 4040's reset requirements (at least 30 nanoseconds with a 5-volt supply), but the RC time must be long enough to ensure proper latch operation (at least 50 nanoseconds with a 5-volt supply). These requirements are easily met by the RC values shown in Fig. 3.

Before you continue with the rest

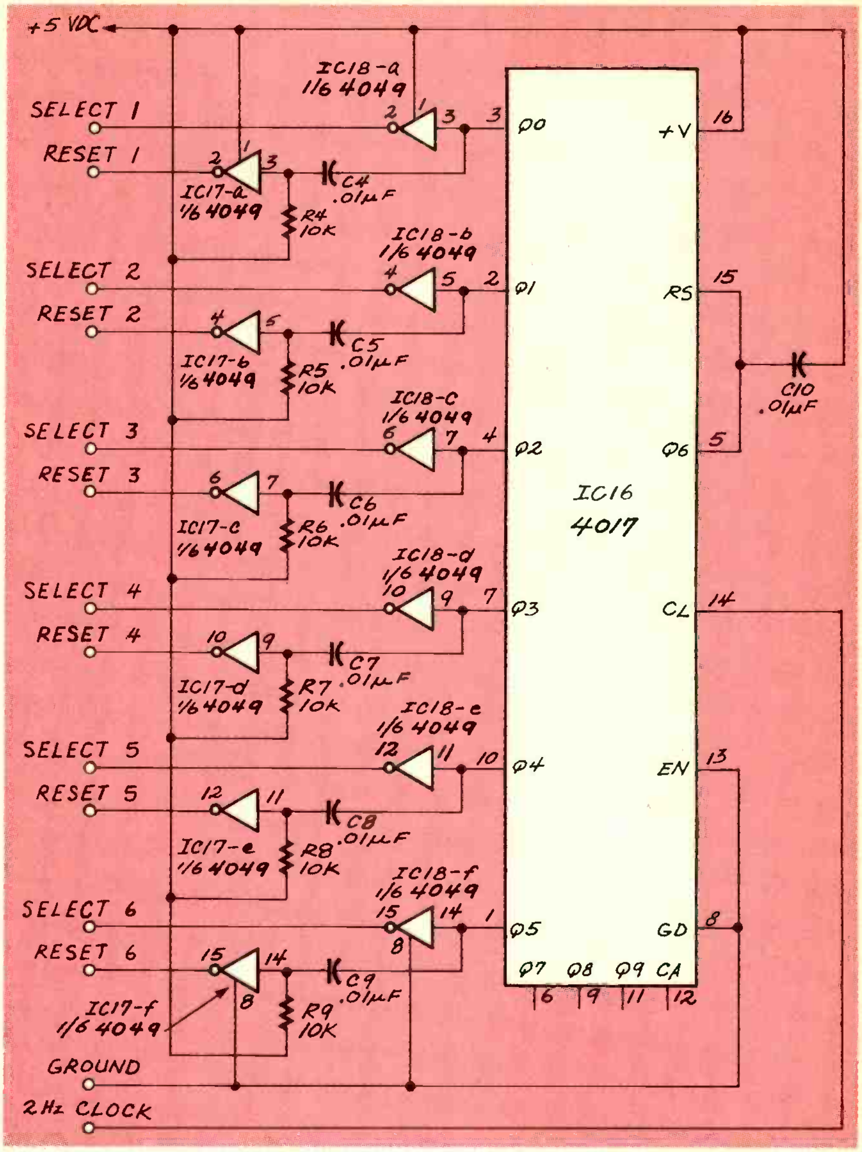
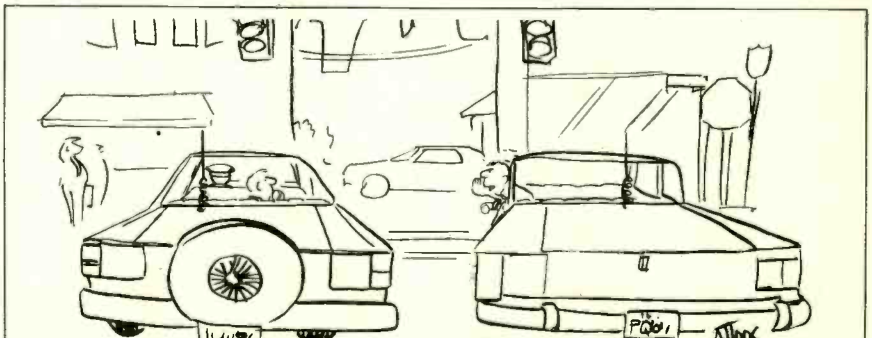


FIG. 3—THE 4017 IS THE MAIN PART of the sequence control section. The 4017 is clocked at an update rate of half a second, or 2 hertz.

of the design, assemble what we've covered so far, and make sure it's working. Check the basic operation of the circuit by feeding the signal input with the 60-hertz output from the 5369 in the timing circuit. If you've used six spark counters, you should get a constant reading of 180 at the latch outputs. With only two spark counters, you should see one second's worth of pulses (60) present at the outputs of the latches. By varying the frequency of the input signal, you should see corresponding numbers at the outputs of the latches. Ω



"Get off the line!"

SEMICONDUCTORS

continued from page 60

However, parts submitted for quality conformance inspection per MIL-STD-883, Method 5005, are usually packaged in the more expensive hermetically sealed metal cases and ceramic packages. In addition to receiving stabilization bake, temperature cycling, constant acceleration, visual inspection, burn-in, and other tests, and the parts must be accompanied by pages of traceability documentation—one reason why their unit pricing is so high.

Special tests have been devised above and beyond MIL-STD-883 to account for special or unusual devices. For example, memory devices will be subjected to tests of write/erase cycles and data retention tests.

JAN Class S devices, intended for use in space shuttles, space probes, spy satellites and other critical applications, are tested more exhaustively than military grade parts. Because they are likely to be exposed to radiation, they receive tests for radiation tolerance or "hardness." Ω

CREATING CHAOS

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with wood screws, making sure the assembly is securely fastened and rigid.

Mount the solenoid on the post with the two screws provided. Fasten the circuit board to the shelf of the post with two flathead wood screws. If the wire connections between the solenoid and circuit board are too long, this is the time to unsolder, trim, and resolder them.

Assemble the ball-spring and solenoid shaft adapter block (Details A and B of Fig. 5) by inserting the coiled end of the wire in the drilled holes of the block and threading it through the holes. Snap the completed assembly over the shaft of the solenoid. The Bonker is now ready to give you hours of relief from those monotonous routines of life. Ω

LETTERS

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lose the prestige it once had is still present. Holtzman noted, "Apple is having trouble convincing DOS/Windows users to switch, yet IBM hopes to convert everyone." Well said! Both Microsoft and Sun Microsystems are showing increasing arrogance.

I predict that the transition to NT will not be as Microsoft hopes. I don't know who will win the race for the next-generation operating-system, but I doubt that it will be either NT or OS/2. In my opinion, Unix is still the *de facto* standard for professionals. MS-DOS, NT, and OS/2 are just not in the same league.

Nevertheless, I acknowledge that MS-DOS is the least expensive and most widely used operating system in the world. That does not, however, qualify it as a technically superior product. Obviously MS-DOS has been a financial success, but that's of no concern to me.

LARRY W. DAUBERT
Garden Grove, CA 92640

It looks as if Mr. Daubert and I are in violent agreement. I wholeheartedly agree that the OS model presented in my article is not a groundbreaker. Nonetheless, it has become a strategic architecture for IBM. How Taligent fits in with either its strategy or the architecture remains to be seen. As for the correspondence between the POSIX model and IBM's, that's IBM's call. I'll just point out that IBM's model covers a much broader spectrum than IEEE's POSIX, which really just confines itself to the Unix world.

I know that the concept of widgets originated with Project Athena at MIT. I regret that my article was not more forthright on that point.

Mr. Dauber says IBM, DEC, and Apple have been playing ostrich, and I agree—but so has the Unix world. That is why MS-DOS took over the small computer market. In my opinion, the Unix market had better watch out for NT, and subsequently Cairo. That takeover won't happen overnight, but within five years, a Microsoft operating system could be running everything that matters.—Jeff Holtzman Ω

COMPUTER CONNECTIONS

What is an operating system?

JEFF HOLTZMAN

What is an operating system? What is the difference between "system software" and "application software"? Where do utilities fit? Are there definite boundaries separating the three categories? Does it matter whether there are boundaries at all, and if so, where they are drawn? Is the definition of an operating system a technical one? Is it legal? Is it market-driven? Is it constant, or does it vary over time?

Consult the typical computer reference or textbooks, and you'll see operating system defined pretty much as follows: "The software responsible for controlling the allocation and usage of hardware resources such as memory, central processing unit (CPU) time, disk space, and peripheral devices. The operating system is the foundation on which applications, such as word-processing and spreadsheet programs, are built. Popular operating systems include MS-DOS, the Macintosh operating system, OS/2, Windows, Windows NT, and Unix." (*Computer Dictionary*, 2nd Ed., Microsoft Press, Redmond, WA, 1994).

Most operating system definitions include hardware resource management. But few cover the necessary and sufficient kids of resource management required for software to qualify as an operating system. At the other end of the scale, if you heap more and more software—particularly programs that clearly are applications—onto the core operating system, what becomes of the definition? Does it need to change? Or does a new product category—OS++—need to be defined?

This might all seem academic, except that the company that published the definition given above has products spanning both the operating-system and applications categories. Over the years, Microsoft has continually evolved and expanded its working definition of the operating system to the point that the computer business as a whole has been affected. Ask utility vendors what they think about the inclusion of 386/486 memory-management and file-undeletion tools in recent versions of MS-DOS. Ask network and electronic mail vendors what they think about the inclusion of peer-to-peer networking and E-mail clients in recent versions of Windows.

Some organizations demand that Microsoft be split in half—operating systems and applications. To which side would the 386 memory-management group go? The E-mail group? The file-undelete group? What about the Windows "applet" group (responsible for Write, Notepad, and Terminal)? What about games?

In the definition given earlier, Windows is cited as an example of an operating system. Windows is sold with a popular version of Solitaire; Windows for Workgroups comes with a version of Hearts. Surely games do not help manage system resources—quite the opposite. In fact, their purpose is to expend system resources. What about programming tools? DOS includes DEBUG and QBASIC, which while not state-of-the-art, are certainly capable programming tools.

Suppose you limit the definition to system-resource management software with no user interface. Doing so would, for example, cut MS-DOS down to just two files: IO.SYS and MSDOS.SYS, that together occupy less than 100K of disk space. Doing so would further eliminate COMMAND.COM; the market would then be dependent on third-party offerings such as JPSoft's 4DOS. (Actually, I like that idea. 4DOS is light-years better than COMMAND.COM.) The Unix world has had alternate "shells" for years; why not here in the PC world as well?

In the Windows 3.x world, the limited definition would eliminate all but three Windows executable files, plus some support DLL's. Gone would be Program Manager and File Manager, along with all the mini applications. That might not be such a bad thing either.

On the other hand, including Xcopy and Find and DelTree and all the rest as part of the operating system helps ensure a consistent level of quality and consistency, at least among the core file- and disk-management utilities. Or does it? When was the last time you used DOS's Recover command?

DOS = OS + Utilities

The trend seems to be that the operating system will push higher and higher, further and further away from the hardware. It will be more encompassing in the resources it manages, and it will include more and more in the way of utilities, "applets," and adequate if not full-blown applications.

For example, look at what has happened in the evolution from MS-DOS 3.3 to MS-DOS 6.2. Table 1 lists software that was not included in DOS 3.3 but that is included in MS-DOS 6.2. Every one of those items was originally conceived and sold by a third-party vendor. Most of them are but shadows of their former selves, and some are no longer even with us. Even the biggest utilities vendors (e.g., Symantec/Norton and Central Point) are totally revamping their strategies and product lines.

Microsoft's definition cited both MS-DOS and Windows as examples of operating systems. When you come down to it, MS-DOS manages disk, some peripherals (via a Frankenstein-like kludge of device drivers and TSRs), and memory at a very low level. Almost no programs written to run under MS-DOS use DOS to manage video display or serial communications.

Windows picks up where MS-DOS leaves off. Together, the two comprise the resource-manager for Intel-based PCs. Together, they include lots of software, utilities, mini-apps, and applications, formerly considered external to the operating system.

OS/2 ratchets the concept a notch higher, as it includes three operating systems (MS-DOS, Windows, and OS/2). And Chicago, though it won't support OS/2, also supports three operating systems, and will likely include even more in the way of utility programs. Outside of the DOS/Intel world, the same kinds of things are happening. New object-oriented operating systems like NextStep and Taligent exhibit the same trend, to an even greater degree.

Growth and expansion is not limited to operating systems. Look at the tools market. A compiler, a linker, and possibly a debugger used to define a programming tool. Now CD-ROM-based programming environments come with fancy screen designers, text and bitmap editors, and huge libraries of precanned routines. Third-party software libraries include complete mini-apps—spreadsheets, word processors, database front ends, communications modules, and more. Such standard applications as word processors occupy 15 megabytes or more of disk space, and they are supplied with all sorts of fancy tools for document design and layout. Application suites (CD-based, of course) are blowing away "single"-function applications.

How big can these things get? Is there a limit to growth? Where do we draw the lines? Share your thoughts; email jkh@acm.org.

On the highway

There are two problems with the so-called information highway as it currently exists: The first is that there are lots of ways to get on the Internet, but few good ones and the second is that once you're on, there is an enormous amount of material to wade through. Many books have been published during the past year or two that purport to help with one or both problems. Surveying this exponentially growing field is beyond my ability, but here are a couple of resources I've run across that might help.

TABLE 1
MS-DOS 6 vs. MS-DOS 3.3

Disk partitions larger than 32 MB
Upper-memory management and optimization
Disk compression
Usable backup and restore
Virus scanning
Disk unformatting
Serial/parallel-port file-transfer capability
Boot-file configuration management
Disk-surface scanning
Disk defragmentation
Disk cache
Power management
Command-line editing and recall
System diagnostics

The first is a slim, minimalist book called *The Internet Companion Plus*. If you want to get up to speed quickly on the differences between archie, gopher, and veronica, or learn about the World Wide Web (WWW), or internet addressing conventions, this slim (150 pages) volume can help you do so painlessly. The book includes a floppy disk containing some Internet access software that connects to an Internet service provider called WorldLink. The software is free, but there are connect-time charges.

At the other end of the scale is *The Internet Directory*, a 700-page blockbuster that is more like a yellow-pages directory of what's available where on the Internet. Once you figure out how to get on, this book will be of immense use in finding what you want.

Deeper than *The Internet Com-*

panion Plus is *Internet Basics*. It gives more detail on commands like whois, finger, and telnet. It also has a special focus on accessing the Internet via the Delphi on-line service. Delphi is something like CompuServe or America OnLine; it currently has the most complete Internet access of all the big-name commercial providers.

Editor's bookshelf

Many people these days think that the first personal computer was the Altair 8800. Plans for the Altair were published in the January 1975 *Popular Electronics*. As few people know, however, the real honor goes to *Radio-Electronics*, which published a construction article six months earlier, in July 1974, on the Mark 8 computer. Stan Veit knows that and a whole lot more. For an enjoyable ride through the wild and woolly days of the PC revolution, read *Stan Veit's History of the Personal Computer*. It is a delightful, first-hand account of the growth of the PC industry from the mid 1970s to the early 1980s.

Software and system designers interested in icons that convey meaningful information should check out *The Icon Book*, by William Horton. Horton is a leading authority on user-interface design, on-line documentation, and related topics. This book distills a lot of research and practical knowledge into a form usable by practitioners, and it includes a set of 500 icons in Windows' format.

For a low-level view of PC video systems, Richard Wilton's *Programmer's Guide to PC Video Systems*, second edition, is an update of one of the true classics in the field. The book discusses details of everything from CGA to SVGA, including memory layouts, register usage, DOS and BIOS calls, VESA BIOS extensions, and many more subjects. Game programmers and device-driver writers will want to master this material. Ω

ITEMS DISCUSSED

The Internet Companion Plus ($19.95), Tracy LaQuey and Jeanne C. Ryer, Addison-Wesley, 1993. ISBN: 0-201-62719-1.
CIRCLE 301 ON FREE INFORMATION CARD

The Internet Directory ($25), Eric Braun, Fawcett Columbine, 1994. ISBN: 0-449-90898-4.
CIRCLE 302 ON FREE INFORMATION CARD

Internet Basics ($27), Steve Lambert and Walt Howe, Random House, 1993. ISBN: 0-679-75023-1.
CIRCLE 303 ON FREE INFORMATION CARD

Stan Veit's History of the Personal Computer ($19.95), Stan Veit, WorldComm Press, 1993. ISBN: 1-56664-023-7.
CIRCLE 304 ON FREE INFORMATION CARD

The Icon Book ($39.95), William Horton, John Wiley & Sons, 1994. ISBN: 0-471-59901-8.
CIRCLE 305 ON FREE INFORMATION CARD

Programmer's Guide to PC Video Systems, 2nd edition ($39.95), Richard Wilton, Microsoft Press, 1994. ISBN: 1-55615-641-3.
CIRCLE 306 ON FREE INFORMATION CARD

WHAT'S NEWS

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since late 1993. Tests will continue before a formal product introduction is made in the first half of 1995.

EIA sponsors electronics skills part of VICA competition

The Electronic Industries Association (EIA) and its member companies sponsored the Electronic Product Servicing part of the Vocational Industrial Clubs of America's (VICA) 30th United States Skills Olympics. The competition took place during the VICA National Leadership Conference held on June 30 in Kansas City, Missouri.

The EIA's Consumer Electronics Group (EIA/CEG) Electronic Product Servicing Technical Committee developed, coordinated, and monitored the contest. The Committee members are representatives from member companies including B+K Precision, Matsushita Services Co., Philips Consumer Electronics, Sencore, Sharp Electronics Corp., Sony Electronics, Thomson Consumer Electronics, Toshiba, and Zenith.

The 1994 VICA event attracted more than 3600 vocational students who competed in 54 different trade, technical, and leadership fields. Forty-seven students participated in the product servicing competition, and six winners were selected in secondary and post-secondary school categories.

The secondary school winners were Thomas Harris of Sykesville, Maryland, in first place, Philip Carmichael of Tyler, Texas, in second place, and Edward Neipris of Plainville, Texas, in third place. In the post-secondary category Jonathan Jensen of Bountiful, Utah, Carlos Lovera of Whittier, California, and Timothy Rau of Pocatello, Idaho, finished in that order.

The winners were presented with scholarships that included several $10,000 technical-school scholarships from the National Education Centers and $250 scholarships from the International Society of Electronic Technicians (ISCET).

The prizes included Panasonic, Hitachi and Zenith VCRs, B+K Precision DMMs, Sony and JVC CD/cassette audio systems, and Sony cordless phones and portable CD players. Other prizes were RCA color TV sets, GE answering machine and Snap-On tool kits. One-year subscriptions were awarded to *Electronics Now*, *Professional Electronics*, and *ES&T* magazines.

Lineman's "third arm"

A robotic arm attached to an electric utility's service truck can stretch over 47 feet and its "hand" can grasp an object, rotate and release it. This "serviceman's third arm," permits line service personnel to trim trees near overhead lines, install and cut wires, and move live wires aside without subjecting them to the dangers of electric shock. By extending the reach of line personnel, it can speed up power line maintenance and the restoration of electric service after an outage.

The robotic arm, which is mounted on a truck like an aerial bucket lift, was developed by Intelisys Automation of Westbury, NY in conjunction with the Long Island Lighting Company's (LILCO) Research and Development group. The truck for supporting the robotic arm was developed by Alabama-based Altec Industries. Ω

BUYER'S MART

FOR SALE

TUBES: "oldest", "latest". Parts and schematics. SASE for lists. **STEINMETZ,** 7519 Maplewood Ave. RE, Hammond, IN 46324.

TUBES, new, up to 90% off, SASE, **KIRBY,** 298 West Carmel Drive, Carmel, IN 46032.

CABLE test chips. Jerrold, Tocom, S.A., Zenith. Puts cable boxes into full service mode! $29.95 to $59.95. 1 (800) 452-7090, (310) 902-0841.

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ACTIVE matrix color LCD 4" screen $75.00 ea. Eprom pulls, bag of 50 $20.00. Lots more, get on our mail list. **RAVEN TECH,** 2335 Cranford, Columbus, OH 43221.

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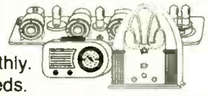

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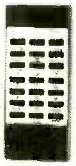

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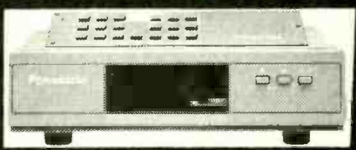

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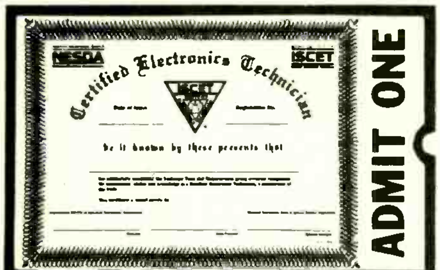

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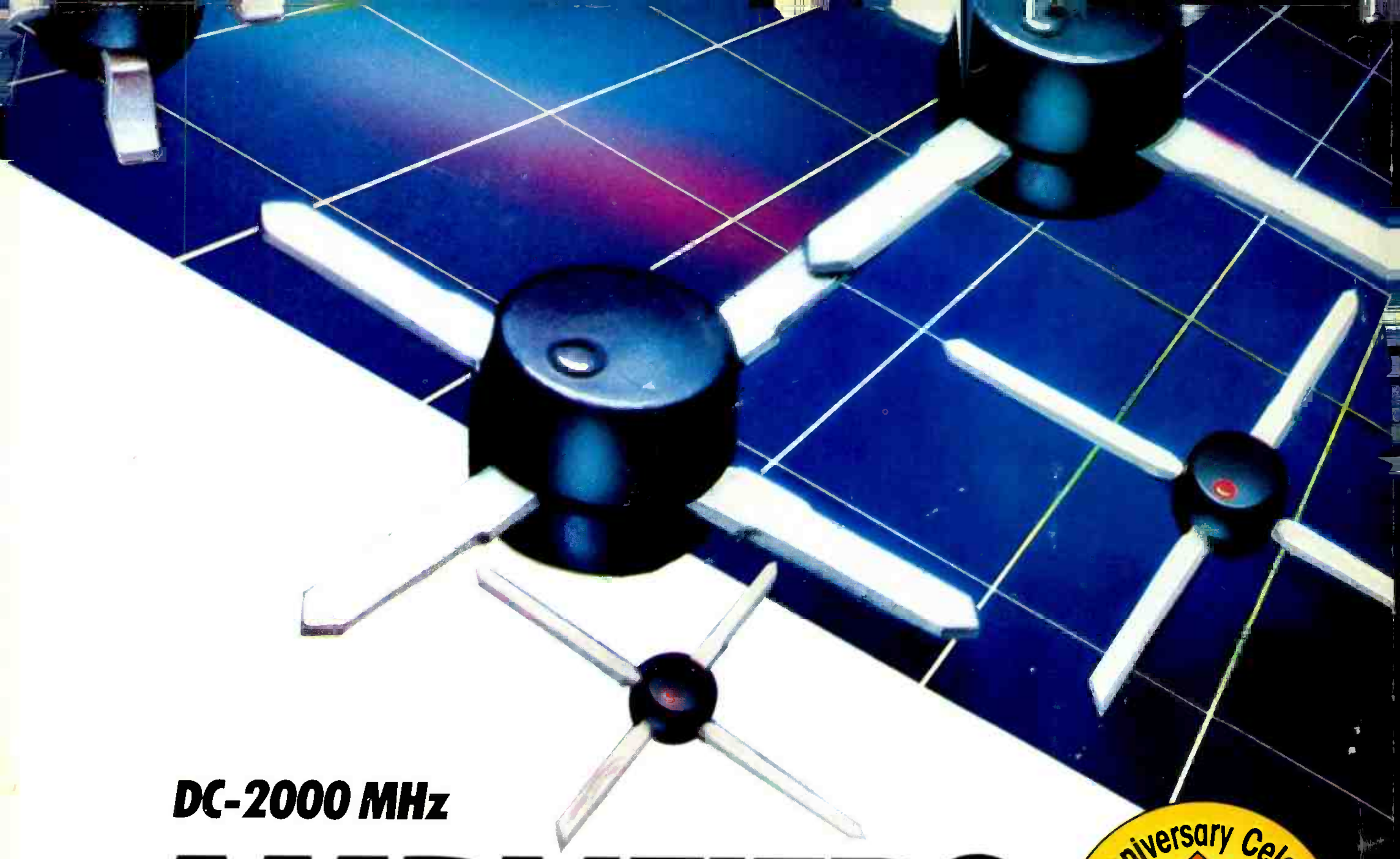

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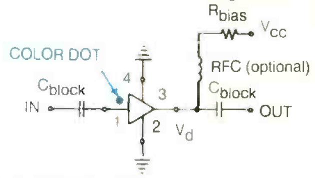

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