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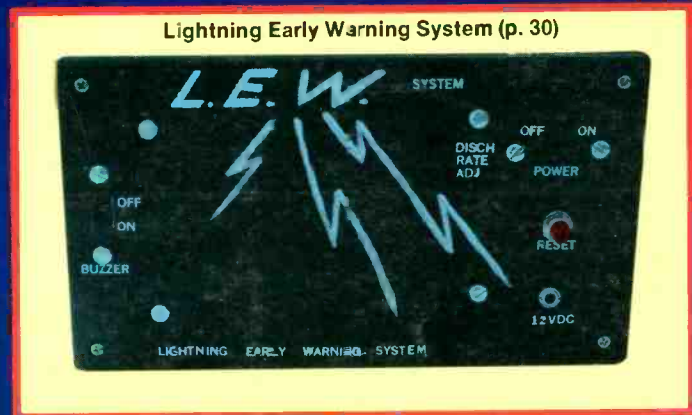
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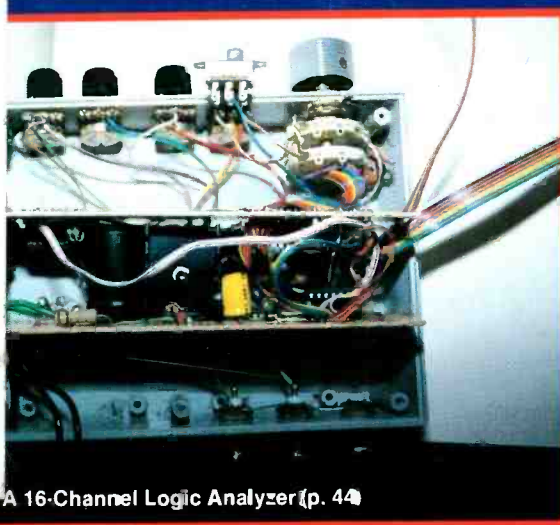
- **Lightning Early Warning Device**
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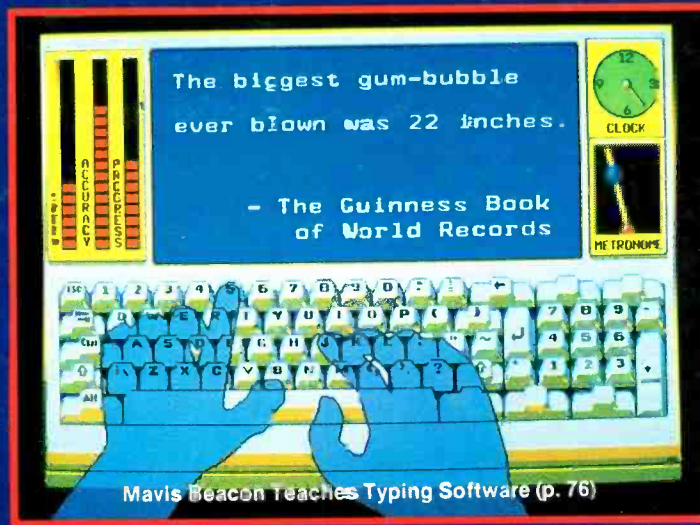
Other Construction Plans:

- **16-Channel Analyzer for Digital Troubleshooting**
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A 16-Channel Logic Analyzer (p. 44)



Mavis Beacon Teaches Typing Software (p. 76)

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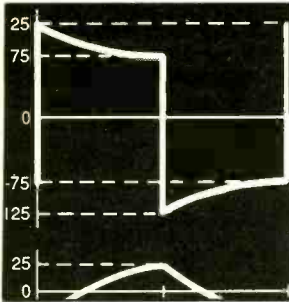
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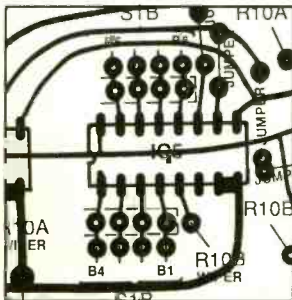


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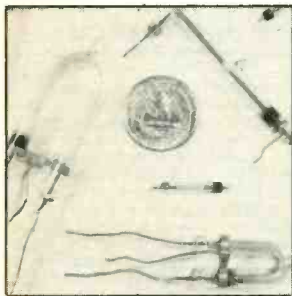
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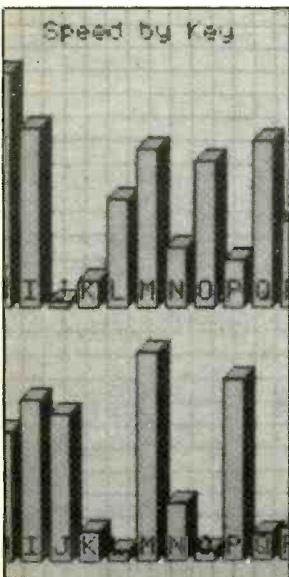
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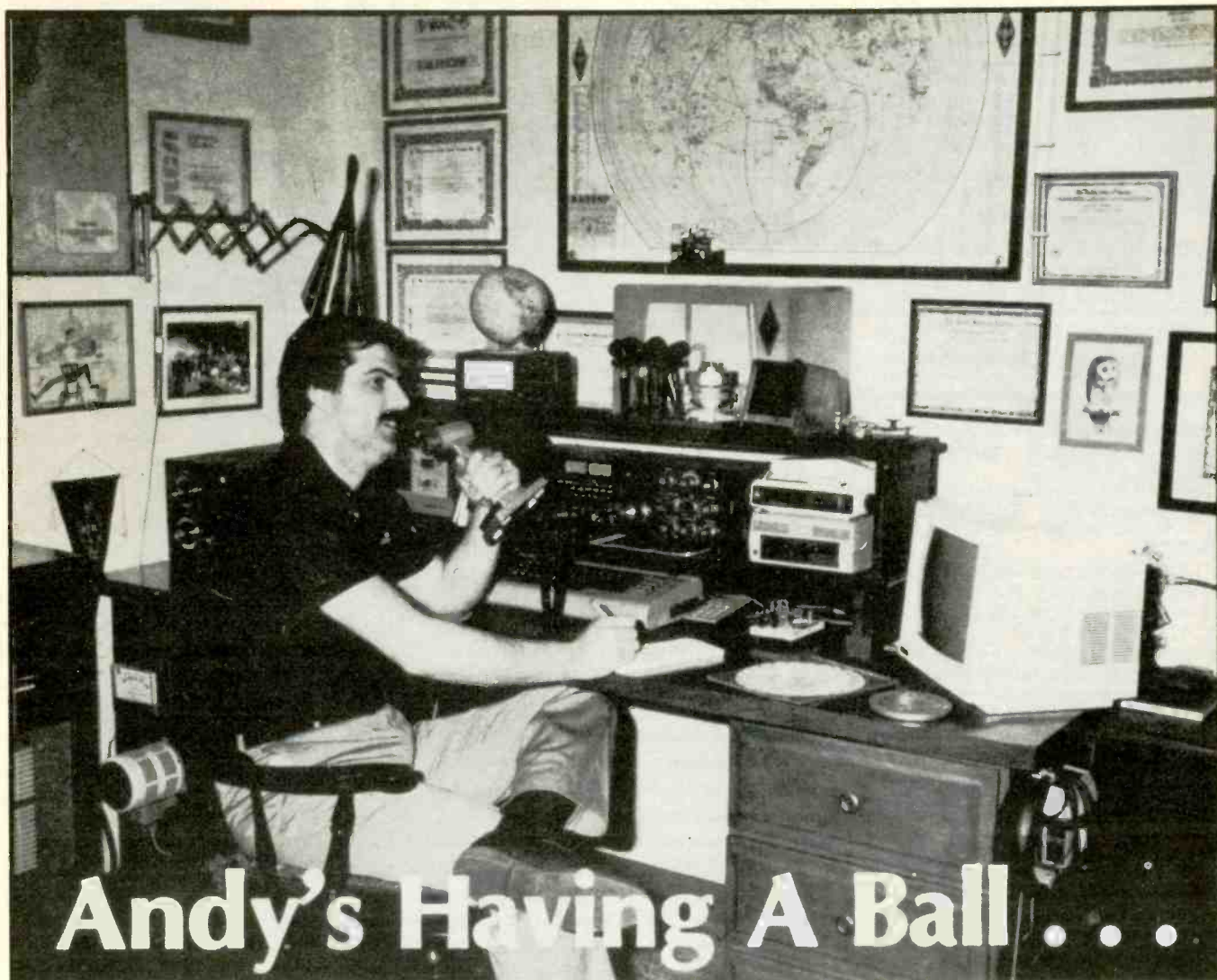
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EDITORIAL

Houses Getting Smarter

For many years now, industry pundits have been predicting that houses will be brimming with automation devices, changing ordinary homes into "smart homes." It's still a struggling concept, though.

Yes, many of us have installed a variety of devices to boost a home's IQ, but this has mostly been tack-on devices for turning on security lights, remotely controlling some devices, and so on. The *real* smart house has to start life in its infancy, when it is being constructed (unless one is willing to spend a lot of money on top of plenty for reconstruction work).

Many of us have seen computer pioneer Dr. Portia Isaacson's smart house featured in some publications a few years back. So they do exist. But it's still in the new-construction area that smart houses will begin to evolve.

The National Association of Home Builders (NAHB) has a smart-house project going, with a handful of manufacturer participants, including Honeywell. Also, General Electric, Mitsubishi and others have demonstrated systems to effect this end, too. But the going is very s-l-o-w. It's more like a wishful dream or publicity puffery now. The NAHB project envisions wiring a home with multiple wires to carry electrical power, control and data signals, and audio and video signals, which is now permitted under a National Electrical Code revision.

Among the many problems facing this revolutionary change to automation (when a washing machine finishes its cycle, it would not only cause a bell to ring, but would also flash a message on TV sets; shut off an operating, noisy vacuum cleaner when the doorbell rings; alert dwellers to product failures such as an air conditioner being low on freon; sense one's flesh on a hot line and thereby not allow current to flow, as well as provide the convenience of receptacles for computer data, audio and video signals, programming control signals for lights and thermostats, etc.), are high cost and the cooperation of appliance makers who would have to provide special, premium-

priced models that could be integrated into the system.

A new \$11.95 book, *Smart House: The Coming Revolution in Housing* by Ralph Lee Smith (GP Publishing, Inc. 10650 Hickory Ridge Rd., Columbia, MD 21044), discusses what's happening in the smart-house field, focusing on an NAHB laboratory smart house for which construction ground was broken in 1987. Research on the prototype is said to be planned through 1989, after which about 100 demonstration homes will be built nationally and in Canada. The author projects this will result in about 8-million homes that are built with the new wiring and appliances needed for full home automation by century's end.

I'd be delighted to see this happen. However, I view this as being highly optimistic. There are plenty of industry people who agree with me and plenty who don't. Meanwhile, those little, low-cost control models sold around everyone's town, which plug in to a power-line receptacle and don't require additional wiring, sell in growing numbers. So the desire and need is there. But I wonder how many of us will spend \$10,000 to \$20,000 for the envisioned future smart-house addition, which is the present cost estimate for the Mitsubishi system, even if the concept comes together?

Meanwhile, the Electronics Industry Association has a consumer electronics bus committee working on a standard (the CEBus) for interactive communications with a variety of products. An EIA spokesman predicts that in another year we'll see products compatible with its bus, which is expected to be finalized at the end of 1988. Perhaps this will provide the spark needed to move the concept along to fruition.

Art Salsberg

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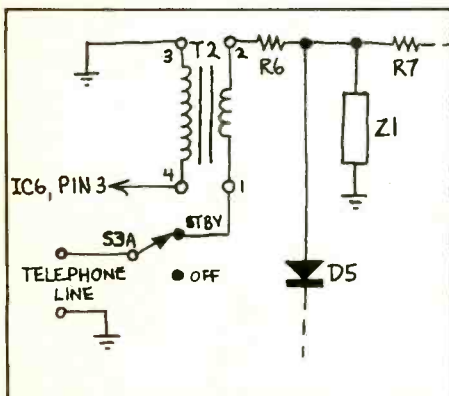
Crash!

• There are two errors I spotted in my December 1987 article, "RC Aircraft Crash Saver." In the printed-circuit diagram, the mounting pads for the trimmer potentiometers were changed in such a way that no normal commercial trimmer would fit the holes. The LM3362 was shown in top view, which is not the industry standard. If the reader assumed it was a bottom view, the unit would burn out as soon as the power was turned on.

Harold Wright

AnswerMate Replies

• The schematic diagram of my "AnswerMate" (Fig. 1) in the April issue has some errors in the vicinity of the telephone line input circuit.



Enclosed is a correct drawing of the circuit. The wiring diagram of Fig. 6 is ok, except that polarity of LED 2 (answer) is shown reversed from what it should be. As far as I can tell the printed-circuit layout of Fig. 4 is correct.

Tony Caristi

Let's Heed Warnings

• In the March "Solid-State Devices" column, you state that Linear Technology *explicitly* warns against using common diodes with the LT1070 as they will be summarily *eaten*, yet you blithely proceed to show three circuits delivering up to 2 amperes using a 1N914, rated at 75

(Continued on page 78) ➔

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ELECTRONIC SERVICING NEWS. Sharp Electronics' Service and Parts Division instituted advanced formal service-training classes for senior dealer technicians, expecting this training to make attendees product technical experts within their dealerships. The company also offers management-level courses for service managers. Courses are at the Sharp Management Institute at West Point (NY), taught by New York University faculty. For more info, call Art Sherman at 201-529-9200....The annual convention of sales and service dealers and technicians will be held in the Chicago area August 1-6 (at Pheasant Run Resort, St. Charles, IL). The week of technical and management seminars, sponsored by the National Electronics Sales and Service Dealers Association (NESDA) and the International Society of Certified Electronics Technicians (ISCET) will also feature a Professional Electronics Trade Show. Tech seminars include a Compact Disc school for two days and half-day schools for super-VHS and camcorders, and full-day schools covering digital VCR and computer service. For more info, contact NPEC at 817-921-9061.

OPTICAL MEDIA BREAKTHROUGHS. Tandy Corporation announced a revolutionary development: a CD-compatible optical disc that can be used to record and erase digital information. Called THOR (Tandy High-intensity Optical Recording), the product potential includes use with CD-ROM drives and compact-disc audio equipment. Furthermore, Tandy says that the media will cost less than alternate digital audio formats. The first commercial use for this product will be for CD-audio, with the additional cost in electronics and drive mechanisms for play/record purposes should be for less than \$500. This product is expected to debut early 1989. Following this, THOR-CD technology is expected to be applied to data storage with storage capabilities in the hundreds of megabytes per five-inch disc....CD-ROM mastering service at a remarkably low price has been announced by Discovery Systems (Dublin, OH). Mastering cost is only \$1,500, while disc replication is only \$2 per disc. Mastering includes High Sierra, ISO-9660 or Apple HFS.

SECURITY EQUIPMENT BOOMING. Residential installations of security equipment, led by single-family and luxury-home use, total about \$6-billion in annual sales now, and is growing at a 20% rate, according to STAT Resources (Brookline, MA), whose 135-page market study is available for purchase. The report notes that the average price of a professionally installed residential security system is \$1,750 and that more than 1.5-million installations were made in 1986....Panasonic introduced a TV-Doorphone System

for security purposes. The VA-8100 model features two CCD TV cameras connected to a base telephone unit with a four-inch diagonal, black-and-white CRT for visual monitoring. The cameras incorporate infrared LED technology for monitoring areas that are in virtual darkness. Additionally, the telephone features an audio intercom and an electrically-controlled door opener.

CELLULAR NEWS. Cellular telephones, first used in a Chicago test in the late 1970s, are selling briskly in areas where mobile and portable users are served. To give you an idea of how fast the service is growing, The Antenna Specialists Co. (Cleveland, OH) recently celebrated the production of its one-million cellular antenna. The company claims that its cellular antennas account for 70 percent of all such antennas in service. Antenna Specialists, working with Bell Laboratories, established such industry standards as the 3-dB gain for mobile antennas and the distinctive antenna pigtail phasing-coil configuration seen on more and more automobiles.

DIGITAL AUDIO EDITOR. CompuSonics Corp. has introduced a cut-and-paste audio editor for broadcasters that uses a digital cartridge recorder. It can replace 1/4" recording tape used for this purpose, eliminating razor-blade splicing and dubbing. It has an optional Macintosh personal computer software package for full-screen access to the tape on the video screen and can be pushed around, rearranged and pasted together there. Software packages for IBM-PC and compatibles are promised later this year.

CAR ELECTRONICS HAPPENINGS. Los Angeles will be the site of a three-year highway research project to test feasibility of electronically linking traffic-condition information with a computerized video monitor located on a vehicle's dashboard. Specially equipped cars (25) donated by GM will be used. Each will have an electronic map of Los Angeles' streets displayed on a console screen. Drivers will be able to run on the electronic map and get current information on traffic conditions, including accidents and a map of alternative routes to avoid congested areas....What's believed to be the first fiber optically controlled car model was reportedly demonstrated in West Germany in April '88. It used 100 feet of polymer optical fibers and a computer local area network to replace about 6,700 feet of complex multiple wire harnesses that interconnect car lamps, switches, motors and relays. The wiring demonstrated several potential advantages for future automotive technology, including immunity to electromagnetic interference, high transmission rates to control future electronic systems, short-circuit immunity, and saving of space and weight....Bose Corporation announced that it will participate with Honda in a unique export of U.S. products by incorporating specially designed, acoustically tailored Bose automotive music systems on all U.S.-built Honda Accord Coupes designated for export to Japan. A total of 4,000 such cars built in Marysville, OH will be shipped to Japan in 1988.

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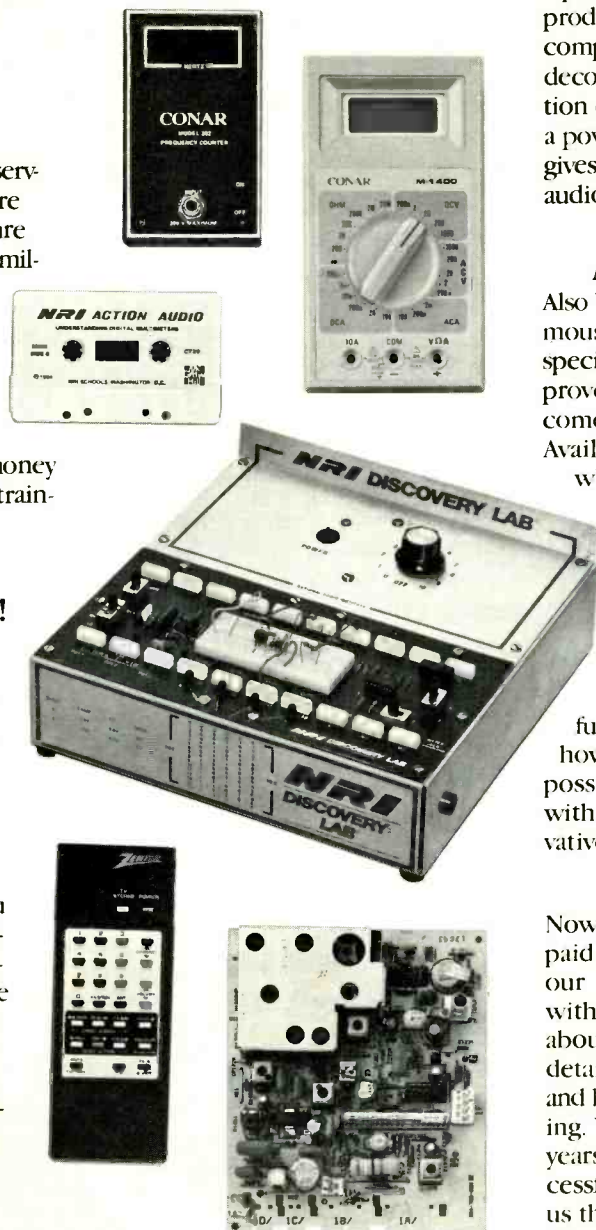
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For more information on products described, please circle the appropriate number on the Free Information Card bound into this issue or write to the manufacturer.

Hand-Held Oscilloscopes

Tektronix, Inc. has announced availability of two new hand-held digital storage oscilloscopes that weigh less than 2 pounds each. The Tek 201 and Tek 202 scopes have flat-panel LCDs instead of CRTs and are small enough at 10"H x 4.5" W x 2"D to fit in a briefcase. Both are said to offer per-



formance and features of full-size digital storage oscilloscopes.

Two different interfaces are available. The Tek 202 offers a traditional interface with front-panel controls divided into familiar function sections. These include separate sections for channels 1 and 2 controls, triggering and other functions. The Tek 201 is for users who are more comfortable with left-to-right manipulations using a calculator-like interface.

Standard features of both scopes include: parameter presets (time-base, sweep speed, trigger mode, cursors); digital voltmeter and timer/counter capabilities; true rms, dc,

peak-to-peak and ground-to-peak voltage measuring capabilities; alphanumeric readouts in the LCD window; and four cursors for each of two channels. The user can store up to nine front-panel settings in non-volatile memory for instant recall as needed. Also, up to nine waveforms can be permanently stored for later analysis. Signal-processing capabilities allow the user to combine waveforms from different channels, process an input channel with a saved reference waveform and combine two saved waveforms. \$1,995, including battery pack, two test probes, carrying case, manual and audio cassette training kit.

CIRCLE 10 ON FREE INFORMATION CARD

20-MHz 80386 PC

Operating at a 20-MHz clock speed, Tandy's new Model 5000 MC 80386-based desktop computer uses a high-speed memory cache controller for superior speed and performance. It is designed for the user who needs the power of the 80386 microprocessor, video graphics array (VGA), high-speed memory caching (using 32K of static RAM) and IBM Micro Channel-type architecture. The computer has VGA capability on the main logic board that provides CGA, EGA, MCGA and VGA software compatibility. For extended VGA capabilities, the required video expansion features are built into an IBM Micro Channel-compatible slot.



CIRCLE 11 ON FREE INFORMATION CARD

Video Movie-Making Kit

If you can press a button on your video camera, you can probably make a professional-like video movie with the Home Moviemaking Kit from Hollywood Make A Movie™. This kit is said to take care of everything, from providing the movie idea to scene-by-scene layouts of what to shoot, dialogue and where to add the sound. Scripts, props, titling, end graphics and an audio cassette with sound effects and music



are included. No special mixers or editing equipment is needed to make a home movie with this kit.

The first in the series of Home Moviemaking Kits is the Comedy Series (Horror, Children's, Short-takes, Commercials and Animation kits are due to be released at about the time this appears in print). Each kit is a complete package of three professionally written scripts on color storyboards, props, professional sound effects, production music and instructions, all designed to turn home movies into mini Hollywood productions.

Props supplied in the Comedy Series Kit include: fake mustache, fake cigar, chef's hat, waiter's vest, fake cleaver, eyeglasses, menu, ransom note and "magic" charm. Also included are dozens of sound effects and production music pieces from the same studios that work with the TV and movie industries. \$49.95.

CIRCLE 20 ON FREE INFORMATION CARD

Digital Weather Computer

The Heath Company's Heathkit Model ID-5001 advanced digital weather computer kit brings micro-processor-based accuracy to the user. According to Heath, it is the only



weather instrument known that averages wind direction to FAA standards and gives true direction at a glance. The 32-point resolution in wind direction and 10-degree resolution through averaging is said to provide exceptional precision. The computer displays wind direction and speed to FAA and National Weather Service standards, as well as peak gust, direction and change in wind speed for the last hour and last 24 hours. Built-in alarms can be set to sound when severe weather conditions are detected, and an optional humidity accessory can be used to display a "FOG" warning.

The system computes rates of barometric pressure changes with a high-accuracy digital barometer. Indoor and outdoor temperatures, including high and low readings, are displayed along with rate of change in temperature and change in temperature during the last 24 hours. Temperatures can be displayed in either degrees C or degrees F.

Options include a rain gauge, indoor/outdoor humidity sensors and an RS-232C serial port. The rain gauge can be used to predict the amount of rainfall if the current rate continues for one hour, and the 24-hour rate gives the rainfall amount in the last 24 hours. The indoor humidity sensor indicates winter comfort index, while the outdoor sensor indicates summer comfort index and evaluates conditions for the likelihood of fog. The RS-232C port interfaces the system to a computer for more data storage. \$499.95.

CIRCLE 21 ON FREE INFORMATION CARD

Surround-Sound Amplifier

The Memorex Surround Sound Amplifier from Memtek Products (Santa Clara, CA) decodes the separate sound channels—three front and two rear—to provide the full effect of Dolby Surround™-encoded video tapes. (More than 1,000 such tapes are currently available.) Front



channels provide directional cues that relate to actions on the TV screen, and the surround-sound channel puts the listener in the middle of the action by creating sound effects throughout the viewing room.

The stand-alone Surround Sound Amplifier works with a stereo VCR and a TV receiver to provide the full audio effect. Built in are power amplifiers to power the left and right front speakers and the two rear speakers. These amplifiers can be used alone, providing 5 watts/channel to the front and rear speakers or 10 watts/channel to each rear speaker when the Amplifier is used in conjunction with a stereo system. The center-front sound channel comes from the TV receiver used for viewing.

Standard features include: true Dolby Surround decoder; three selectable audio inputs; front-rear and left-right balance controls; tape output; tone control to adjust high-frequency sound level; and stereo synthesizer for mono sources. \$149.95.

CIRCLE 14 ON FREE INFORMATION CARD

Pocket DMM

An ultra-compact, shirt-pocket-size digital multimeter that features a 3½-digit (3,200-count full-scale) liquid crystal display and a high-sampling-speed 32-segment bargraph display is available from GC Soar Corp. (Dayton, OH). Bargraph sampling at a rate of 12 times per second provides quick updates of analog events and speeds peaking and nulling operations. The meter measures up to 450 volts dc and ac and resistance to 32 megohms. It has continuity (audible buzzer indication) and semiconductor-junction test func-

NEW PRODUCTS . . .

tions as well and is protected to 450 volts rms even in the ohms function.

Auto/manual range selection is via a pushbutton switch on the front panel. Another pushbutton switch

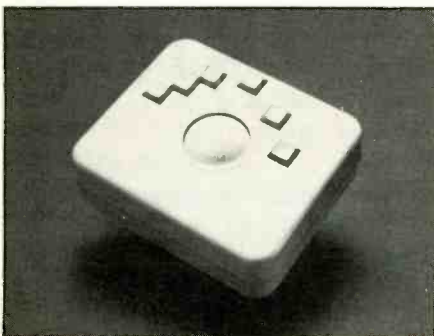


allows the user to select between dc/ac volts and resistance/continuity/junction test. A three-position slide switch applies power in the volts or resistance function and disables power manually. An automatic-off function disables power 10 minutes after the last function/test has been performed to conserve battery power. Power is supplied by two readily available button cells for approximately 250 hours. \$59.95.

CIRCLE 15 ON FREE INFORMATION CARD

Computer Trackball

Fulcrum Computer's (Healdsburg, CA) new Trackball Plus is a stationary RS-232 computer input device that can emulate 10 different pointing devices, including the Microsoft Mouse, the Mouse Systems Mouse and the Summagraphics Bit Pad



One. It can also be used to emulate the arrow-key functions for programs that are not mouse driven. Ball motion is detected by optical means and is transformed to one of many formats by an on-board microprocessor before being sent to the host computer. Power for the Trackball Plus is supplied by a plug-in adapter.

Six user switches are provided for flexibility with menu-driven software like Autocad and other CAD/CAM applications. A unique alternate cursor function, which allows having a current cursor position and switching to a second cursor position, is software-transparent and is actuated by one of the switches on the unit. Easy configuration is made possible, without setup utilities, via the user switches, which feature tactile feedback and easy-reach semicircular positioning.

Trackball Plus interfaces to any RS-232 computer interface via a DB-9 or DB-25 connector. It features six automatic communication rates from 300 to 19.2K baud. The high-resolution device supports "drag" functions and downloadable auto-scaling and other parameters. Its space-saving design measures just 5.37 x 4.62 inches. \$95.

CIRCLE 16 ON FREE INFORMATION CARD

Automatic Wet/Dry CD Disc Cleaning

Signet's Model SK35 offers a best-of-both-worlds way to clean compact discs. Resembling a portable CD player, the system contains two cleaning pads that are designed to automatically clean CDs in both wet and dry form.

To clean a compact disc, a few drops of the supplied cleaning fluid are applied to the wet cleaning pad. The disc is dropped into the SK35. Closing the case and pressing a button starts the cleaning operation, with the wet cleaning pad scrubbing the disc's surface in a radial cleaning motion for 15 seconds. The wet cleaning pad then automatically re-



tracts and is replaced by a dry cleaning chamois-type pad that polishes the disc in the opposite direction for about 25 seconds.

CIRCLE 17 ON FREE INFORMATION CARD

Chip Resistor Kits

Designers who need small quantities of thick-film chip resistors should be able to find what they need in three chip resistor design kits now available from Bourns, Inc. (Riverside, CA). Each kit contains 50 different resistance values, with a strip of 25 chip resistors for each value. Product specifications and applications information are included.



Available kits include: H-810/CR1206 Series, which contains 1/8-watt, 1% tolerance chips; H-811/CR1206 Series, which contains 1/8-watt, 5% tolerance chips; and H-812/CR0805 Series, which contains 1/10-watt, 5% tolerance chips. Each kit is supplied in a loose-leaf binder. All devices feature an anti-tombstoning design, with wide bottom termination electrodes and what is claimed to be the industry's tightest tolerance on this dimension. \$75 and up.

CIRCLE 18 ON FREE INFORMATION CARD

Remote Control (E)EPROM Programmer

Writer-RX from Bytek Corp. (Boca Raton, FL) is a new 8085-based stand-alone workstation that provides the user with an inexpensive method of programming most commercially available EPROMs and EEPROMs when connected to any computer terminal or IBM PC-compatible computer. All voltages and waveforms required are generated under software control, eliminating the need for personality modules and adapters. Included is Bytek's IBM PC Software, PROMsoft, that further expands the capabilities of the programmer. PROMsoft has the ability to issue commands to and control the operation of the Writer-RX through its RS-232 interface. The program is menu driven and displays data through five information windows.



With its standard 32K bytes of RAM, Writer-RX lets you load the data once and program repetitively from memory. You can save the data stored in your master devices into binary files and then program directly from the files. Device operations include load program, compare, read, verify, edit, display, blank check, etc. System operations include transfer, file, serial in (download) and serial out (upload).

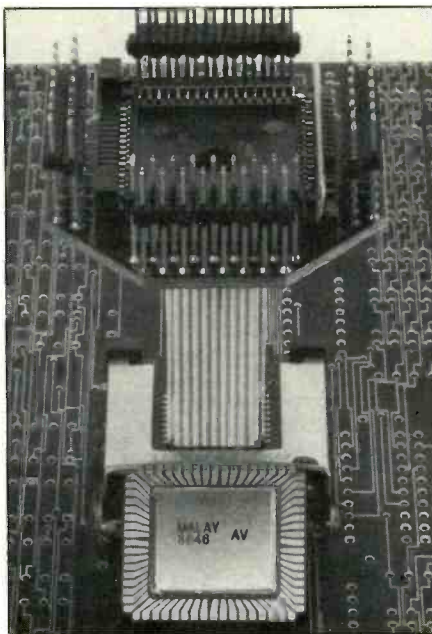
Standard features include: a single 28-pin ZIF socket; ability to program all 2716 through 27256 EPROMs and 2816 EEPROMs in a single pass and 27512 EPROMs in two passes; fast intelligent algorithms; 12 popular formats; baud

rates from 110 to 9,600; and a bi-color pass/fail LED indicator for socket status. The programmer measures 10.5 x 7.5 x 3.7 inches and weighs 4 pounds. \$345.

CIRCLE 58 ON FREE INFORMATION CARD

Test Adapter For Socket-Mounted LCCs

A new series of test adapters that provide accessible points for testing socket-mounted leadless chip carriers (LCCs) has been introduced by Pomona Electronics (Pomona, CA).



The adapters mate with the installed LCC socket at one end and accept the LCC under test at the other end. Both ends are interconnected pin for pin. Chip carrier output signals are accessed via 0.025" square pins that are spaced on 0.100" centers. A supplied nonconducting template that fits over the adapter's test pins identifies LCC pins. A claimed major benefit of the new adapters is the reduced setup capacitance and inductance achieved as a result of using a circuit board replacing the LCC in the socket.

Three models are available: Model 5445 for 44-pin LCCs, Model 5447 for 68-pin LCCs and Model 5448 for 84-pin LCCs.

CIRCLE 59 ON FREE INFORMATION CARD

HAM RADIO IS FUN!

It's even more fun for beginners now that they can operate voice and link computers just as soon as they obtain their Novice class license. You can talk to hams all over the world when conditions permit, then switch to a repeater for local coverage, perhaps using a transceiver in your car or handheld unit.



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CIRCLE 37 ON FREE INFORMATION CARD

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New Logic Function Symbols

Here is what these latest graphic symbols mean and why they are now being used in many data books and schematics

By Jan Axelson

To the surprise (and confusion) of many readers who refer to manufacturers' data books for information, different graphic symbols are used to portray logic functions. In these new symbols the familiar shapes of AND and OR gates may not be seen. Instead, digital logic can be illustrated by rectangular symbols that contain a variety of other special symbols and notations. Texas Instruments, for example, use these modern symbols in their data books while also illustrating logic diagrams with the well-known symbology.

What are the new graphic symbols, and why and where are they used? The following article answers these questions. In addition, by decoding the symbols for three different ICs, you'll learn how to go about interpreting the graphics symbol for just about any logic chip.

A New Logic Language

Why develop a whole new graphic language when one already exists? The reason rests on the fact that functions and capabilities of integrated circuits are becoming more and more complex. Consequently, it's becoming very difficult to draw a logic diagram that describes both fully and completely how a particular IC behaves.

Realizing this, the IEEE (Institute of Electrical and Electronics Engineers) developed a new standard for symbols that could show the functions and behavior of any logic cir-

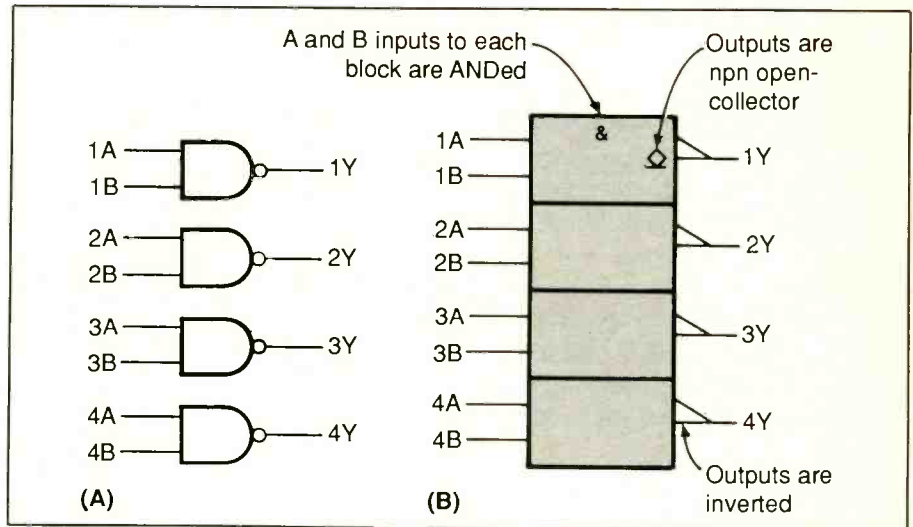


Fig. 1. The newer logic symbol in (B) represents the same device as the logic diagram in (A) does. Each rectangle in the logic symbol represents a dual-input NAND gate.

cuit much more concisely. The new standard (ANSI/IEEE Std 91-1984 and IEC Publication 617-12) was written to be compatible with the recommendations of the IEC (International Electrotechnical Commission), whose standards are followed world-wide. Contributors included members of industry, government, and education.

The new logic symbols can portray the functions of complicated logic circuitry in detail, yet compactly. In contrast, "old-style" logic diagrams often require a maze of connections among logic gates and other circuit elements. To understand how a device operates, you often find yourself laboriously tracing a signal through the maze.

A space-saving alternative way to portray a device is to draw a simple rectangle and label the inputs and

outputs. But this doesn't tell you very much about how the circuit behaves—you have to go back to the data sheet to find out more.

The new logic symbols offer a third choice. They're concise because many functions can be described by a single symbol within the main logic symbol, and related signals are coded to show how they affect each other. Also, logic symbols can give you more information—there are notations to represent open-collector, open-emitter, and three-state outputs, for instance.

(From here on, I'll refer to the "old-style" drawings as logic diagrams, and to the "new-style" drawings as logic symbols.)

The official document describing the new symbols is called Graphic Symbols for Logic Functions. As standards go, this one is easy to un-

derstand and use. It includes full definitions of terms used, many examples, and much more detail than this brief article does.

Single copies of the full standard cost \$12 plus \$4 shipping and handling, from the American National Standards Institute, Attention: Sales Department, 1430 Broadway, New York, NY 10018. Ask for ANSI/IEEE standard 91-1984. Also, a helpful summary of the symbols and their meanings can be found in *The TTL Data Book*, Volume 1, 1984, from Texas Instruments.

Decoding a Symbol

How do you interpret the new symbols? A logic symbol is made up of two, or sometimes three, elements: the outline, qualifying symbols and, optionally, dependency notation. Each of these elements has its own symbolic language. In addition, inputs and outputs are normally labeled on the symbol.

Let's look at an example. Figure 1 shows both the logic diagram and the logic symbol for a 7403 quadruple NAND gate. The logic diagram consists of four familiar NAND gate symbols and their inputs and outputs.

In the logic symbol, the outline is four rectangles stacked vertically. Unless arrows indicate otherwise, inputs are assumed to be, as here, on the left, and outputs on the right. The particular dimensions of the rectangles aren't significant. However, the fact that the rectangles are stacked vertically—perpendicular to the left-to-right signal flow—is significant. It tells you that there is no logic connection between the blocks and that each block functions independently.

The logic symbol for the 7403 uses three different qualifying symbols. Qualifying symbols are notations that describe logic characteristics affecting the inputs, outputs or overall characteristics of a logic circuit.

Table I shows some of these as specified by the standard. Many of the symbols represent functions that

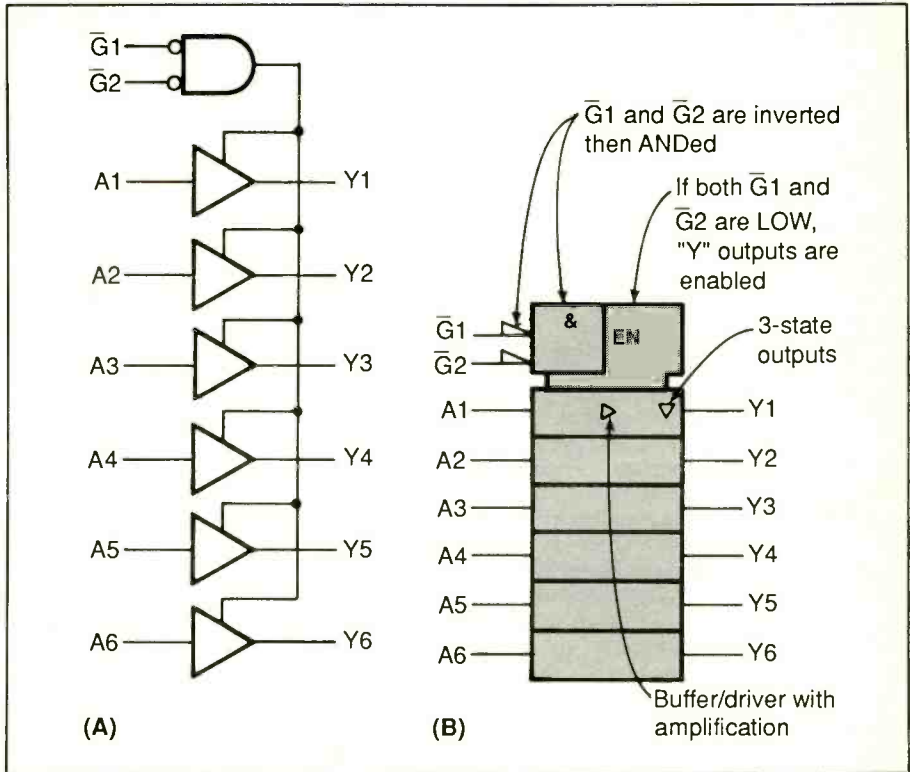


Fig. 2. The familiar logic diagram for a 74365 hex bus driver is shown in (A), the logic symbol in (B). The distinctively shaped common control block in the logic symbol contains the signals that enable the six drivers.

are difficult to portray concisely using the traditional logic gates. By using a qualifying symbol, you can describe a logic operation without showing every circuit element and connection involved.

One qualifying symbol in Fig. 1 is easy to guess the meaning of: the & means that the two inputs to each block are ANDed. If there is little chance for confusion, a symbol that applies to all blocks in a row need be included only in the top block. In this example, you can assume that the & applies to all four rectangles.

The triangular symbols at each output tell you the outputs are active-LOW, or inverted. Combine these inverters with the AND function and you have four NAND gates.

The other qualifying symbol in the top block indicates NPN open-collector outputs. This is the kind of information that is helpful to have included in the logic symbol; you no

longer have to search through the data sheet to ferret out such details.

From this example, you can come up with ways to portray similar circuits. To draw the symbol for a quad NOR gate, replace the AND symbol with the symbol for an OR gate. To show AND gates, leave out the inverting triangles. And so on.

Pin numbers can be added to the symbol if desired. Power supply connections can also be shown, using the symbol for non-logic connections (see Table I).

Finally, you may be relieved to learn that the NAND-gate symbols in 1A aren't forbidden by the new standard. Either system is allowed—it's up to you to choose the appropriate symbols for a particular situation.

Common Control Blocks

Drawing or reading the logic sym-

Table I—General Symbols

GENERAL SYMBOLS	
SYMBOL	FUNCTION
&	AND gate
≥ 1	OR gate
= 1	EXCLUSIVE-OR gate
▷	Buffer/driver with amplification
∟	Schmitt trigger; input with hysteresis
X/Y	Coder (example: BIN/BCD)
MUX	Multiplexer
DMUX	Demultiplexer
Σ	Adder
∟	Retriggerable monostable
∟	Astable element
SRG _m	Shift register; m = number of bits (example: SRG 4)
CTR _m	Counter; m = number of bits (example: CTR 8)
ROM*	Read-only memory; * = number of addresses and bits (example: ROM 256 X 4)
RAM*	Random-access memory, *number of addresses and bits (example: RAM 256 X 1)
⎓	Negated input (external 0 causes internal 1) specify (positive logic: LOW = 0, HIGH = 1) or (negative logic: HIGH = 0, LOW = 1)
⎓	Active-LOW input (same as ⎓ in positive logic)
⎓	Dynamic input, transition causes temporary logic 1
J	J input to JK flip-flop
K	K input to JK flip-flop
R	Reset
S	Set
T	Toggle
D	Data input to storage element (flip-flop, shift register, etc.)
EN	Enable input
∟	Analog input
⊗	Non-logic connection (such as to power supplies)
SYMBOLS DESCRIBING OUTPUTS	
⎓	Negated output (internal 1 causes external 0) (specify positive logic or negative logic)
∟	Active-LOW output (same as ⎓ in positive logic)
⊗	NPN open-collector output, or equivalent
⊗	NPN open-emitter output, or equivalent
∟	Three-state output
∟	Postponed output (change in state delayed until initializing input returns to its original state)

bols for simple logic gates is relatively straightforward. A symbol that's a little more complex is the one describing a 74365 hex bus driver, shown along with its logic diagram in Fig. 2. The outline of the logic symbol is made up of six matching rectangles topped off by a distinctively shaped common control block. And the common control block has another rectangle embedded in it.

The common control block is identifiable by its indentations at the bottom (or top, if that's where it attaches to the rest of the circuit). The inputs to a common control block affect the signals in the blocks in the

row attached to the control block's indented end.

The symbol shows that G1 and G2, the inputs to the control block, are inverted, and the & tells you that the two inverted inputs are then ANDed inside the chip.

Note that the two blocks making up the common control block have a vertical side in common. This tells you that there *is* a logic connection between the blocks. When the output of the AND function is active (logic 1), the Enable function is also active, and the six Y outputs are enabled.

Common control blocks might have any of a number of functions

besides Enable. Counter (CTR), Shift Register (SRG), and Multiplexer (MUX), all functions that may affect several circuit elements at once, are just a few.

Two other qualifying symbols complete the logic symbol. The triangular symbol in the center signifies a buffer or driver with amplification. The downward-pointing triangular symbol at Y1 tells you that the outputs are three-state: When enabled, they are either HIGH or LOW. Otherwise, they are in a state of high impedance. Again, the symbols in the top driver block apply to the blocks below them—each of the six blocks represents a driver with three-state output.

Dependency Notation

Figure 3 shows the logic diagram and logic symbol for a 74LS378 hex D-type flip-flop. This symbol introduces the one type of notation we haven't yet seen—dependency notation. Dependency notation describes functions that affect only some of a circuit's signals.

Many functions, such as AND and Enable, can be portrayed with either qualifying symbols or dependency notation. But dependency notation is unique because each notation includes a code to indicate which inputs and outputs are affected. If an enable input affects a particular signal, the enabling input can be labeled EN1 and the enabled signal labeled 1 to show the relationship.

The position of the numeric code in the label distinguishes the affecting, or controlling, signal from its affected, or controlled, signals. In the affecting signal, the identifying number follows the dependency label (as in C1). In the affected signal, it precedes the signal label, if one is present (as in 1D). Any convenient numeric code can be used, as long as a different number is chosen for each dependency effect in the symbol.

In all, eleven kinds of dependency

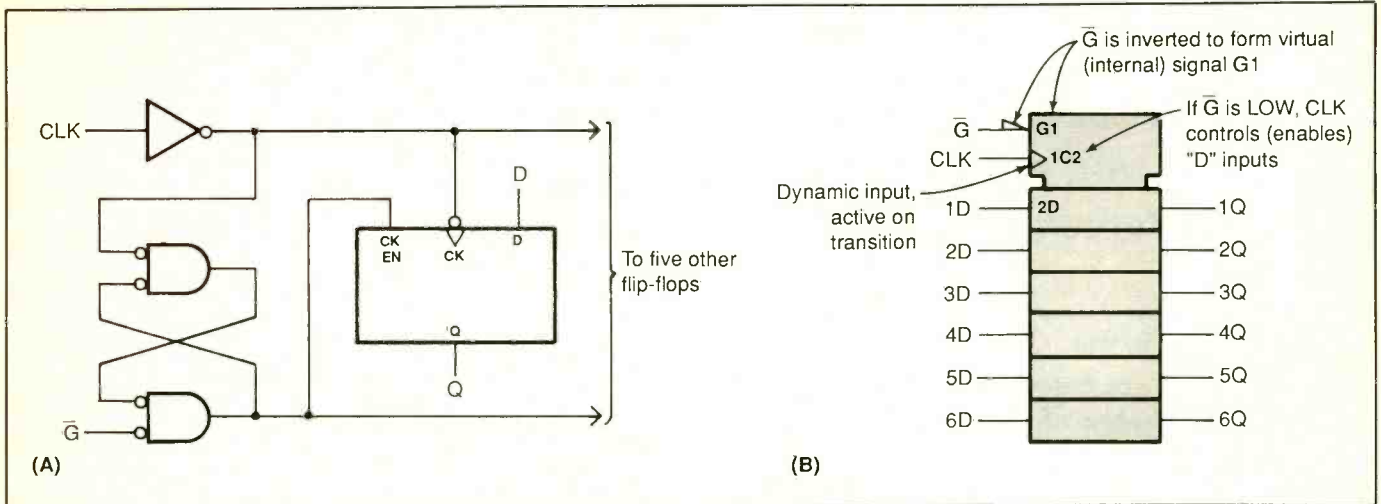


Fig. 3. In the logic symbol for the 74LS378 hex D-type flip-flop, signals G1, 1C2, and D2 are coded to show which signals they affect and/or are affected by.

notation are specified by the standard. They're listed in Table II. The symbol for the 74LS378 uses two of these: AND (G) and Control (C) Dependency.

Examining the symbol tells you just what effects the dependency no-

tations describe in the circuit. The label G1 describes the virtual, or internal, signal created by the negated G input. Inside the outline, signals labeled 1 are active only when G is LOW. The affected signal in this case is 1C2, at the CLK input.

In turn, the 2 in 1C2 tells you that CLK controls inputs labeled 2D inside the outline. Again, because the bottom five blocks are unlabeled, you can assume that the notation 2D applies to all six flip-flops. (Be careful here not to confuse the qualifying symbol 2D, which applies to each of the six flip-flops, with the input label 2D, which identifies the second flip-flop.)

The triangular symbol at CLK means that CLK is a dynamic input: When CLK changes state from LOW to HIGH, the rising edge of CLK causes a transitory, or temporary, logic 1 at 1C2. So in all, the symbol tells you that when G is low, the rising edge of CLK transfers the data at the six inputs to their corresponding outputs.

Other types of dependency notation show OR, exclusive-OR, mode select (such as count up and count down), and other functions. The R and S dependency notations specify what happens in a bistable when both Set and Reset are HIGH. An output that is affected by two or more dependencies is analyzed by determining the effects of the dependencies from left to right as shown on the symbol.

(Continued on page 92) ➔

Table II—Dependency Notations

Symbol	Type	Result when affecting input =		Comments
		Logic 1	Logic 0	
Boolean Functions				
G	AND	Does not alter state	Logic 0	Acts like an AND gate
V	OR	Logic 1	Does not alter state	Acts like an OR gate
N	Negate	Complements logic state	Does not alter state	Acts like an Exclusive-OR gate
Enable Functions				
C	Control	Permits action	Prevents action	Produces an action
EN	Enable	Permits action	Prevents action	Has a single preparatory effect
M	Mode	Permits action	Prevents action	Has alternative effects
A	Address	Permits action	Prevents action	Selects an address
Bistable Functions				
R	Reset	Acts as if S = 0, R = 1	No effect	In bistables, specifies result when R = S = 1
S	Set	Acts as if S = 1, R = 0	No effect	
Other Functions				
X	Transmit	Path established	No path established	Forms transmission path
Z	Interconnect	Logic 1	Logic 0	Indicates a logic connection

512K Hardware RAMdisk

Super-fast, non-mechanical logical "drive" for PCs uses no system memory

By Stuart R. Ball

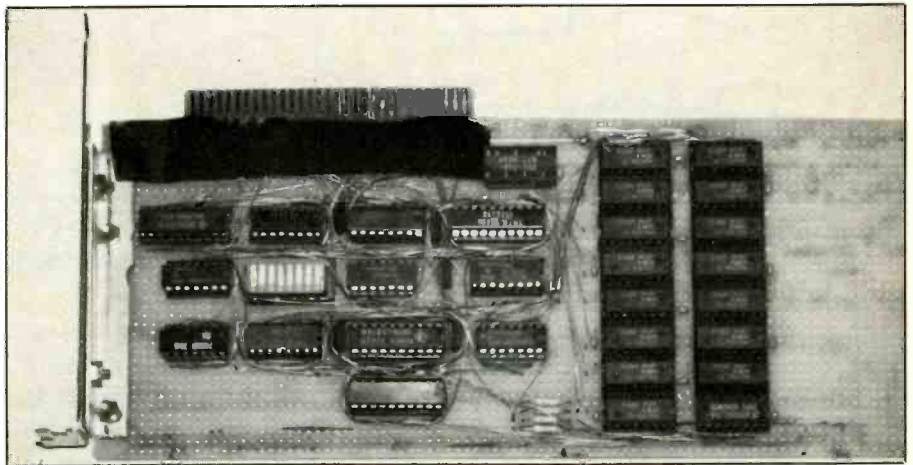
How would you like to have a half-megabyte of super-fast RAMdisk in your IBM PC or compatible computer? "Sure," you say, "and in my 512K machine, that leaves me exactly zero bytes of memory for everything else." This might be true if the traditional software approach is used to set aside a block of system memory to be used as a RAMdisk. However, the 512K Hardware RAMdisk to be described is implemented in *hardware*, using its own block of dedicated memory that is accessed through the computer's I/O space. Therefore, it uses *no* system memory. The only "software" needed to implement it in your system is a device driver that tells DOS to recognize its existence and use it as another logical drive.

Since our Hardware RAMdisk drive is entirely electronic, it has a great speed advantage over a mechanical disk drive. There is no waiting for motors to come up to speed, a head to step to the desired track, and so on. With a hardware RAMdisk, data access and retrieval occur virtually instantly.

Background

The MS-DOS computer operating system permits the user to add peripherals to his system, using a device driver implemented in software. The device driver is a program, usually written in assembly language, that controls some peripheral device and uses a standard protocol to communicate with DOS.

Since DOS allows each device



driver to set aside as much memory as it needs to perform its task, a driver can emulate a disk drive by reserving for itself a large block of memory (180K being a common amount) and partitioning the memory into "sectors." Of course, the disadvantage of taking this tack is that the reserved block of memory is no longer available for use by the application program being run.

Because DOS does not care where the device driver stores its data, it is possible to implement a fast RAMdisk that is accessed entirely through the system's I/O (input/output) space. Doing this leaves *all* of the system's RAM memory free for use by the application program.

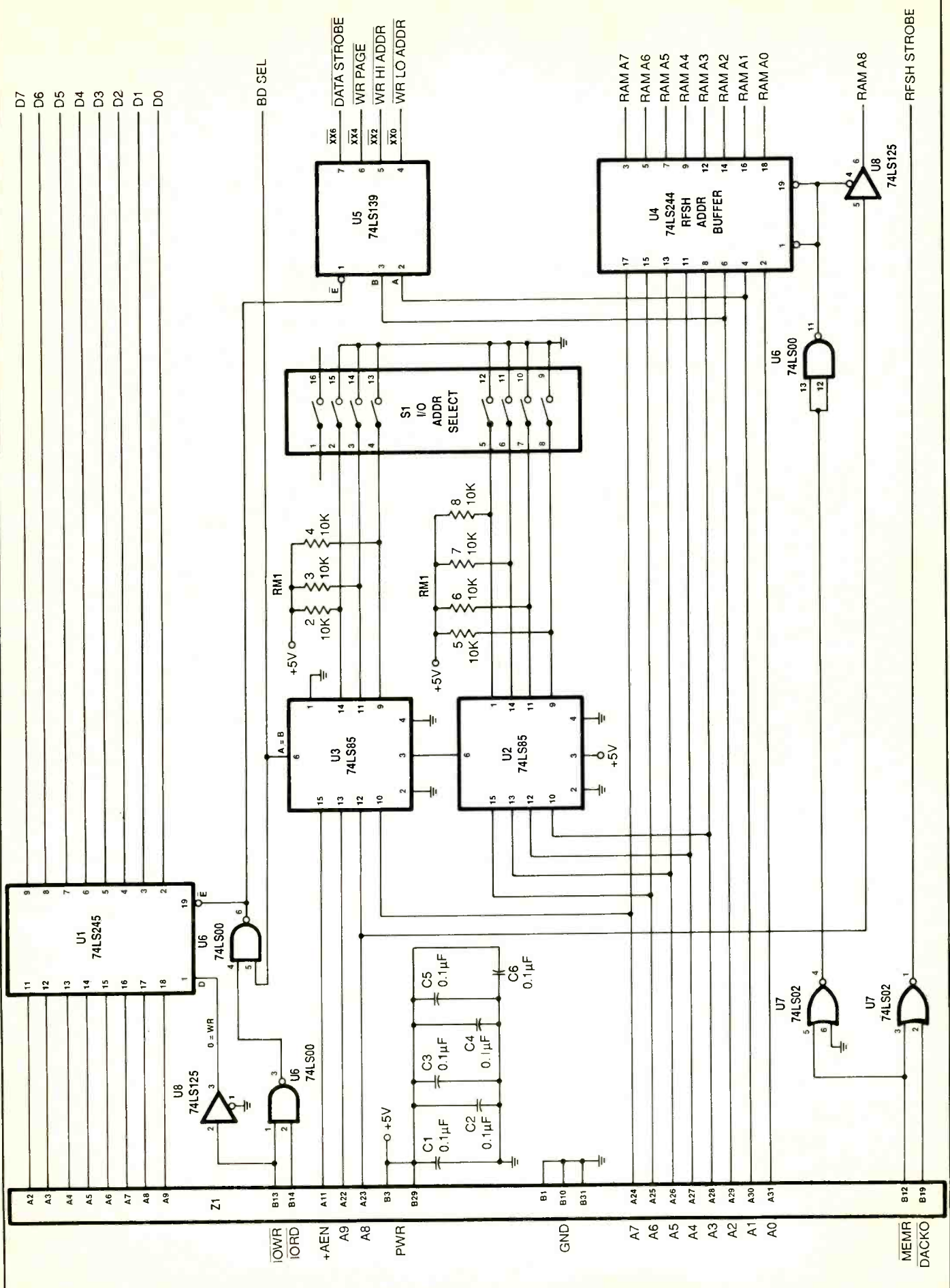
The 8088 microprocessor used in the IBM PC and compatible computers can access a memory space of 1M byte plus an additional I/O space of 64K bytes. However, because of the constraints in the design of the PC/XT, the PC can use only 1K of this 64K I/O space. The Hardware

RAMdisk occupies eight of these 1,024 locations. A device driver for the Hardware RAMdisk accesses this I/O space to read and write data.

Of the eight locations reserved by the Hardware RAMdisk, only four are actually used: Low Address, High Address, Page Register and Data Port. The RAMdisk's memory is partitioned by the device driver into sectors, just as it would be if the disk were implemented in software. The difference is that the software RAMdisk accesses a sector by deriving the address of the sector and reading or writing the block of memory corresponding to that sector.

The Hardware RAMdisk derives the address and then writes the address to the four I/O ports to access the memory. Nineteen address bits are required to access 512K of RAM

Fig. 1. "Input" end of Hardware RAM disk. Long vertical bar at left details computer's expansion-bus connector contacts used in project.



PARTS LIST

Semiconductors

U1—74LS245 octal bus transceiver
 U2,U3—74LS85 4-bit magnitude comparator
 U4—74LS244 tri-state octal buffer
 U5—74LS139 octal D flip-flop
 U6—74LS00 quad 2-input NAND gate
 U7—74LS02 quad 2-input NOR gate
 U8—74LS125 tri-state quad buffer
 U9,U10—74LS374 octal D flip-flop
 U11—74LS175 dual D flip-flop
 U12—74S02 quad 2-input NOR gate
 U13 thru U28—41256-15 150-ns, 256K × 1 dynamic RAM

Capacitors

C1 thru C3—0.1- to 0.01- μ F disc capacitor (see text)

Resistors

R1 thru R4—33-ohm, $\frac{1}{4}$ -watt, 5% tolerance
 RN1—10,000-ohm × 9 SIP resistor network (or individual 10,000-ohm, $\frac{1}{4}$ -watt, 5% tolerance resistors)

Miscellaneous

DLY1—Delay line in dual in-line package (Nytronics No. DDL-200; Valor No. DL1914; Sprague No. 65Z14A200; Belfuse No. 0447-0200-20; or Delta Delay Devices No. DDU-66-200—see text)

S1—8-position DIP switch

PC-type plug-in prototyping board; sockets for all ICs; Wire Wrap or soldering hardware; wire; solder; etc.

Note: A 5.25-inch floppy disk that contains the software needed to implement the Hardware RAMdisk is available for \$10 plus \$1.50 P&H from: Stuart R. Ball, 741 Okie Ridge, Yukon, OK 73099. Also, Mouser Electronics (2401 Hwy. 287 N., Mansfield, TX 76076; tel. 817-483-4422) has four delay lines that should work for DLY1. Part Nos. (from Catalog No. 557) are: ME461-42A5201, ME461-42A5101, ME461-31A5251 and ME461-31A5151.

memory. The Low Address port is a register that is written with the least-significant eight bits of the memory address. The High Address register gets the next eight bits of the address. Collectively, these sixteen bits permit access to 64K of memory.

The most-significant address bits are written to the 4-bit page register. The fourth bit of the page register

controls whether the memory access will be a read or a write operation. The Data Port accesses the actual memory. By writing the nineteen address bits to the address registers, any location in the 512K RAM space can be accessed through the Data Port.

Our Hardware RAMdisk uses 41256 dynamic random-access memory (DRAM) chips that are arranged in a 245K × 1 format for memory storage. DRAMS like the 41256 employ multiplexed addressing. Because the 41256 DRAM has only nine address lines to access 256K locations, these lines contain two addresses during a single access. The first nine bits applied to these lines are the *row* address, the second nine bits the *column* address. The Hardware RAMdisk multiplexes the addresses onto the RAM address lines when the Data Port is accessed.

Of course, a dynamic memory device must be "refreshed" periodically to prevent loss of the data written into it. The PC and its compatibles uses a direct memory access (DMA) channel to provide refresh for the memory system. The Hardware RAMdisk uses this system refresh to maintain the data in the RAM chips. Hence, anything that stops the system from refreshing its RAM memory will also stop refresh to the RAMdisk.

About the Circuit

Due to its large size, the schematic diagram of the Hardware RAMdisk is shown here in two parts, Figs. 1 and 2. Connection of the Hardware RAMdisk to the computer is via the long vertical connector shown at the left in Fig. 1. In this circuit, 4-bit magnitude comparators U2 and U3 decode the bus address and determine when the RAMdisk is accessed. Four of the eight D flip-flops in U5 generate the specific I/O strobes, shown coming off pins 4 through 7, when one of the circuit's addresses is accessed.

Table II—Bus Wiring

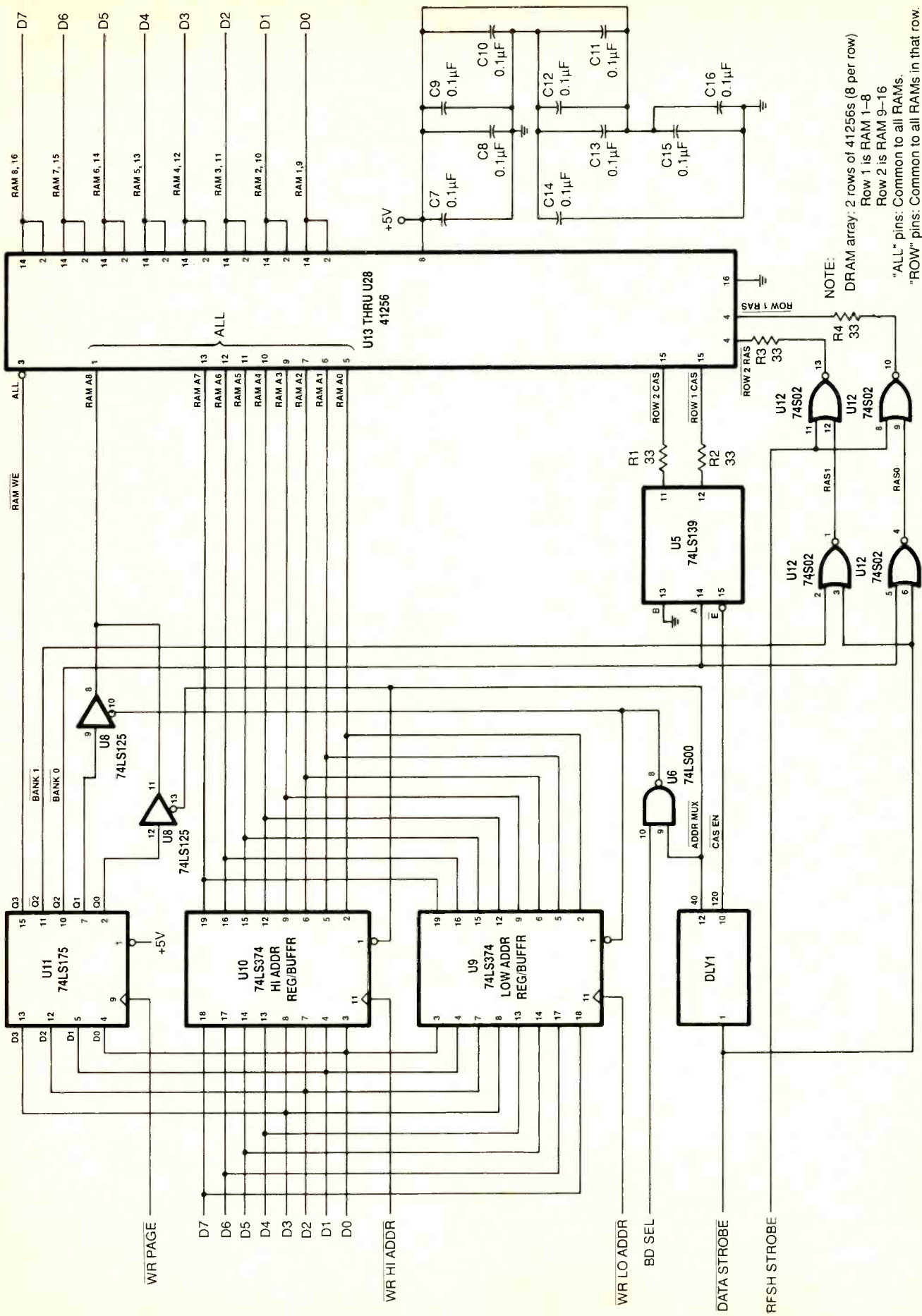
IC No.	+5V Pin	Ground Pin
U1	20	10
U2	16	8
U3	16	8
U4	20	10
U5	16	8
U6	14	7
U7	14	7
U8	14	7
U9	20	10
U10	20	10
U11	16	8
U12	14	7
U13-U28	8	16

Tri-state octal buffer U4 then multiplexes the address lines into RAM chips U13 through U28 by tying the RAM0 through RAM 8 outputs from U4 and U8 to the pins of the RAMs (Fig. 2) with the same labels.

Referring to Fig. 2, octal D flip-flops U9 and U10 latch and multiplex the low and high addresses onto RAM when the Data Port is accessed. The low address is enabled when the Hardware RAMdisk is selected, and the RAM $\overline{\text{RAS}}$ (row address strobe) occurs when the $\overline{\text{IORD}}$ or $\overline{\text{TOWR}}$ occurs on the bus. The row address is disabled and the column address is enabled 40 nanoseconds after $\overline{\text{RAS}}$ occurs, followed 80 nanoseconds later by the $\overline{\text{CAS}}$ (column address strobe), which strobes the data into or out of the RAM. The remaining four flip-flops in U5 select which bank of RAM will receive a $\overline{\text{CAS}}$ strobe.

Whenever the system DMA is refreshing memory, $\overline{\text{DACK0}}$ is active. This causes U4 to drive the bus address lines, A0 through A8, onto the RAM address lines, which provides

Fig. 2. Remainder of Hardware RAMdisk circuit. Note that lines labeled D0 through D7 and RAM A0 through RAM A8 tie together and back to same points in previous circuit.



NOTE:
 DRAM array: 2 rows of 41256s (8 per row)
 Row 1 is RAM 1-8
 Row 2 is RAM 9-16
 "ALL" pins: Common to all RAMs.
 "ROW" pins: Common to all RAMs in that row.

the refresh address. Some time after DACK0 goes active, the DMA asserts the MEMR signal, causing a RAS to be sent to both banks of RAM. Neither bank of RAM receives a CAS during the refresh cycle.

The primary disadvantage of using I/O space to address memory is loss of speed as compared with a RAMdisk implemented entirely in software and using the computer's existing user memory. A software RAMdisk merely accesses a memory location to read or write data. The Hardware RAMdisk, on the other hand, must use processor cycles to write the address out, followed by the data transfer. The device driver attempts to minimize this overhead by writing out the high address bits only when they need to be updated. Even so, this still cannot match the speed of the software approach.

In the above, the data transfer rate of the Hardware RAMdisk is about equivalent to that of a floppy-disk drive. Too, it does not have the step/seek overhead of a floppy drive, which is where much of the wasted operating time is spent, anyway. For example, a 70K .EXE file copied from one floppy disk to another took a bit more than 16 seconds to complete with the prototype of the Hardware RAMdisk in a typical computer. The same file copied with the RAMdisk installed in the same computer took only 7 seconds to copy the same file, or approximately half the time it took to accomplish the same thing with actual floppy disks.

Time is saved using the Hardware RAMdisk because the overhead associated with the destination drive is eliminated, as is some of the overhead associated with switching between drives. What accounts for lost time with regard to the latter is that, to switch drives, the source drive must be turned off, the destination drive must be turned on, and then the system must wait for the destination drive's motor to come up to speed before writing data to it. Then the

Line	From	To
RAM A0	U4 Pin 18	U13-U28 Pin 5
RAM A1	U4 Pin 16	U13-U28 Pin 6
RAM A2	U4 pin 14	U13-U28 Pin 7
RAM A3	U4 Pin 12	U13-U28 Pin 9
RAM A4	U4 Pin 9	U13-U28 Pin 10
RAM A5	U4 Pin 7	U13-U28 Pin 11
RAM A6	U4 Pin 5	U13-U28 Pin 12
RAM A7	U4 Pin 3	U13-U28 Pin 13
RAM A8	U8 Pin 6	U13-U28 Pin 1
D0	U1 Pin 2	U10 Pin 3, U13 & U21 Pins 2 & 14
D1	U1 Pin 3	U10 Pin 4, U14 & U22 Pins 2 & 14
D2	U1 Pin 4	U10 Pin 7, U15 & U23 Pins 2 & 14
D3	U1 Pin 5	U10 Pin 8, U16 & U23 Pins 2 & 14
D4	U1 Pin 6	U10 Pin 13, U17 & U23 Pins 2 & 14
D5	U1 Pin 7	U10 Pin 14, U18 & U24 Pins 2 & 14
D6	U1 Pin 8	U10 Pin 17, U19 & U27 Pins 2 & 14
D7	U1 Pin 9	U10 Pin 18, U20 & U28 Pins 2 & 14

Notes: (1) D0 through D7 lines go to pins on U9 and U11, as well as those indicated here; (2) Find **From** lines in Fig. 1; (3) Find **To** lines in Fig. 2.

whole process must be repeated when switching back to the source drive for the next read. This overhead, along with the time needed for the drive's head to step out to a track and wait for the sector of the disk containing the data desired to pass by, is what makes floppy-disk drives so slow.

Device Driver

The RAMdisk device driver software tells DOS that the "disk" has a 512K capacity, that it uses a nonstandard format, and that it is configured into 512-byte "sectors." To limit the number of sectors required to hold the directory and FAT (File Allocation Table) information, the disk is limited to 64 directory entries and four sectors per allocation unit.

The driver assumes that the RAMdisk is located at addresses 330H through 337H. However, this can be changed by altering the constants for LOADDR, HIADDR, PAREG and DPORT in the source code. Of course, the address-select switch (SI) in the Hardware RAMdisk unit must be set accordingly.

You can configure the Hardware

RAMdisk for 256K instead of 512K of RAM, if you wish. To do this, change the constant of 1023 in the BPB and Boot image tables to 512. This constant defines for DOS the total number of sectors on the disk. For more information on how device drivers in general work, see the DOS technical reference manual.

A RAMdisk diagnostic program was originally written to allow the author to test his prototype Hardware RAMdisk accessory. The diagnostics include tests for static read, static write and full RAM. The static read and write tests just read from and write to location 00000 of the Hardware RAMdisk and are meant to be used with an oscilloscope to verify the RAS/CAS and address multiplexing timing.

The full RAM test checks every location in RAM memory and, if allowed to run continuously, will repeat the test with different data. If the test is allowed to run long enough, every location in RAM will eventually be tested with every possible value.

The diagnostic program prints a menu on the computer's video display screen. From this, you simply

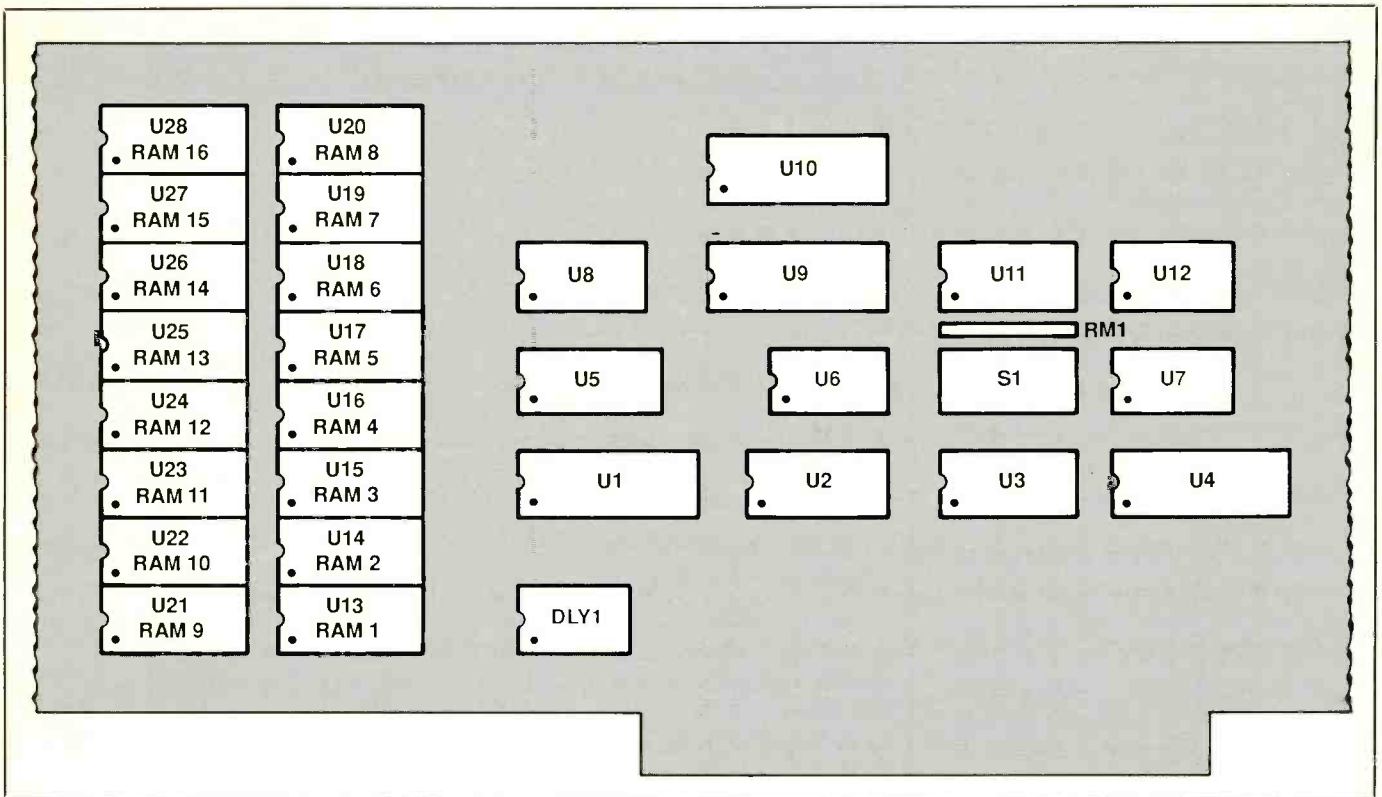


Fig. 3. Suggested component layout on prototyping board that plugs directly in to computer's expansion-bus slot.

select the test you want to run. After this, pressing any key on the computer's keyboard terminates the test.

No messages appear on-screen when you run the static read and write tests. The full test, however, will print a message every time it completes one pass at testing the full 512K of RAM. Each pass takes almost a minute to complete. If you wish to reduce testing time, the full diagnostic test can be made to terminate at the end of a pass (the only time it can be made to do so). Hence, if you press a key to terminate the test, this terminate command will be ignored until the terminate message for the current pass is printed.

Construction

You can build the Hardware RAM-disk on a standard IBM-type prototyping card that plugs into the computer's expansion bus, as illustrated in the lead photo. This gives you the

option of point-to-point wiring the circuit using either Wire Wrap or soldering technique. Whichever technique you choose, use sockets for all ICs, the delay line and the DIP switch. Do not install the ICs in the sockets until after preliminary voltage checks have been performed.

A suggested component layout for the prototyping board is shown in Fig. 3. Begin assembly by installing the IC sockets, four discrete resistors and resistor network (if you wish, you can replace the last with discrete 10,000-ohm resistors) on the board.

Referring to Figs. 1 and 2, wire the +5-volt and ground buses to the various sockets. Though some +5-volt and ground connections for the ICs are shown in the schematics, not shown are the main power-bus connections to them. You must make these connections as follows: +5 volts to pin 14 of all 14-pin sockets, pin 16 of all 16-pin sockets and pin 20

of all 20-pin sockets; ground to pin 7 of all 14-pin sockets, pin 8 of all 16-pin sockets and pin 10 of all 20-pin sockets. Table I summarizes the pinouts for the power buses for the IC devices.

Once the power buses have been wired, wire the rest of the circuit exactly as detailed in the schematics. To minimize the possibility of wiring errors, mark off each wire run as you complete it.

Keep in mind that all RAM A0 through RAM A8 lines in Fig. 1 tie to the same-numbered lines in Fig. 2. The same applies to the data D0 through D7 lines in both circuits. Make the connections between the various ICs as detailed in Table II.

Next, wire into the circuit the 0.1- to 0.01-microfarad bypass capacitors. Install them as close as possible to the +5-volt main power pins of the IC sockets. Though you may not need all the capacitors specified in

the Parts List, you should use at least one for every other RAM chip and another for every two or three TTL chips. Wiring into the circuit a bypass capacitor for every IC device provides maximum insurance against noise on the power bus affecting circuit operation.

A TTL active-type delay line in a standard DIP package is specified in the Parts List. The delay time is not critical, as long as it is between 30 and 50 nanoseconds. If you use a delay line other than those specified, make appropriate changes in pinouts to accommodate it.

Although no attempt was made to implement it, the Hardware RAMdisk should be expandable to accommodate 1 megabyte of RAM storage by using the other two CAS lines from U5 and adding to the page register to address the additional memory. If you decide to make this change, the two new RAS lines will have to share the existing RAS lines, or additional logic must be added to the circuit. Be sure to change the device driver's code if you expand the RAMdisk's memory in this manner.

Checkout & Use

Before you plug any ICs into the sockets on the circuit board, perform voltage tests as follows. With your computer turned off, plug the Hardware RAMdisk board into an unoccupied bus expansion slot in the computer. Power up the computer and connect the common lead of a dc voltmeter (or a multimeter set to indicate dc volts) to a convenient circuit-ground point on the board. Then, while observing the meter's display, touch its "hot" probe to the +5-volt power bus pin of each socket (see Table I for pinouts). Then refer to Figs. 1 and 2 and take readings at the other socket pins shown connected to the +5-volt bus. In all cases, you should obtain a +5-volt reading on the meter.

Switch off power and set your meter to read resistance on a low-ohms

Device Driver Installation

To install the Hardware RAMdisk, after plugging it into a free expansion slot, first make any desired changes in the device-driver software code (available on 5.25-inch diskette from the author for a nominal fee; see the Note at the end of the Parts List) and assemble the code using MASM. Link the code and, when the linker gives a warning that no stack segment is defined, ignore the warning. Run the EXE2BIN program to produce a .COM file:

```
EXE2BIN RAMDISK.EXE  
RDISK.COM
```

Copy the RDISK.COM file to your system disk. If you built the 512K Hardware RAMdisk version and, therefore, have no reason to make changes in the device-driver code, use the RDISK.COM file provided on the program disk, and skip the process of assembling, linking and converting the source file. Just COPY the RDISK.COM file to your system disk.

Your system disk now contains the device driver, but DOS must still be informed that it exists. When DOS is loaded into your computer, it looks on the system disk for a CONFIG.SYS file, which tells DOS to load device drivers. The CONFIG.SYS file will be an ASCII file that contains such statement lines as:

```
DEVICE = file.sys (or file.com)  
DEVICE = file.sys  
etc.
```

(File.sys files are device-driver filenames and can be called anything. The RAMdisk device driver is a .COM file, but it can also be a .SYS file.) You can TYPE your CONFIG.SYS file to the screen just as you can any other ASCII file.

To tell DOS to install the Hardware RAMdisk device driver, you must create a CONFIG.SYS file or, if it already exists, modify it. To create a CONFIG.SYS file if it does not already exist, use a text editor to create a file of the

same name that has just one line in it:

```
DEVICE = RDISK.COM
```

If your system disk already has a CONFIG.SYS file, just add the above line to the end of the existing file. This will install the Hardware RAMdisk as the next drive in the system. If you already have two floppy-disk drives, for example, the Hardware RAMdisk will become drive C:. If you have a hard disk as drive C:, the RAMdisk will become drive D:.

After installing the device driver, just turn power off and then back on or press CTRL/ALT/DEL to reset to install the RAMdisk on the system.

To test the installation, try copying some short text files out to the Hardware RAMdisk drive and then TYPE them to the screen.

Special Note: Some computers—particularly early IBM PCs—did not have provision for an internal hard disk. An external hard disk was sometimes added, requiring a floppy disk to boot the system. If your computer is like this, the system disk is the boot floppy, not the hard disk. The floppy will contain the CONFIG.SYS file, along with the device driver for the hard disk. In this case, the Hardware RAMdisk device driver should be installed on the boot floppy and suitable modifications should be made to the CONFIG.SYS file on the same floppy disk.

If you are already using a software RAMdisk, you might want to remove it from the system by deleting the line in the CONFIG.SYS file that installs it. Of course, you can leave it in and have two RAMdisks. If you do this, the system will install them in the order they are defined in the CONFIG.SYS file.

If your system has two floppy-disk drives and both RAMdisks and the software RAMdisk is installed first, this RAMdisk will be drive C: and the Hardware RAMdisk will be drive D:. DOS always names drives in the order they appear in the CONFIG.SYS file.

(Continued on page 92)



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Lightning Early Warning System

Sounds an audible alert of approaching electrical storms to give you time to protect computer and other electronic equipment from damage



By Tom Fox

A surge-protected multiple-outlet power strip is far from adequate protection for your computer and other electronic equipment when nature unleashes an electrical storm. If you are a typical computer user, cost-effective protection is best taken when you install a lightning arrester at the fuse box, install a surge protector at the computer, and shut off your computer system when an electrical storm approaches. For maximum protection, also pull the plug from the ac outlet until the storm has passed.

The fly in the ointment is that you probably operate in a fairly noisy and isolated environment. Therefore, you may not hear an electrical storm approaching until it is too late to take protective measures. What you need is an audible alert that sounds before atmospheric electrical activity is close enough to fry your equipment. The LEW (Lightning Early Warning) project described here does just that. It can be adjusted to detect a lightning strike as far as 30 miles away. When the alarm sounds, you will have sufficient time to save your files to disk and perform an orderly shut-down. In addition to LEW, a surge-protected power strip you can build that includes a self-

contained thunderstorm detector will also be described.

About the Circuit

Shown in Fig. 1 is the complete schematic diagram of the LEW system, minus its ac power supply. The sensing unit for the system is an inexpensive AM broadcast-band pocket radio. This radio is normally set to a frequency close to 550 kHz on which no radio station is broadcasting. Though designed to receive audio (voice and music) signals, the radio is also quite effective in picking up sferics (see "Detecting Thunderstorms" box for details on sferics).

LEW uses the audio output, taken at the radio's earphone jack, to do what it does. The audio output from the radio is coupled into the LEW system through $C1$, which blocks dc but passes the audio signal from the radio. Resistors $R1$ and $R2$ keep $C1$ from continuously charging, while diode $D1$ rectifies any pulses that get through $C1$. These pulses are used to charge $C2$.

Because of the presence of $D1$ in the circuit and the high resistance at the noninverting input at pin 12 of $IC1$, $C2$ can discharge by either of only two means—through DISCHARGE RATE trimmer control $R5$ or by closing RESET switch $S3$. Normally, $R5$ is used to adjust the rate of discharge of $C2$. However, $C2$ can be instantly discharged by closing $S3$ if needed.

Detecting Electrical Storms

Atmospherics (also known as "sferics") are the electromagnetic radiation (radio waves) produced by the lightning-discharge process. Basically, sferics and static electricity are identical in nature. However, static electricity is a less-precise term because it is often applied to any "noise" a radio receives, whether natural or man-made. The frequency spectrum of sferics produced by lightning ranges from less than 10 Hz to beyond 10 MHz. Apparently, average maximum amplitude occurs in the range between 1 kHz and 1 MHz.

It is relatively common practice for weather enthusiasts, as well as some experienced professional meteorologists, to listen for static on a standard AM broadcast-band radio to determine if an electrical storm is in the vicinity. With experience, one can do more than simply determine if a thunderstorm is in the general area; an experienced listener can know whether a storm is approach-

ing or departing the area, its relative intensity and whether it is increasing or decreasing in intensity.

Listening to an extremely weak station with the radio tuned to a frequency below 700 kHz is probably the optimum way to keep up to date on electrical storm activity. However, this is far from convenient for a computer user who must keep his attention focused on what he is doing at the keyboard, rather than on a radio. This was why the Lightning Early Warning, or LEW, system described in the main text was designed. This electrical-storm monitoring system does all the listening necessary. When it detects electrical activity in the air, it sounds an audible alert that signals the computer operator that it is time to save his current work to disk, perform any backups that are necessary, orderly power down his equipment and pull the power plug from the wall ac receptacle.

The voltage across *C2* is applied to the noninverting input at pin 12 of one of the four operational amplifiers contained inside *IC1*. (Note that only one of the four op amps in this IC is used in this project.) This op amp is wired as a variable-gain non-inverting dc amplifier whose amplification factor is set by GAIN trimmer control *R4*, over a range from about 5 to 55.

The output of this dc amplifier, at pin 14 of *IC1*, is coupled via *R7* and *R8* to the bases of *Q1* and *Q2*, respectively. Transistor *Q1* provides current drive for solid-state buzzer *A1*, while transistor *Q2* provides current drive for light-emitting diode *LED1*. Because the values of base-emitter resistors *R9* and *R10* are dissimilar in the *Q1* and *Q2* circuits, the lower-value resistor will normally cause *Q2* to conduct and turn on *LED1* before *Q1* conducts and turns on *A1*. Even so, sudden intense sferics from a thunderstorm may cause the LED to turn on and the buzzer to sound simultaneously.

Despite its simplicity, the LEW circuit is quite sensitive. If *R4* were to be set for maximum circuit gain, just 40 millivolts across *C2* will cause *LED1* to light. Normally, however, *R4* is set closer to its midpoint to provide a gain of around 20. The circuit's sensitivity is inversely related to the capacitance value of *C2*; so a smaller capacitance will increase the circuit's sensitivity.

Diodes *D2* and *D3* permit the project to be powered by two different sources simultaneously—battery *B1* and an external ac adapter plugged into *J1*. (If you build the combination power strip/surge suppresser described later, you can use its built-in 12-volt dc power supply to power the LEW circuit, instead of the external ac adapter.)

Diode *D2* prevents *B1* from discharging through the ac adapter when the latter is connected to the project but is unplugged from the ac outlet. If *D3* is omitted from the circuit, *B1* can be damaged when the ac adapter is used.

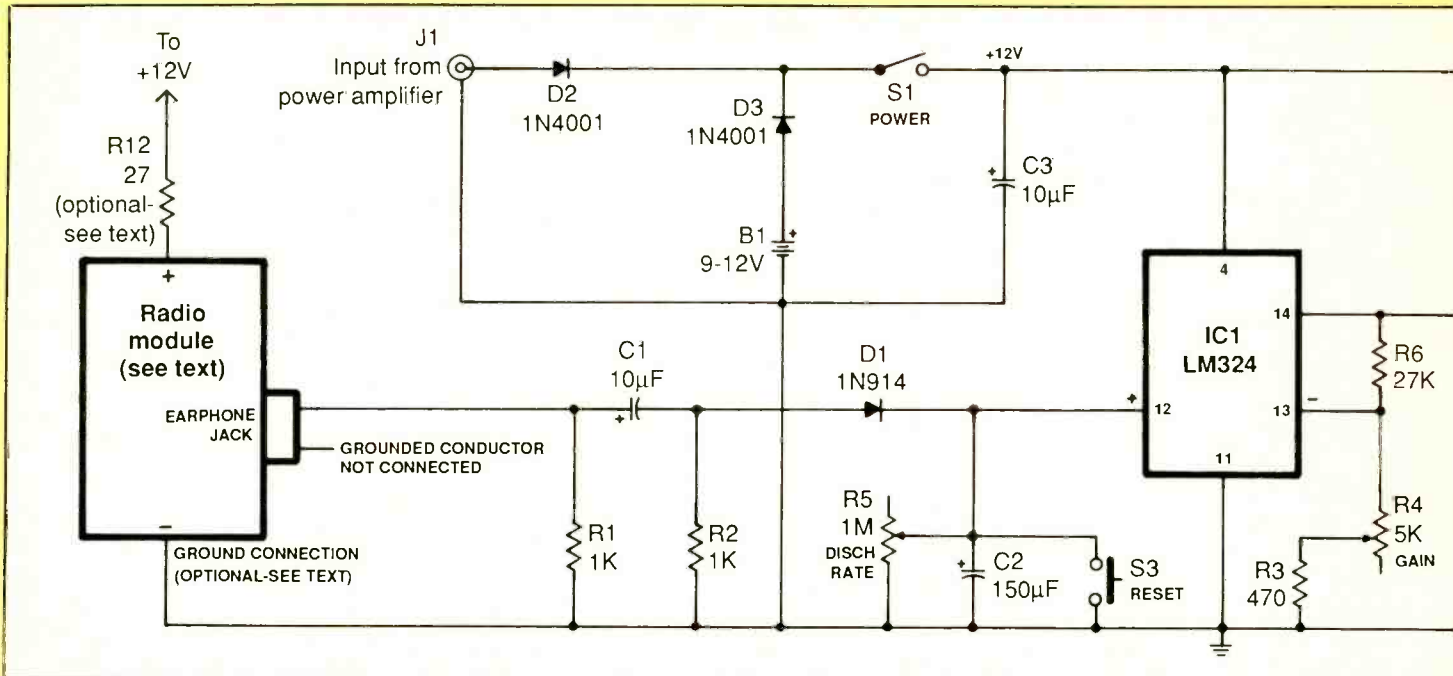
Resistor *R12* drops the system's 12-volt dc supply to a safe 9 volts for use by the radio. This resistor is not necessary if the project is powered by a 9-volt battery. Bear in mind, too, that some pocket radios are designed to be operated from either a 9- or 12-volt supply. If this is the case with the radio you use with the project, omit *R12* from the circuit.

Users who do not have a surge-protected power strip (or even if you have one but it has insufficient ac outlets) can custom-make a surge-protected power strip with built-in lightning alert. The schematic diagram for this accessory is shown in Fig. 2. In addition to an on/off switch, a fuse, a number of ac receptacles, identified as *SO1* through *SO6*, and a surge protector, this accessory includes a built-in 12-volt dc power supply. This supply can be used in place of the ac adapter for the Fig. 1 circuit, if desired. If not, you can eliminate this portion of the combination power strip/surge protector accessory.

A device similar to a MOV (metal-oxide varistor) is the *Z1* device that provides surge suppression across the ac power line. The *ZNR* device, which is optional, is a laser-cut spark-gap that provides surge suppression from the ac line's neutral conductor to chassis ground. This surge absorber is also used in the Heath Company's unique Smart Outlet Box. Most other inexpensive surge-protected power strips use only MOVs for protection.

Though the Fig. 2 circuit shows a full complement of six ac receptacles (*SO1* through *SO6*), you can use fewer if you desire, but not more than six. The fuse used for *F1* should be a fast-blow type. Do *not* use a low-voltage automotive type here.

In the dc power supply, incoming 117 volts ac is stepped down to 12.6 volts ac by power transformer *T1*. This low ac voltage is then converted to pulsating dc by the rectification action of diodes *D1* and *D2* and is



smoothed to dc by filter capacitor C4. Bypassing is provided by capacitors C1, C2 and C3.

Construction

Though the LEW device is fairly sophisticated in design, construction of the project is simple and straightforward. You can assemble and wire the circuit on a printed-circuit board or use perforated board with holes on 0.1-inch centers and suitable Wire Wrap or soldering hardware.

If you wish printed-circuit wiring, you can make your own pc board using the actual-size etching-and-drilling guide shown in Fig. 3. When the board is ready to be populated, orient it as shown in Fig. 4. (Note: If you opt for perforated-board assembly, use approximately the same size board as that shown in Fig. 1 and then use Fig. 4 as a rough guide to component placement and orientation.)

Start wiring the board by installing a 14-pin DIP socket in the IC1 location. Do not install the IC in the socket until after voltage checks have been made. Next, plug into the speci-

fied holes the leads of the fixed resistors and solder them to the copper pads on the bottom of the board. Determine whether or not you need R12 (you do if the AM radio with which the project is used requires a 9-volt dc supply and do not if it will accommodate a 12-volt power supply). If your project needs this resistor, install and solder it into place in the R12 location. If it does not, install and solder into place a solid bare wire in place of the resistor.

Install and solder into place the two trimmer potentiometers. Notice that R4 is a vertical-mount control, while R5 is a flat-mounted type. Once the resistors have been installed, do the same with the capacitors and then the diodes. Observe polarization for the electrolytic capacitors and orientation for the diodes.

Next, install and solder into place the transistors. Make absolutely certain that their leads plug into the appropriate holes before soldering them to the copper pads. Do not mount the solid-state buzzer (A1) in the location indicated just yet.

Strip ¼ inch of insulation from both ends of two 6-inch lengths of

hookup wire, preferably with red and black insulation. If you are using stranded wire, tightly twist together the fine conductors at both ends of both wires and sparingly tin with solder. Plug one end of the black-insulated wire into the hole labeled LED1 K and one end of the red-insulated wire into the unidentified LED1 hole. Solder both into place.

Connection of the AM radio to the LEW circuit is made through its earphone jack. If you do not have a spare earphone plug, use the cable attached to the earphone supplied with the radio, after first cutting off and discarding the earphone assembly. After doing this, carefully strip about ¼ inch of insulation from the cut end of both conductors in the cable.

Because the radio's circuit is already grounded at the negative battery connector, no connection should be made to the ground side of the earphone jack. Therefore, you should clip and tape the cable's ground conductor.

Use an ohmmeter or continuity tester to determine which conductor is connected to circuit ground. To do

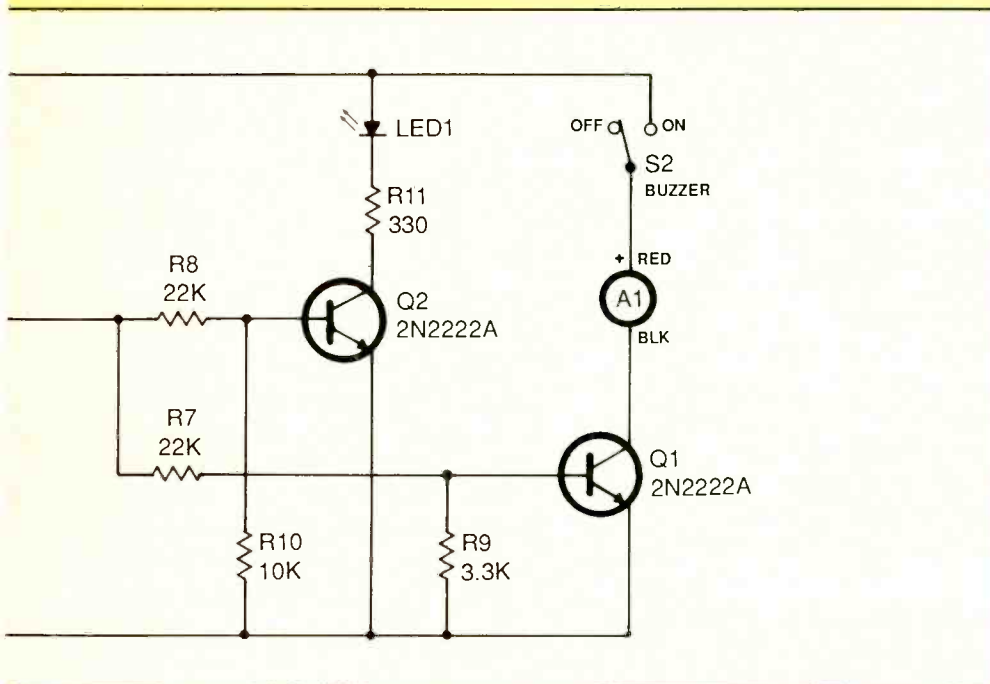


Fig. 1. Complete schematic of the Lightning Early Warning (LEW) device minus its dc power supply.

PARTS LIST (LEW system circuit)

Semiconductors

- A1—Solid-state buzzer
- D1—1N914 silicon diode
- D2,D3—1N4001 silicon rectifier diode
- IC1—LM324 low-power quad operational amplifier
- LED1—Red light-emitting diode
- Q1,Q2—General-purpose npn silicon transistor (2N2222A or equivalent)

Capacitors

- C1,C3—10- μ F, 50-volt electrolytic
- C2—150- μ F, 25-volt electrolytic

Resistors ($\frac{1}{4}$ -watt, 5% tolerance)

- R1,R2—1,000 ohms
- R3—470 ohms
- R6—27,000 ohms
- R7,R8—22,000 ohms
- R9—3,300 ohms
- R10—10,000 ohms
- R11—330 ohms
- R12—27 ohms, 1-watt (see text)
- R4—5,000-ohm, vertical-mount pc-type trimmer potentiometer
- R5—1-megohm, horizontal-mount pc-type trimmer potentiometer

Miscellaneous

- B1—9-volt battery (eight AA cells in series for 12 volts—optional; see text)
- J1—Power adapter jack
- S1,S2—Spst slide or toggle switch
- S3—Momentary action pushbutton spst switch
- Printed-circuit board or perforated board and suitable Wire Wrap or soldering hardware; AM pocket radio (Radio Shack Cat. No. 12-201, 12-202 or 12-203); suitable enclosure; socket for IC1; 12-volt dc power supply (optional; see text); machine hardware; hookup wire; solder; etc.

this, first plug the cable's plug into the radio's earphone jack. Then connect one ohmmeter lead to the radio's negative battery connector and touch its other lead to the exposed wires of first one and then the other cable conductor. Only one conductor connection should yield a short-circuit indication on the meter or audible tone from the continuity tester. This is the ground lead, which should be clipped short to remove any possibility of it being connected back at the LEW circuit.

Since metal will interfere with reception, the enclosure in which the LEW device is housed should be nonmetallic. The one featured in the lead photo is an ABS plastic type that can be obtained from Radio Shack and some mail-order houses. Its 7.5 \times 4.5 \times 2.25-inch dimensions make it an ideal size for the project.

To determine where to drill the mounting holes for the circuit-board assembly, orient the assembly, solder side down and with the buzzer to the left, on the outside of the front panel. Leave enough space between the assembly and left and right edges of the panel on which to mount the

switches where they will not interfere with each other. Use a pencil to mark on the panel where to drill the holes.

Remove and set aside the circuit-board assembly. Then strike light pencil lines horizontally across the panel parallel to each other and centered on the board mounting hole outlines and make cross marks on the centers of the hole marks. Extend the horizontal parallel lines all the way across to the right edge of the panel and continue them down the right wall.

Now measure the horizontal and vertical distances from the top-right board mounting holes to the center of the adjustment slot on horizontal trimmer control R5. Transfer these dimensions to the front panel and make an X mark in the indicated location. Feed a 4-40 \times 1/4- or 1/2-inch machine screw into each of the board's four mounting holes from the solder side of the board. Follow up with a 1-inch spacer on each and a 4-40 machine screw. Now measure how far down from the *nut end* of the spacers and how far from the bottom-right mounting hole is the center of the adjustment slot on ver-

tical trimmer control R4. Transfer these dimensions to the right wall of the enclosure (take into account the thickness of the front panel, which is usually about $\frac{1}{16}$ to $\frac{3}{32}$ inch).

You now know where to drill the board's mounting holes in the front panel and the access holes to the ad-

(Continued on page 82) \blacktriangleright

A Live-Well Timer

Controls on/off time to adjust oxygen content in live-well water to keep fishing catch alive

By James H. Brown

Have you ever placed the fish you caught in your boat's live well only to find at the end of the day that your catch is no longer alive? If so, your fish died of oxygen starvation or too much free oxygen in the water because you forgot to switch on or off the pump's motor at the appropriate times. Of course, you could purchase a commercial timer that will relieve you of having to remember when to switch on and off the pump for about \$30. However, you can build the timer described here for about \$10 and pocket the \$20 saved for other things.

Our Live-Well timer is a fairly simple device in terms of circuitry. It has only two controls. One is a switch that lets you select between fully automatic and manual operation of the live-well pump or turning off the system altogether. The other is a control that lets you adjust the timer's duty cycle so that it turns on the pump for about 32 seconds every 1.5 to 6 minutes. Power for the circuit is supplied by your boat's 12-volt dc electrical system.

About the Circuit

Shown in Fig. 1 is the complete schematic diagram of the Live-Well Timer. The main elements in this circuit are 555 timer *IC1* and the TIP120 power Darlington transistor. The timer is wired to operate in the astable mode and has a duty cycle of approximately 32 seconds for its on time and an adjustable off time between 1.5 and 6 minutes.

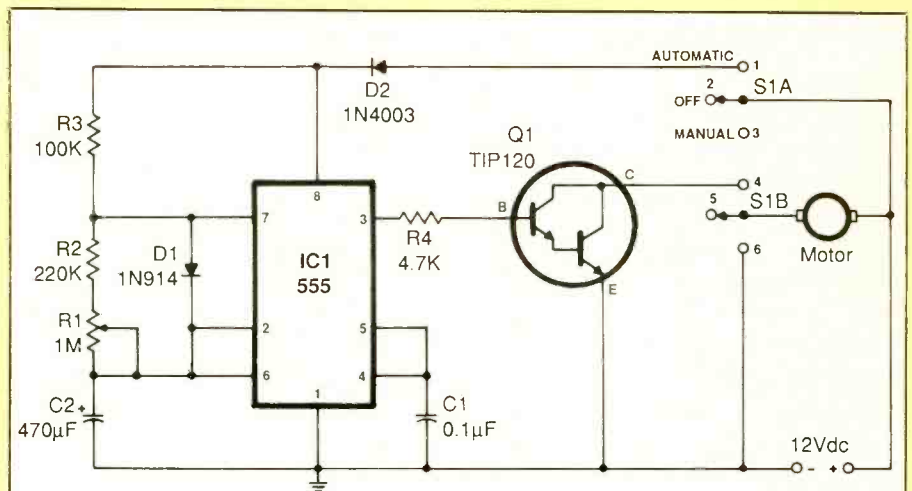
Resistor *R2* and potentiometer *R1* control the off-time period. When

the circuit is initially powered, the circuit's on-time is approximately equal to $1.1(R3C2)$. Thereafter, the duty cycle will be approximately equal to $0.69(R3C2)$. When the timer is in its on period, *D1* bypasses *R1* and *R2*.

Double-pole, double-throw switch *S1* has a center-off position. Note that this switch is wired into the cir-

cuit to provide MANUAL, OFF and AUTOMATIC functions.

The live-well pump motor connects between the toggles of *S1A* and *S1B*, with one side connected directly to the +12-volt power bus. With this arrangement, with *S1* set to AUTOMATIC, drive power for the motor is through *Q1*, which is turned on and off by the output signal that appears



PARTS LIST

Semiconductors

- D1—1N4003 rectifier diode
- D2—1N914 or similar small-signal diode
- IC1—555 timer
- Q1—TIP120 power Darlington transistor (Radio Shack Cat. No. 276-2068 or similar)

Capacitors

- C1—0.1-µF ceramic disc
- C2—470-µF, 25-volt, radial-lead electrolytic

Resistors (¼-watt, 5% tolerance)

- R2—220,000 ohms
- R3—100,000 ohms
- R4—4,700 ohms

- R1—1-megohm linear-taper potentiometer

Miscellaneous

- S1—Dpdt switch with center-off (Radio Shack Cat. No. 275-620 or similar)
- Printed-circuit board or perforated board with Wire Wrap or soldering hardware; suitable enclosure (Radio Shack Cat. No. 270-230 or similar 3¼" × 2½" × 1⅞" project box); control knob; 4-position screw-type terminal strip (see text); lettering kit and spray acrylic; two-conductor zip cord; spade lugs; machine hardware; hookup wire; etc.

Fig. 1. Overall schematic diagram of Live-Well Timer.

at pin 3 of IC1. Setting S1 to MANUAL completes the return side of the motor circuit to the negative side of the dc power source and energizes the motor continuously.

Power for the circuit can be any 12-volt dc source, such as a boat electrical system or battery, that can supply sufficient energy to power both the Live-Well Timer's controlling circuit and pump motor.

Construction

Because its circuitry is so simple, this is a very easy project to build. There is nothing critical about circuit layout. If you would like printed-circuit wiring, use the actual-size etching-and-drilling guide shown in Fig. 2 to fabricate the board. Otherwise, use a piece of perforated board with holes on 0.1-inch centers and suitable Wire Wrap or soldering hardware to build the circuit. Regardless of the wiring technique chosen, it is a good idea to use a socket for the 555 timer chip.

From here on, we will assume you are wiring the circuit on a printed-circuit board. With the board oriented as shown in the Fig. 3 wiring diagram, plug a socket into the IC1 location and solder it into place. Be careful to avoid creating solder bridges between the closely spaced copper pads on the bottom of the board as you solder the socket into place.

Next, install and solder into place the fixed resistors. Follow with the two diodes (make certain they are properly oriented before soldering their leads to the pads on the bottom of the board), followed by the capacitors (observe polarity with electrolytic capacitor C2).

Now cut six 5-inch lengths of stranded hookup wire and strip 1/4 inch of insulation from both ends of all of them. Tightly twist together the fine conductors at both ends of all wires and sparingly tin with solder. Plug one end of these wires into the holes labeled S1,1, S1,4, S1,6, GND and R1 (there are two wires for the R2 potentiometer) and solder into place.

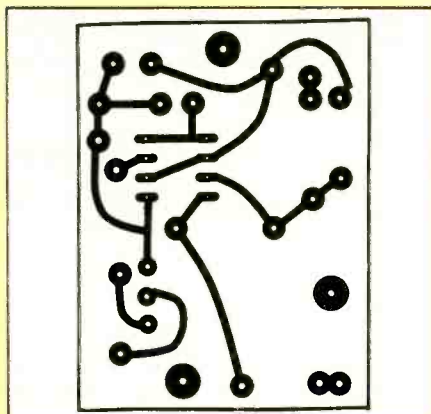


Fig. 2. Actual-size printed-circuit etching-and-drilling guide.

Bend the pins of the TIP120 power Darlington transistor at a right angle to the rear of its case at the points where the pins change from narrow to wide. Plug the pins into the appropriate holes in the board and secure the transistor in place with a 4-40 x 1/4-inch machine screw, lockwasher and nut via the holes in its metal tab and the circuit board. Turn over the board and solder the pins in place.

Connect the free ends of the wires coming from the holes labeled S1,1 and GND to +12 and ground or common of a dc supply or battery. Connect the common lead of a dc voltmeter or multimeter set to dc volts to the

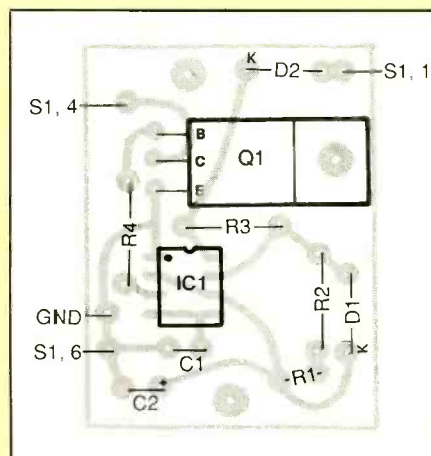


Fig. 3. Wiring guide for pc board. Use this as a rough guide to component layout if you use perforated-board construction.

free end of the wire coming from the hole labeled S1,6 and touch the "hot" probe to the pin-8 receptacle of the IC socket. If your wiring is okay, you should obtain a reading of +12 volts. If not, remove the dc power source and check all your wiring and component installation. Rectify the problem before proceeding.

Once you are certain that your wiring and component installation are correct, plug the 555 into the IC socket. Make sure it is properly oriented and that no pins overhang the socket or fold under between IC and socket as you press home the 555.

You can install the circuit-board assembly in any enclosure that will accommodate it and the switch and potentiometer without crowding. Machine the enclosure as needed, including drilling mounting holes for the circuit-board assembly, potentiometer and switch and cutting a slot and drilling mounting holes for a four-contact screw-type terminal strip for making power and motor connections. Deburr all holes and the terminal-strip slot if the enclosure is metal.

Then label the control and switch positions, and use +12V, GND, MOTOR+ and MOTOR- legends for the terminal strip. If you use a dry-transfer lettering kit, spray over the legends two or more light coats of clear acrylic to protect them from scratching. Allow each coat to dry before spraying on the next.

Mount the switch, potentiometer and terminal strip in their respective locations. Now, referring to both Fig. 1 and Fig. 3, connect and solder the free ends of the wires coming from the circuit-board assembly to the lugs of the switch and potentiometer. When the circuit-board assembly is oriented as in Fig. 3, the wire coming from the R1 hole nearer the center of the board goes to the center (wiper) lug of the potentiometer. Also take note of the numbering scheme shown for S1A and S1B. Use

(Continued on page 80)

Broadcast the Weather

A simple device that rebroadcasts U.S. weather summaries on vhf for reception on an ordinary AM radio

By Paul M. Danzer

We have become a nation of weather "junkies." Each morning and throughout the day, until we retire for the night, most of us listen to weather forecasts, discuss the weather and even make predictions of our own. Recognizing this mania for weather reports, the U.S. Government now transmits weather summaries and forecasts 24 hours a day, every day of the year.

Government weather broadcasts are on vhf FM channels (see Table for frequencies). Originally reserved for marine weather transmissions, these frequencies in the last few years have been extended to cover both in-shore and inland areas, as well as the shore. The only requirement for receiving these broadcasts is that you be within range of the transmitting antenna and have a receiver that will tune the specific frequency.

Most people who are within 25 to 50 miles of the transmitting antenna will usually have no difficulty picking up the broadcast signal on a 12- to 15-inch vertical whip antenna indoors. However, if you live outside the range of the transmitter or have a mountain or high hill between you and the transmitter, you will have to put up a reasonable outdoor antenna to use with your scanning monitor radio or other vhf FM receiver.

If you are one of those unfortunate individuals who have difficulty receiving U.S. weather-forecast broadcasts, the convenience of being able to place a weather receiver anywhere in your home is lost. However, the simple circuit shown here will restore this convenience.

Circuit Operation

Beginning with a good antenna and a scanner tuned to the weather broadcast channel in your area, our simple crystal-controlled oscillator can be made to rebroadcast the weather transmission throughout your home. This rebroadcast signal can then be received by an ordinary AM broadcast-band radio or receiver.


In this circuit, the oscillator's output signal serves as an AM carrier that is set at about 1,000 kHz (1 MHz). Plug *P1* connects to your scanner or vhf FM receiver via the latter's auxiliary speaker jack. The audio output from the scanner or receiver is then used to amplitude modulate the oscillator's carrier signal.

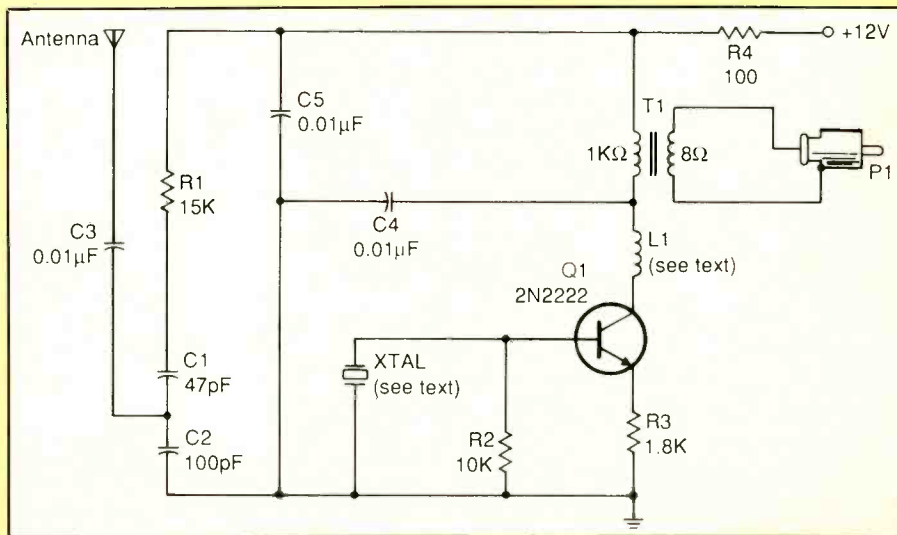
A 1,000-kHz oscillator frequency was chosen for this project mainly because the crystal required for it is commonly available and is used in most frequency calibrators. Fortu-

nately, this frequency falls in about the middle of the AM broadcast band. A good source for this crystal is Digi-Key (Cat. No. X066, \$6.45), among others.

The value of inductor *L1* is not critical, though 2.2 millihenrys is specified in the schematic diagram and Parts List. This can be a J.W. Miller Part No. M7222ND (listed in the Digi-Key catalog for \$1.71). Alternatively, you can purchase Radio Shack's Cat. No. 273-1601 inductor assortment and use any inductor in it that looks like it has a few hundred turns on it.

Power for the circuit can be any 12-volt dc source. If you wish to use battery power only, simply connect eight 1.5-volt AA, C or D cells in series. Alternatively, you can build and use a simple voltage-regulated ac-powered supply for continuous operation. If you are really ambitious, you can arrange things so that

(Continued on page 81) 



Schematic diagram of transmitter that rebroadcasts U.S. Government weather forecasts for reception with an ordinary AM broadcast-band radio.

How to Read Oscilloscope Waveforms (Part I)

Useful tricks of the trade for getting the most out of your oscilloscope

By Robert G. Middleton

In this series, we will explore oscilloscope waveform interpretation and applications. Our emphasis in this first part is on electronic circuit action, its relationship to scope display, and practical usage of the powerful test instrument.

Types of Circuit Action

The most basic types of circuit action are concerned with steady-state response, transient response, linear characteristics and nonlinear characteristics. The steady state, for example, is an operating condition under which voltages and currents in a circuit remain constant, after initial transients have decayed to zero. Conversely, transient response is characterized by voltages and currents in a circuit that do not remain constant but instead decay to zero (in a typical situation).

Linear characteristics are present when the output voltage is directly proportional to the input voltage. On the other hand, nonlinear characteristics are present when the output voltage is not directly proportional to the input voltage. In a purely resistive circuit, for example, the output voltage will double in response to a doubling of the input voltage. However, in a nonlinear resistive circuit, such as a circuit that contains a semiconductor diode, the output voltage

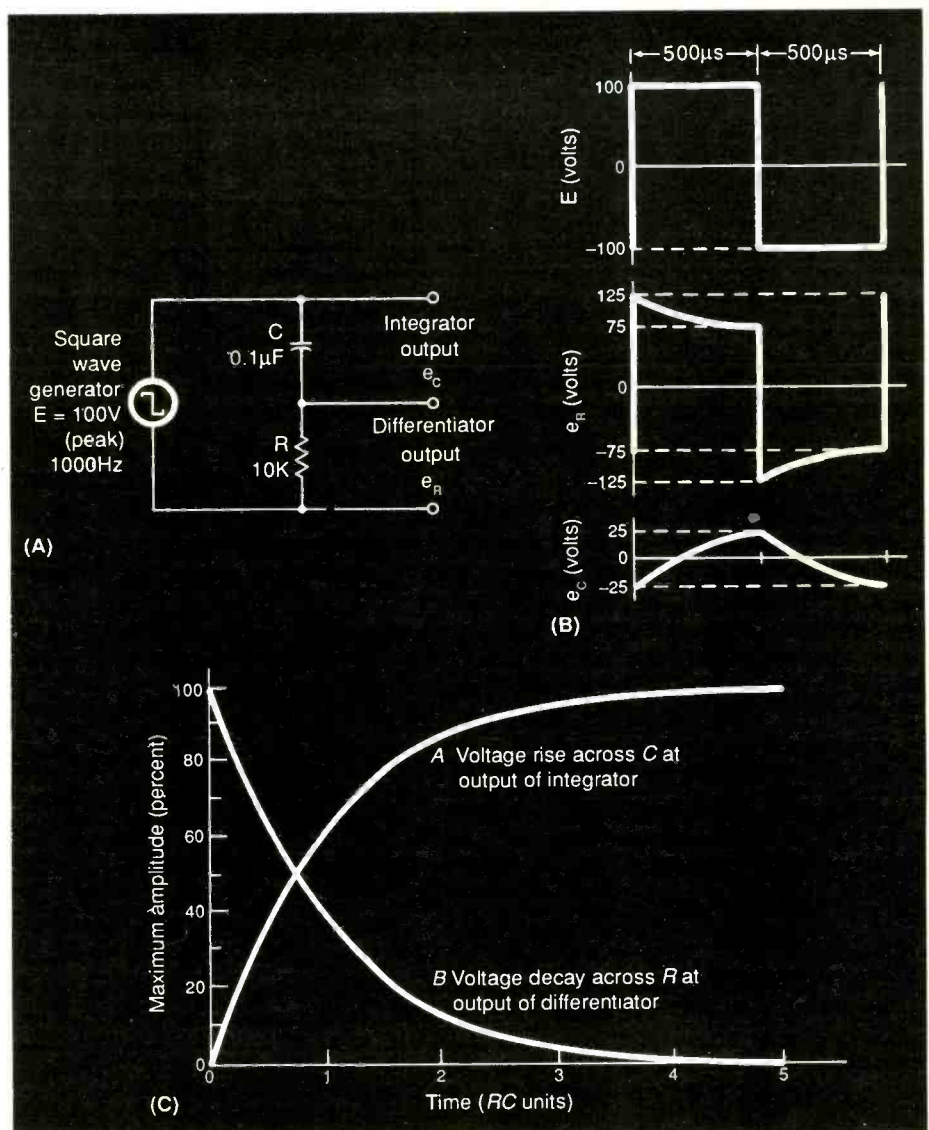


Fig. 1. Basic laws of transient waveforms: (A) differentiator and integrator outputs from a simple RC circuit; (B) circuit waveforms obey Kirchoff's law; (C) waveforms follow the universal time-constant chart.

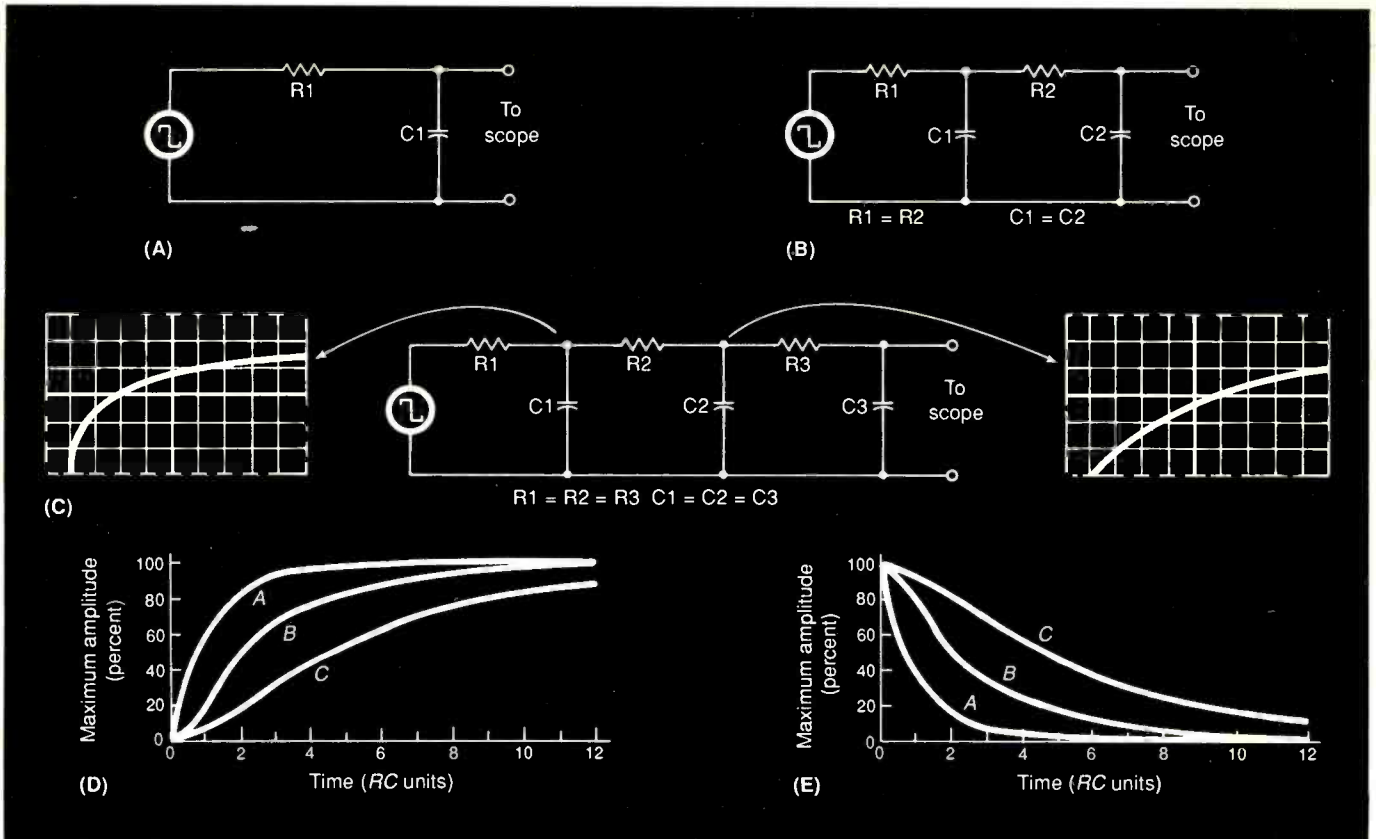


Fig. 2. Basic derived exponential waveforms: (A) single-section RC circuit; (B) two-section RC circuit; (C) three-section RC circuit; (D); universal time-constant chart for leading edge of output waveform; (E) universal time-constant chart for trailing edge of output waveform.

will not double in response to a doubling of the input voltage.

The basic laws of transient waveforms are illustrated in Fig. 1, which shows a simple series RC circuit whose input is driven by a square-wave voltage. Output voltage across the resistor is an exponential waveform, which is an example of the natural law of growth and decay in which the response during the next interval depends upon the response during the preceding interval.

Waveforms in the simple series RC circuit are fundamentally the same regardless of the resistance (R) and capacitance (C) values used in the circuit. As you probably already know, the time constant of the circuit is equal to the product of resistance in ohms multiplied by the capacitance in farads, with the result in seconds, or $t = RC$. The time con-

stant denotes how long it takes for the initial voltage to fall (or rise) to 63.2 percent of its starting (or final) value. These principles are summarized in the universal RC time-constant chart shown in Fig. 1(C).

Derived exponential waveforms occur in two- and three-section RC circuits as well, as illustrated in Fig. 2. If all resistors have the same value and all capacitors have the same value in all three circuits shown, the output waveforms will always be given by derived universal time-constant charts, as in Figs. 2(D) and (E). Observe that when the $R2C2$ network is connected to the output of the $R1C1$ network, the second section is driven by the output waveform from the first section, and the first section is loaded by the input impedance of the second section. It is this loading action that makes the

output waveform shown in Fig. 2(B) a derived exponential waveform, instead of the elementary exponential waveshape in the Fig. 2(A) circuit.

Next, risetime is defined as the time required for any waveform's leading edge to rise from 10 percent to 90 percent of its final amplitude. Hence, the waveform depicted by curve B in Fig. 2(D) has a slower risetime than the waveform depicted by curve A but a faster risetime than the waveform depicted by curve C.

Active Versus Passive Circuitry

So far, the RC circuits we have described are passive. That is, the circuit does not contain an energy source. In the "real world," though, we are usually concerned with active circuitry, as illustrated in Fig. 3. An active circuit contains one or more

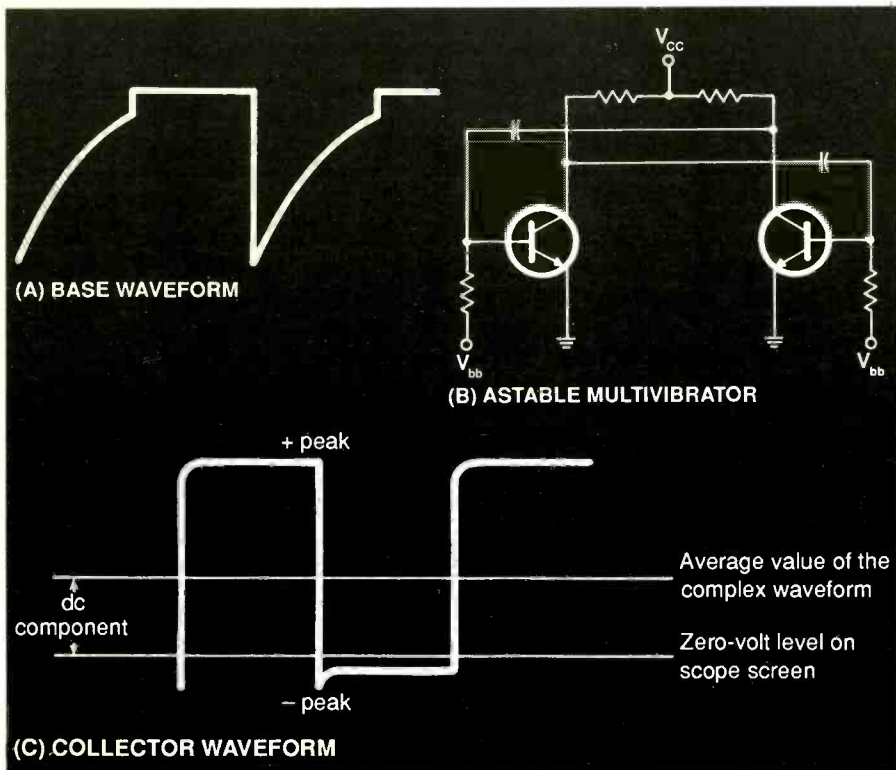


Fig. 3. An elementary astable multivibrator circuit.

energy sources, such as transistors. Note that the base and collector waveforms are generated by alternate switching of the transistors into saturation and past cutoff. If symmetrical circuitry is used, each transistor remains in cutoff for the same length of time it is in saturation.

As a practical consideration, the peak-to-peak voltage of the generated waveform exceeds the V_{CC} voltage if the capacitors have comparatively

large values. Observe that the curved portion of the base waveform represents an exponential discharge (decay) of the dc charge on the base capacitor. This charge is developed by rectification of the signal drive voltage via the base-emitter junction in the transistor and is the result of signal overdrive.

Now examine the collector waveform in Fig. 3. The 0-volt level on the oscilloscope's screen is displayed by

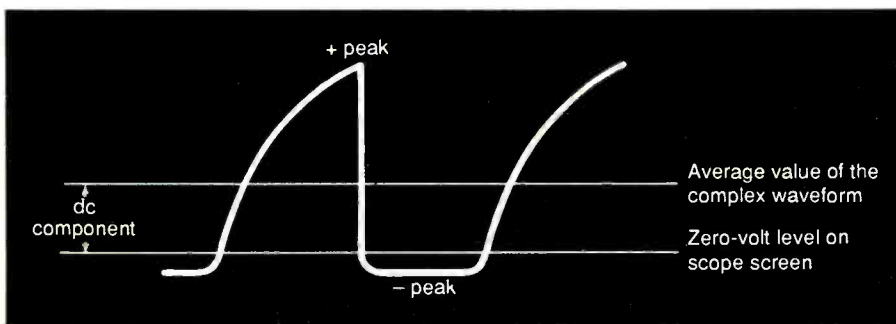


Fig. 4. Typical distortion of the collector waveform in an astable multivibrator circuit in which transistor's emitter and collector leads have been transposed.

the horizontal trace when there is no signal applied to the input of the scope. The average value of the waveform is seen when the scope is operated in its ac mode; the 0-volt level then cuts through the waveform at its average value. When the scope is in its dc mode, the waveform's trace rises on the screen (in this example). As illustrated, the waveform rises by an amount such that the separation between the average value and the 0-volt level is equal to the dc voltage component in the waveform.

The distorted collector waveshape shown in Fig. 4 results when the emitter and collector terminals of the transistor are accidentally transposed. This kind of error can lead to "tough-dog" service problems. The gain of the transistor is less (often much less) when its emitter and collector terminals are interchanged. Moreover, a transistor often has a base-emitter junction that exhibits a zener region that clamps the waveform here, as shown in Fig. 4. This clamping action significantly upsets normal operation conditions in the circuit.

Nonlinear Circuit Action

Illustrated in Fig. 5 is a simple example of a square-wave response in a nonlinear circuit. Here, the square-wave voltage applied to the circuit produces a voltage drop across the 100-ohm resistor that is proportional to the current demand of the circuit. Accordingly, the voltage drop across the resistor serves to display the current waveform of the circuit. The left waveshape in Fig. 5 is symmetrical because the circuit is being tested at a low level, with the result that it has linear response.

In the right waveform in Fig. 5 we note an asymmetrical waveshape whose positive-peak voltage is greater than its negative-peak voltage. This results because the circuit is being tested at a higher level where the diode junction is turned on. This

change in waveform characteristics in high/low-level tests affords a clue to the fact that a semiconductor junction is located in the vicinity of the test point.

A battery-powered square-wave generator is preferred in this type of test because of its negligible effective capacitance to ground. Substantial capacitance across the 100-ohm resistor could cause waveform distortion, particularly at high square-wave repetition rates.

Resistance, Reactance and Impedance

To be able to read oscilloscope waveforms effectively, you must recognize the properties of resistance, reactance and impedance. Though in this discussion we will consider only capacitive reactance, you can easily apply it to inductive reactance, which is similar to capacitive reactance except that it has exactly the opposite phase angle.

To obtain a Lissajous pattern on the scope's screen, you feed the voltage waveform to the vertical input and the current waveform to the horizontal input of the oscilloscope. The proportions of the Lissajous pattern show the relative values of resistance R , reactance X and impedance Z in the circuit. This might seem to be of no practical concern in troubleshooting procedures, but its importance becomes obvious when you turn your attention to comparative tests on a malfunctioning unit and a unit that is operating as it should. If resistance (or reactance) in the malfunctioning unit is not normal, this fact becomes evident in the Lissajous patterns. Pattern proportions also show the fault is resistive or reactive.

Relative values of R , X and Z can be determined from the Lissajous figure (ellipse) in Fig. 7(A) as follows:

(1.) Center the ellipse on center point CP with the signals applied to the scope's inputs as detailed above. First use the scope's beam-position-

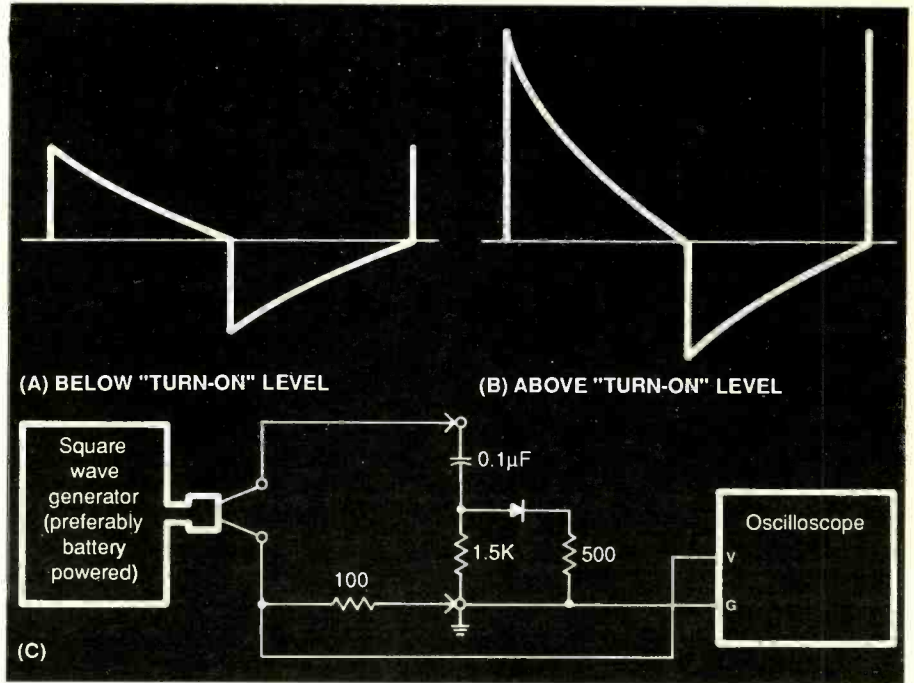


Fig. 5. Typical square-wave responses in linear and nonlinear circuit operation and a typical test arrangement.

ing controls to center the CRT beam with no signals applied to the scope.

(2.) Next, set the scope's vertical and horizontal gain controls to any desired positions, but keep the entire ellipse pattern on-screen.

(3.) Count the number of divisions on the scope's graticule to determine the relative values of A and B . These values are related to Z , as shown in Fig. 7(B). Thus, A shows the relative proportion of capacitive reactance X_c in the circuit and B the relative proportion of impedance Z .

(4.) To determine the relative proportion of R in the circuit, as in Fig. 7(B), draw X units downward and then R units to the right at a 90-degree angle to X . Then strike an arc with a radius equal to Z units. Intersection of this arc with the R line gives the relative proportion of R in the circuit. Finish the geometric drawing by striking the impedance Z line from the origin on the X line to the intersection point of the arc on the R line as shown.

Oscilloscope users who are handy

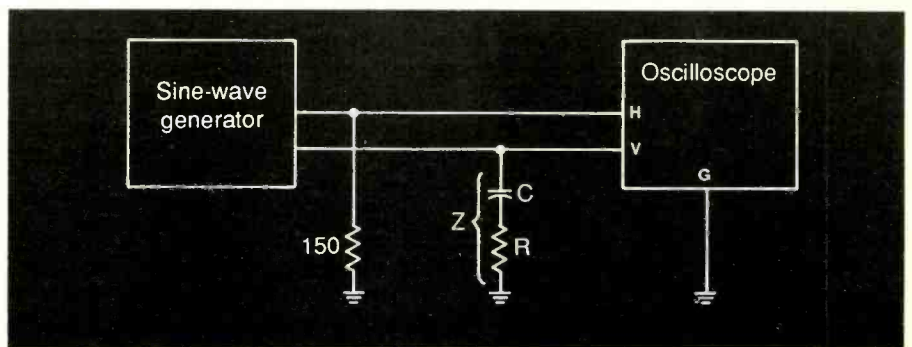


Fig. 6. Hookup arrangement for performing tests using Lissajous patterns.

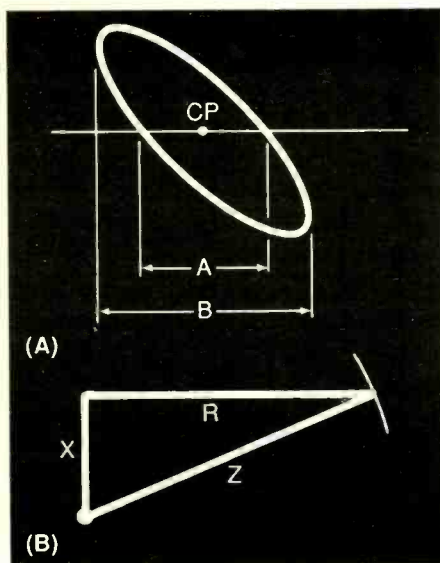


Fig. 7. Centering a Lissajous ellipse pattern on the center point of an oscilloscope's graticule (A) and constructing a geometric scale of relative proportions of reactance, resistance and impedance (B).

with electronics mathematics can calculate the relative proportion of R by algebraic means, instead of constructing it geometrically, by using the formula $R = \sqrt{Z^2 - X^2}$. The value of R can then easily be calculated on a pocket calculator.

Relative values of A and B are also given by the vertical positions of the

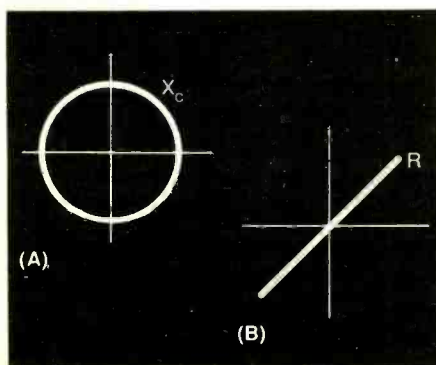


Fig. 8. Relative proportions of A and B are also given by the vertical proportions of the elliptical Lissajous pattern.

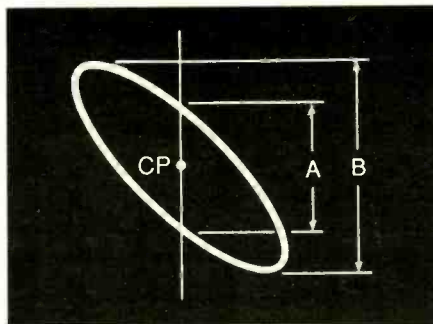


Fig. 9. Lissajous patterns for a pure capacitive reactance (A) and a pure resistance (B).

ellipse, as well as by the horizontal proportions, as shown in Fig. 8.

Keep in mind that when performing tests using Lissajous patterns that the sine-wave generator used to display the patterns should have a waveform that has very low harmonic content. Otherwise, a true ellipse will not be displayed and interpreted and calculated values will be in error.

Two special cases are shown in Fig. 9. If pure capacitive reactance is being tested, a perfect circle will be displayed, as in (A), provided the vertical and horizontal gain controls have suitable relative settings. If a pure resistance is being tested, a straight oblique line will be displayed, as in (B).

If an inductive impedance is being tested, an ellipse will be displayed, much as if a capacitive impedance were being tested. To distinguish between the two types of display, you can apply a suitable sawtooth voltage to the oscilloscope's Z (intensity-modulation) input. The pattern will show whether the beam is traveling clockwise or counterclockwise.

It is evident from inspection of the test arrangement that the total vertical excursion is a measure of the voltage across the impedance, if the oscilloscope has been properly calibrated vertically. Similarly, it is evident that the total horizontal excursion is a measure of the current through the impedance, if the scope

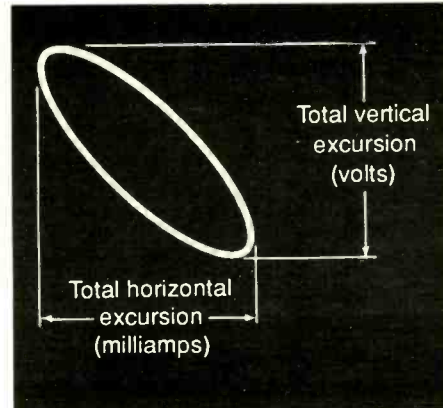


Fig. 10. The ratio of the total vertical excursion to the total horizontal excursion of the Lissajous elliptical pattern is a measure of impedance.

has been properly calibrated horizontally. In turn, the ratio of the total vertical excursion to the total horizontal excursion is a measure of the impedance, as illustrated in Fig. 10.

Let us now analyze a test procedure, using a hypothetical example. If the scope has been calibrated for a vertical deflection of 10 divisions for 1 volt dc and for a horizontal deflection of 1 division for 1 milliamper dc, impedance in ohms is equal to (vertical divisions/horizontal divisions) \times 1000. Under these conditions, if you observe 20 divisions of vertical deflection and 30 divisions of horizontal deflection (20/30), impedance is equal to approximately 667 ohms. The impedance value is generally a function of test frequency. Therefore, any impedance should be stated in terms of both its value in ohms and the frequency at which the test was performed, such as 600 ohms at 1 kHz.

Coming Up

This concludes the first part of this series. Next month, we will focus on the principles of comparative circuit-action tests, how to use a dual-trace oscilloscope and dc components of basic waveforms. **ME**

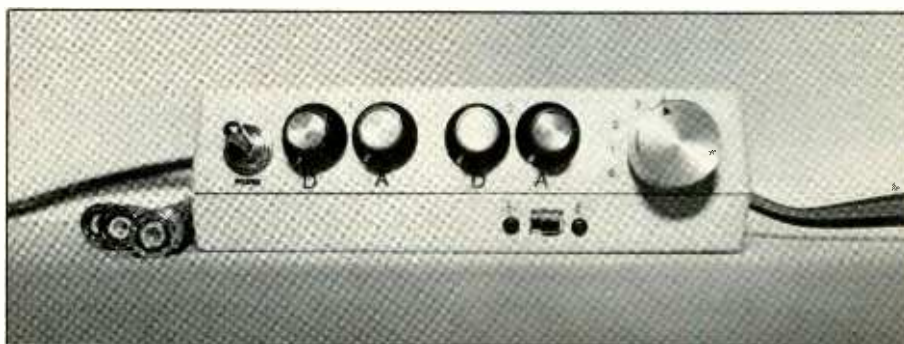
A 16-Channel Logic Analyzer

Multi-channel digital test instrument gives troubleshooters a leg up in pinpointing circuit problems

By Michael Swartzendruber

When troubleshooting digital systems, it is often necessary to see how two or more different signals relate to the system's clock and each other over a period of time. In many cases, it is desirable to monitor several signals simultaneously to appraise their relationships and compare them against timing diagrams. For example, in a computer you may have to monitor eight or sixteen lines simultaneously to track a problem down to its source. An ordinary single-channel digital logic probe, though handy to check activity at one point in such a circuit, is inadequate for the type of monitoring required in signal-related multi-channel systems. For this, you need a multi-channel digital logic analyzer.

Though there is no shortage of commercial multi-channel logic analyzers, most such instruments are quite costly. Fortunately, however, the 16-Channel Logic Analyzer to be described is very simple in design and, thus, is quite low in cost to build. This project will turn just about any single-trace oscilloscope into an 8-channel logic analyzer and will give a dual-channel scope a 16-channel capability. For maximum flexibility, the project also provides a sync output and switching arrangement that can be used to trigger your scope on any of its 16 data channels.



About the Circuit

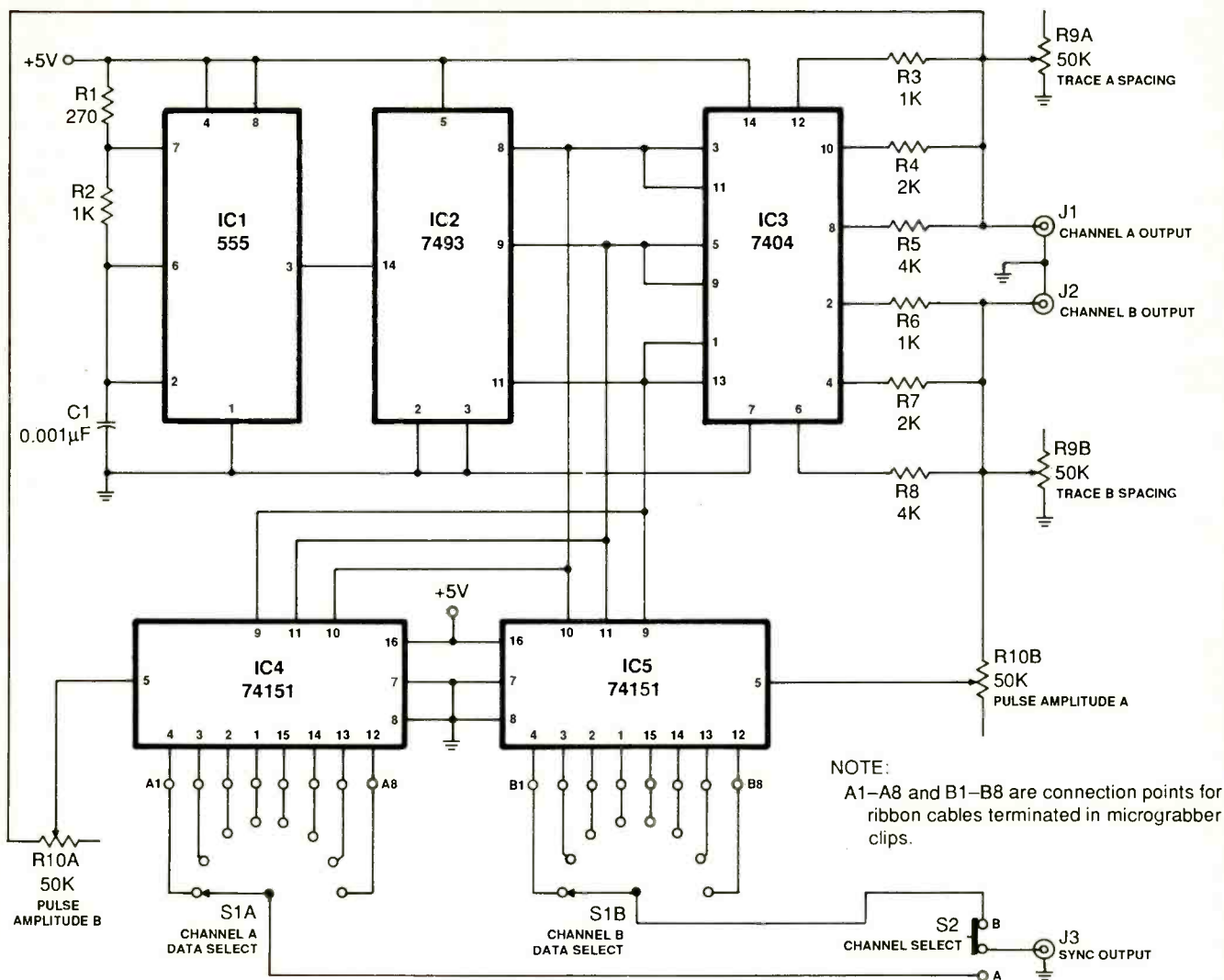
Three basic subsystems make up the Logic Analyzer: a power supply, a clock source and a signal multiplexer for the oscilloscope's inputs. The power supply and system clock are optional items if you already have a TTL-compatible supply and signal source on your testbench.

As shown in Fig. 1, this clock-driven signal multiplexer is operated in sync with a simple digital-to-analog (D/A) converter. The "heartbeat" of the system is 555 timer *IC1*, which is wired here as an astable, or free-running, oscillator and serves as the system's clock. Operating frequency is controlled by the RC network composed of *R1*, *R2* and *C1*. With the component values specified, operating frequency is approximately 65 kHz and duty cycle of the square-wave pulse train is 50 percent with the 5-volt dc supply used in this project.

The output at pin 3 of *IC1* is di-

rectly coupled to input pin 14 of divide-by-16 counter *IC2*. If *IC1* is like a heartbeat, *IC2* is like a traffic light whose counting actions determine which of eight possible signals per channel will be output from *IC3* at pins 6 and 8 and appear at CHANNEL A OUTPUT jack *J1* and/or CHANNEL B OUTPUT jack *J2*, respectively. This chip constantly counts up from 000 to 111 in binary, or 0 to 7 in decimal (base 10). Whatever signal appears at either OUTPUT jack is what drives the input to which it is connected on the oscilloscope.

Refer to the Table to follow the sequence of logic events that occur as *IC2*'s input at pin 14 is toggled by pulses from *IC1*. As *IC1* sends out its pulse train, the count output of *IC2* is triggered and changes with each pulse. In this project, *IC2* is wired to operate in the divide-by-8 mode. Thus, it continuously counts from binary 000 to 111. This count is routed to signal multiplexers and the D/A converters.



NOTE:
A1-A8 and B1-B8 are connection points for ribbon cables terminated in micrograbber clips.

PARTS LIST

Semiconductors

- IC1—555 timer
- IC2—7493 divide-by-16 counter
- IC3—7404 hex inverter
- IC4, IC5—74151 8-to-1 multiplexer
- IC6—LM317 positive dc voltage regulator

RECT1—50-volt, 3-ampere bridge rectifier

Capacitors

- C1—0.001- μ F disc
- C2—2,200- μ F, 35-volt electrolytic
- C3—470- μ F, 25-volt electrolytic

Resistors (1/2-watt, 10% tolerance)

- R1—270 ohms
- R2, R3, R6—1,000 ohms
- R4, R7—2,000 ohms
- R5, R8—4,000 ohms

- R12—680 ohms
- R13—227 ohms (200 and 27 ohms in series)
- R11—10 ohms, 1-watt
- R9A, R9B, R10A, R10B—50,000-ohm ganged dual potentiometer

Miscellaneous

- F1—1-ampere slow-blow fuse
- J1, J2, J3—Female chassis-mount BNC connector
- S1—2-pole, 8-position nonshorting rotary switch (or CTS No. T-215 2-pole, 12-position switch)
- S2—Spdt miniature slide or toggle switch
- S3—Spst miniature toggle switch
- T1—6.3-volt ac power transformer (Triad No. 13-X or similar)

Printed-circuit board or perforated board with holes on 0.1" centers and suitable Wire Wrap or soldering hardware; sockets for all DIP ICs (optional—see text); 6-ft. of 8-conductor ribbon cable; suitable enclosure—see text; pointer-type control knobs for S1, R9 and R10; ac line cord with plug; 16 micro-grabber test clips, preferably 2 each of 8 different colors (Pomona No. 4233 or similar); lettering kit and clear spray acrylic—see text; electrolytic capacitor for reducing noise—see text; 74193 up/down binary counter and solderless breadboard for test circuit—see text; 1/4" to 1/2" spacers; machine hardware; stranded hookup wire; solder; etc.

Fig. 1. Schematic diagram of basic 16-Channel Logic Analyzer accessory, minus its ac-operated power supply.

At time T0, when power is first applied to the circuit and IC1 has not sent its first pulse cycle to IC2, the count output of the counter is binary 000. This is input into the address selector pins of the 74151 IC4 channel-A or IC5 channel-B multiplexers, depending which of the two lines is connected to a signal source. (To avoid confusion, the following will discuss the sequence of events that occur in the channel-A portion of the circuit only. Operation of the channel-B section is identical.) This instructs either IC4 to pass the signal at its pin 4 D0 (data 0) input to its pin 5 output.

Note that the outputs at pin 5 of IC4 and IC5 go through ganged PULSE AMPLITUDE A and PULSE AMPLITUDE B potentiometers R10A and R10B, respectively. As their legends imply, these pots allow you to adjust the amplitude of the displayed pulse(s) on the oscilloscope's CRT screen.

The 000 count is also sent to inverters inside hex inverter IC4 via pins 11, 9 and 13 for channel A (pins 3, 5 and 1 for channel B). This 000 count causes all inverter outputs at pins 10, 8 and 12 for channel A (pins 2, 4 and 6 for channel B) to go high. (A low on the input of an inverter generates a high on its output, and vice-versa). This causes currents that are proportional to the binary count to flow through the resistor adder composed of R3, R4 and R5 that develop dc voltage levels at the input of the oscilloscope connected to the project via J1. The signals from the multiplexer are superimposed on

Sequence of Logic Events				
Clock Cycle	7493 Output	Inverter Output	Resistive Adder Voltage Level	Data Line Selected
T0	000	111	7 units	D7
T1	001	110	6 units	D6
T2	010	101	5 units	D5
T3	011	100	4 units	D4
T4	100	011	3 units	D3
T5	101	010	2 units	D2
T6	110	001	1 unit	D1
T7	111	000	0 units	D0

Notes: Resistive adder consists of R3/R4/R5 for channel A and R6/R7/R8 for channel B. Resistive Adder Voltage Levels are in arbitrary units that are not to scale.

these dc levels so that whatever logic events are present at pin 4 of IC4 appear on the trace lines created by the D/A converter.

Ganged TRACE A SPACING and TRACE B SPACING potentiometers R9A and R9B permit bias voltage into the oscilloscope's vertical amplifiers to be adjusted. This allows the spacing between the traces on the CRT screen to be set so that they do not overlap and interfere with each other to confuse the displayed image.

When the count from IC2 reaches 111, the multiplexer selects D7 at pin 12 to be routed to J1 and into the oscilloscope. The output from the inverter network in IC3 is at a dc level of 0 volt. All other clock counts from 001 through 110 and the resulting dc levels and data lines selected are summarized in the Table.

Overall, the action of the inverters inside IC3 establishes a clock-dependent dc voltage level for the oscil-

loscope's vertical amplifier. At the same time this level is present, the corresponding data channel from the multiplexer is superimposed on this level. The resulting visual effect on the scope's CRT is eight lines of pulse trains in each channel, with D0 on the lowest and D7 on the top-most traces displayed.

DATA SELECT rotary switch S1, CHANNEL SELECT slide switch S2 and SYNC OUTPUT connector J3 are options that add to the versatility of the Logic Analyzer. With these options installed, the project has the capability of feeding a timing pulse from any data line of either channel to the scope's trigger input. This improves readability of the signals displayed if many different frequencies are present. Omitting these components in no way affects basic operation of the Logic Analyzer.

Inputs to the Logic Analyzer from a circuit under test are through rib-

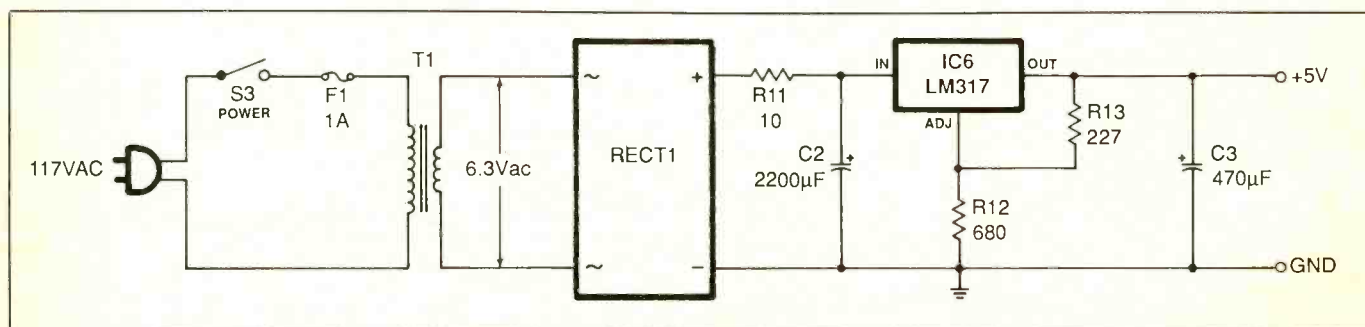


Fig. 2. Schematic diagram of ac-operated power supply used in this project.

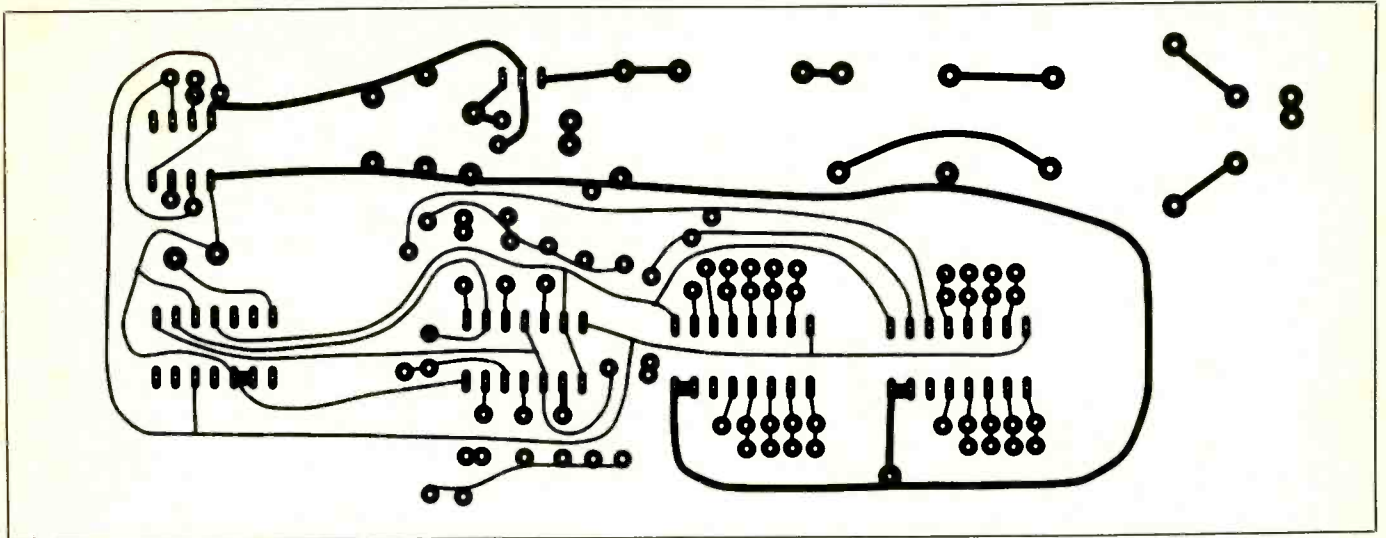


Fig. 3. Actual-size etching-and-drilling guide for printed-circuit board.

bon cables that connect into the circuit at points A1 through A8 for channel A and points B1 through B8 for channel B. (A1 through A8 and B1 through B8 correspond to data input lines D0 through D7 in each channel.) The test ends of these cables terminate in micro-grabber clips.

Shown in Fig. 2 is the schematic diagram of a typical ac-operated dc power supply that can be used with the Logic Analyzer. (Because of its moderate power demands, the project cannot usually be powered by the dc source in the circuit under test as can simple logic probes.) This one is built around adjustable voltage regulator *IC6* and uses a standard 6.3-volt power transformer and 1-ampere bridge rectifier assembly, *TI* and *RECT1*. The 227 ohms specified for *R13*, not a commonly available value, is obtainable by connecting in series standard 200- and 27-ohm resistors to make up the required value for the circuit to output +5 volts.

If you already have a 5-volt dc power supply capable of providing at least 400 milliamperes of current, you can substitute this instead and use a 7805 +5-volt regulator with it. Keep the values specified for filter capacitors *C2* and *C3* the same or in-

crease them if you do this, of course, but eliminate *R11*.

Construction

Owing to the basic simplicity of the circuitry, this project lends itself well to either point-to-point wiring, using perforated board with holes on 0.1-inch centers and suitable Wire Wrap or soldering hardware, or to printed-circuit wiring. If you wish to go the pc route, fabricate the board using the actual-size etching-and-drilling guide shown in Fig. 3.

Orient the board as shown in Fig. 4. (The following details how to wire the printed-circuit version of the project. If you are using perforated-board construction, install the components in approximately the same locations shown for the pc version, and refer back to Figs. 1 and 2 for wiring details.) Start stuffing the board by installing the sockets for *IC1* through *IC5* in the indicated locations. These sockets are an option that in no way affect the performance of the circuit if omitted. However, it is a good idea to include them to simplify troubleshooting and IC replacement should this ever become necessary.

With the sockets installed (do *not* install the ICs in them until after you have performed preliminary voltage checks), plug in and solder into place the resistors, followed by the capacitors. Most resistors mount on-end to conserve space on the board. Also, make sure you properly polarize the electrolytic capacitors before soldering their leads to the pads on the bottom of the board. Note in Fig. 4 that the circuit board has an extra pair of holes to the right of those for *C3*. These are provided in case you must add extra filtering to deal with excessive noise levels. Do nothing with these holes at this time. If needed during operational checkout, you will install another electrolytic capacitor here.

Install and solder into place the nine jumper wires in the indicated locations. You can use bare solid hookup wire for all but the longest jumper, which should be insulated.

Next, prepare two 36-inch or so lengths of eight-conductor ribbon cable by separating the conductors at one end a distance of about 1 inch, but make the separation 2 inches between conductors 4 and 5. Strip ¼ inch of insulation from all conductors at this end. Then tightly twist to-

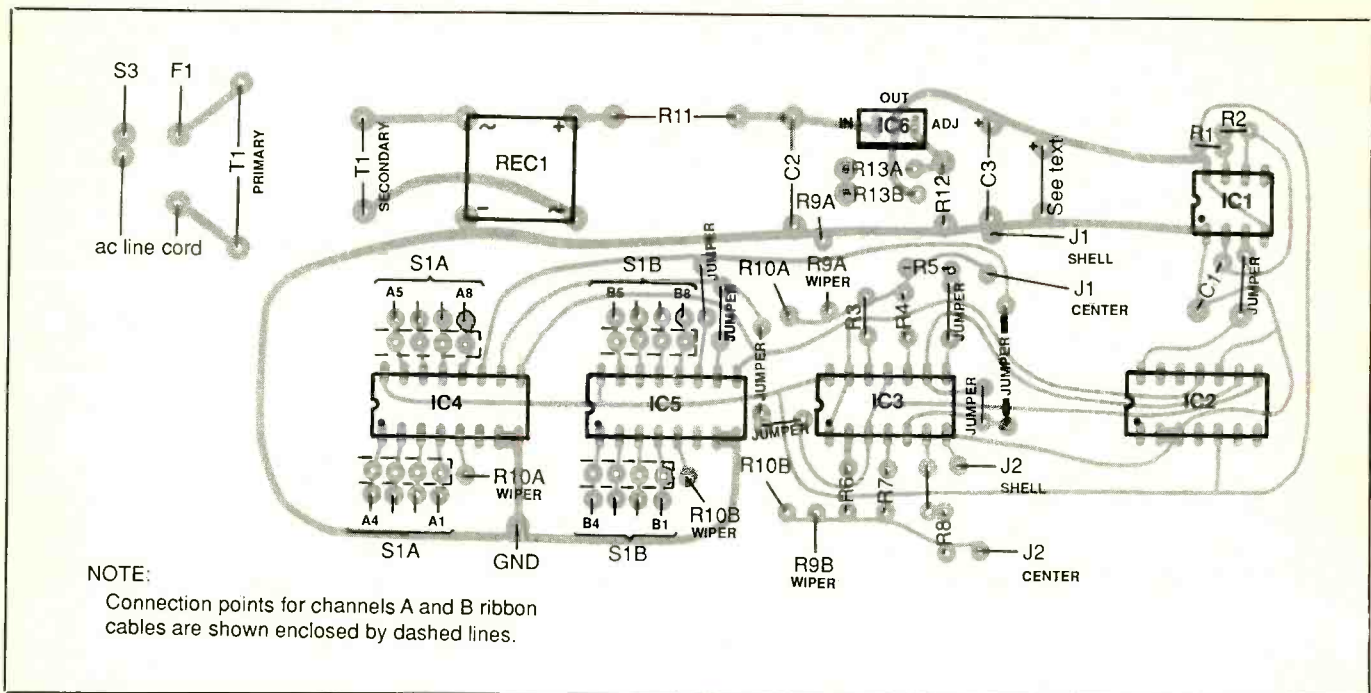


Fig. 4. Wiring diagram for pc board. Use this as rough guide to component placement and orientation when point-to-point wiring circuit on perforated board.

gether the fine wires in each conductor and sparingly tin with solder. Use heat judiciously to avoid charring the insulation. Do not prepare the other ends of these cables at this time.

Plug four conductors of one cable into the holes labeled A1 through A4 nearest the IC4 socket and solder into place. Repeat with the other four conductors in this cable and the holes labeled A5 through A8. Then do the same for the other cable and the holes labeled B1 through B8 nearest the IC5 socket. Be careful when soldering these wires and the IC sockets into place to avoid creating solder bridges between the closely spaced pads.

You need three short lengths (about 6 to 8 inches) of coaxial cable for the outputs to the BNC connectors that go to the oscilloscope with which the project is used. Remove 1/4 inch of the outer plastic jacket from both ends of all three cables and separate the shields back to the cut-off outer jackets.

Twist together the fine wires of each shield into tight bundles and sparingly tin with solder. Then strip 1/4 inch of insulation from the inner conductors. If you are using cable with stranded inner conductors, twist together the fine wires and sparingly tin with solder. Set aside one cable for use later on with the SYNC OUTPUT BNC connector.

Plug the inner conductor of one cable into the hole labeled J1 CENTER and solder into place. Do the same with the inner conductor of the other cable and the hole labeled J2 CENTER. Then plug the shields into the respective J1 SHELL and J2 SHELL holes and solder into place.

You now need 24 5-inch lengths of stranded hookup wire. (Alternatively, you can use two 6-inch lengths of 8-conductor ribbon cable and only eight stranded hookup wires.) Prepare both ends of all wires as described above. If you are using ribbon cable, separate the conductors at both ends a distance of 1 inch. Then prepare the ends of the cable as you did for the

other ribbon cables. Plug one end of each of 16 wires or both ribbon cables into the end holes labeled A1 through A8 and B1 through B8 and solder into place. The remaining eight wires plug into all holes labeled R9 and R10. The other ends of these wires will be connected later.

Plug the voltage regulator and bridge rectifier into the IC6 and RECT1 holes in the board and solder their pins into place. Make absolutely certain these components are properly oriented—especially that the metal tab on IC6 faces toward the center of the board—before soldering any pins to the copper pads on the bottom of the board!

Two final stranded hookup wires, both about 6 inches long, are needed for connection to fuse F1 and to POWER switch S3. Prepare these as before and install and solder into place one end of each into the F1 and S3 holes in the board. If you plan on using a metal enclosure for your project, also prepare a 5-inch wire and

install and solder it into the hole labeled GND.

Final circuit-board assembly wiring comes with installation of power transformer *TI*. Make absolutely certain that you plug the transformer's primary and secondary winding leads into the appropriate holes before soldering them into place. Once this is done, mount the transformer on the circuit board with ¼-inch machine screws, lockwashers and nuts.

You can use any type of enclosure that will accommodate the circuit-board assembly and has room on the front panel for the switches, jacks, and binding posts and for exit of the ribbon cables. If you use a metal enclosure, you will have to cut two slots measuring about 3/16 inch wide by 5/8 inch long through which the ribbon cables can exit. The easiest way to do this is with a Moto-Tool or similar tool and thin abrasive grinding wheel. If you use a plastic enclosure, you can have the cables exit the box at opposite ends, with the lid securing them in place. To do this, you need use only a file to cut shallow channels in the box walls where they join the lid.

Having prepared the ribbon cable slots, decide where on the front panel to mount the rotary, toggle POWER and slide switches (you can substitute a toggle switch for the slide switch, if you wish, to ease your machining task), potentiometers and binding post. Arrange these items on the panel in a logical manner to simplify use of the project as much as possible. Size each hole to accommodate the component that is to mount in it.

Next, drill the hole for the fuse block for *F1* and entry of the ac line cord through the rear panel. Then drill the four mounting holes for the circuit-board assembly through the floor of the enclosure.

Temporarily mount the rotary switches and potentiometers in their respective holes, making the hardware only finger-tight. Place a pointer-type knob on the shaft of each.

Starting with the rotary switch, rotate its knob through all eight positions and note where the pointer starts at position 1 and stops at position 8. (If you are using a switch that has more than eight positions, the first and last should still be symmetrical and connections to it should be offset to reflect the actual positions selected for the hookups to it.) If these two points are not symmetrical, reposition the switch until they are and then tighten the hardware. Once again, rotate the knob through all eight positions, making a light pencil mark on the panel where the pointer's index stops.

As you did with the rotary switch, note the start and end positions of the indexes of the pointers on the knobs of both potentiometers. If necessary, loosen the hardware and reposition either or both pots until these points are symmetrical on the panel. Mark the start, end and mid-point positions.

Remove all control knobs and dismount the rotary switch and both potentiometers. Label the front per the legends detailed in Figs. 1 and 2. At the marked positions for the rotary switch, use labels that read D0 through D7 going clockwise. For the potentiometers, place a mark at the indicated mid-position point. To the left and right of this mark, apply legends that read DECREASE and INCREASE, respectively. Then at the extreme counterclockwise and clockwise positions, apply legends that read MIN and MAX.

If you are using a dry-transfer lettering kit to apply the legends, spray two or three *light* coats of clear acrylic over the panel to protect them from scratches. Allow each coat to dry before spraying on the next.

When the acrylic spray has completely dried, mount all components on the front panel and the fuse block on the rear panel. Tightly twist together the fine wires of both ac line cord conductors and tin with solder. Pass the free end of this cord through

its hole in the rear panel. If your enclosure is metal, line the hole with a rubber grommet to prevent the sharp edge from cutting through the insulation and creating a short circuit. Tie a knot in the cord about 8 inches from the prepared end inside the enclosure to serve as a strain relief. Then plug the prepared conductors into the holes labeled AC LINE CORD in the circuit board assembly and solder into place.

Mount the circuit-board assembly on the floor of the enclosure. Use ¼- to ½-inch spacers and appropriate length machine screws, lockwashers and nuts. If you are using a metal enclosure, solder a No. 6 solder lug to the free end of the GND wire and secure this between the bottom of the board and spacer at one corner of the assembly to make a good ground connection.

Position the rotary switch and potentiometers as needed so that their knob pointers fall at the appropriate legends on the front panel. Then securely tighten the hardware for these components.

Locate the free ends of the coaxial cables coming from the J1 and J2 holes and connect and solder their center conductors to the center lugs and shields to the ground lugs on J1 and J2. Prepare another 6-inch length of coaxial cable as described above and crimp and solder the center conductor and shield at one end to the center contact and shell lug on J3. Terminate the other end's center conductor at the center lug of the CHANNEL SELECT switch and the shield at any convenient ground point in the circuit. (Add a length of insulated hookup wire if needed.) Then crimp and solder the free ends of the ribbon cables or hookup wires coming from the holes near the IC4 and IC5 sockets to the stationary-contact lugs on the rotary switch (see Fig. 1 for hookups).

Use the lugs closest to the front panel as the tie points for R9A and R10A on the two potentiometers.

Crimp and solder the free end of the wire coming from the hole labeled R9A WIPER to the center lug of the TRACE A SPACING pot and the free end of the wire coming from the R10A WIPER hole to the center lug of the PULSE AMPLITUDE A potentiometer. Tack-solder the free ends of the other R9A and R10A wires to either outer lug on the same pot elements. Repeat the procedure with the free ends of the wires labeled R9B and R10B and the lugs of the remaining pot elements.

Crimp and solder the free ends of the wires coming from the holes labeled F1 and S3 to one lug of the fuse holder and one lug of the POWER switch. Cut a stranded hookup wire to sufficient length to bridge from the unused lugs on the POWER switch and fuse block. Strip ¼ inch of insulation from both ends, tightly twist together the fine wires at both ends and sparingly tin with solder. Connect and solder one end of this wire to the free lug on S3 and the other end to the free lug on F1's fuse block.

Route the free ends of the input ribbon cables through the slots in the enclosure. If you are using a metal enclosure, first line the slots with rubber grommets or plastic grommet material to protect them from abrasion and possible short circuits. Separate all conductors of both cables a distance of 4 to 5 inches at this end. Strip ⅜ inch of insulation from all conductors, twist together the fine wires in each and sparingly tin with solder. Use heat judiciously to avoid charring the insulation.

Terminate each wire in the ribbon cables in a micro-grabber test clip, preferably using eight different colors of clips on each channel's ribbon cable. Alternatively, label each micro-grabber clip with the appropriate D0 through D7 legend. Then use a permanent marker to label on the cables' insulation the appropriate channel A and B identifications. Exercise care when working with the micro-grabber clips. Their lugs are

fragile and easily damaged. Be sure not to pull the lugs out of the clip housings as you are disassembling the micro-grabber clips preparatory to making the soldered connections.

Initial Checkout

With no DIP ICs installed in the sockets, plug the project's line cord into an ac receptacle. Clip the common lead of a dc voltmeter, or a multimeter set to indicate dc volts, to a convenient circuit-ground point, such as a grounding lug on either J1 or J2. Set the meter to indicate between 5 and 10 volts and the project's POWER switch to ON. Touch the point of the meter's "hot" probe to the OUT pin of IC6 and note that the reading is approximately +5 volts. You should obtain the same reading when you touch the "hot" probe tip to pins 4 and 8 of the IC1 socket, pin 5 of the IC2 socket, pin 14 of the IC3 socket and pin 16 of the IC4 and IC5 sockets.

Caution: Whenever the project's line cord is plugged into an ac outlet, exercise extreme caution in the vicinities of the POWER switch, fuse block and primary side of T1. The ac line voltage at these locations can be lethal!

If you do not obtain the proper reading at any or all points mentioned, immediately power down the project and unplug it from the ac line. Carefully check the orientations of the electrolytic capacitors and ICs, including regulator IC6. If all appears to be okay, check your soldering for poor connections and solder bridges between closely spaced pads and conductors. Do not proceed until you have rectified the problem.

When you are certain that your project has been properly wired, install the DIP ICs in their respective sockets. Make sure each is properly oriented as you install it and that no pins overhang the socket or fold under between IC and socket as you push it home.

Plug the project's line cord into an ac outlet and set the POWER switch to ON. Now verify that the circuit is operating properly as follows:

Use your oscilloscope to monitor the activity at output pin 3 of IC1. You should observe a fairly "clean" pulse train here. However, if you notice noise in the pulse train, power down the Logic Analyzer and disconnect it from the ac line. Dismount the circuit-board assembly and install and solder into the holes immediately to the right of C3 a 47-microfarad electrolytic capacitor (observe polarity!) to increase the filtering on the power-supply bus to deal with the noise. Then reassemble the project, once again power it up and check that the noise problem has cleared up. If not, try larger-value electrolytic capacitors in place of the 47-microfarad unit until you have cleared up the noise problem. Excessive noise on the +5-volt supply rail will result a distorted image on the scope's screen.

Next, use your oscilloscope to monitor the activity at binary-count output pins 8, 9 and 11 of IC2 as the clock pulses from IC1 are fed into this chip. The frequency of the pulses at pin 9 should be half that of the clock speed at pin 3 of IC1. Moving to pin 8 of IC2, you should obtain a frequency reading that is one-quarter the clock speed, while at pin 11 it should be one-eighth the clock speed. Using a frequency counter should give you the following indications: pin 9—half the frequency of the clock (32.5 kHz); pin 8—half the frequency of pin 9 (16.25 kHz); and pin 11—half the frequency at pin 8 (8.125 kHz).

Connect the vertical inputs of your oscilloscope to the CHANNEL A and CHANNEL B OUTPUT jacks on the Logic Analyzer with suitable coaxial test cables with BNC connectors at both ends. (If your scope has only a single trace, you can perform this test alternately on each OUTPUT jack on the project.) Set the scope's volts/di-

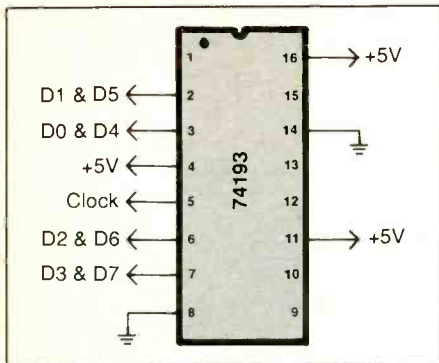


Fig. 5. Use this circuit to test basic operation of Logic Analyzer.

vision control to 0.5 volt. As you adjust the setting of the TRACE SPACING control, eight traces should appear on the scope's CRT and the spacing between them should increase as the control is rotated clockwise. If the spacing *decreases*, the control sections are wired backward. In this event, power down the project and disconnect it from the ac line. Then move the wires that go to *both* outer lugs of the ganged TRACE SPACING controls to the opposite outer lugs. Do *not* move the center (wiper) wires.

Set the PULSE AMPLITUDE control on the Logic Analyzer to mid-rotation. Then connect one or more channel A micro-grabber clips to points in a digital circuit known to have pulse activity when the circuit is turned on. Power up the circuit and observe the pulse activity on the

scope's CRT screen. You should observe pulses on the traces for each data line to which a data-input mini-grabber clip is connected and flat lines for any data-input lines that are not connected. If the spacing between traces is too close together for easy viewing, readjust the setting of the TRACE SPACING control to separate them.

Adjust the setting of the PULSE AMPLITUDE control clockwise while observing the CRT display. The height of the pulses should *increase* as you do this. If it does not, the PULSE AMPLITUDE control is wired backward and must be corrected exactly as described above for the TRACE SPACING control.

Initial Operation

To operate the 16-Channel Logic Analyzer with your oscilloscope, make the following settings on the latter. If you are testing an eight-trace unit, set the volts/division control to 0.5 volt, trigger source to external and seconds/division control to about 5 milliseconds. If you are testing a 16-trace unit, change only the volts/division setting to 1 volt.

Set the project's TRACE SPACING and PULSE AMPLITUDE controls to minimum and the rotary switch to D0. Connect a cable between the Logic Analyzer's SYNC OUTPUT binding post to the scope's external input. Similarly, connect cables between

the Logic Analyzer's OUTPUT jacks and the appropriate vertical input jacks on the scope.

On a solderless breadboarding socket, wire a 74193 up/down binary counter as shown in Fig. 5. Then, with nothing powered, connect the micro-grabber clips on the channel A input ribbon cable to pins 2, 3, 5 and 7 as indicated.

Turn on your oscilloscope. If you are testing an eight-trace unit, set the displayed trace at the bottom of the CRT screen. If you are testing a sixteen-trace unit, position one trace at the bottom and the other at the center of the CRT screen. Alternatively, if you wish, you can check channels A and B individually and then simultaneously.

Turn on your 16-Channel Logic Analyzer and adjust trace spacing as desired. Power up the test circuit and adjust the project's PULSE AMPLITUDE control to a level that displays the pulses on the screen on the CRT with no overlapping. Set the rotary DATA CHANNEL switch so that all channels are displayed on the screen. Then adjust the scope's seconds/division control until you are satisfied with the displayed image. When you are finished with your settings, you should observe an eight-trace display like that shown at the left in Fig. 6 if you are using a single-channel scope or a sixteen-trace display like that shown at the right if you are using a dual-channel scope.

With use, you will find the 16-Channel Logic Analyzer accessory described in this article to be an invaluable tool in troubleshooting digital systems. With the micro-grabber input clips connected to selected points in a TTL system, you will easily be able to compare notes with service manuals for any equipment being tested. You will be able to see what is happening in the circuit at many different places simultaneously. This will considerably ease and speed your analyses, saving you valuable time at a testbench. **ME**

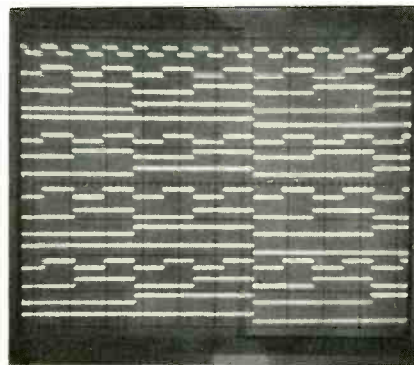
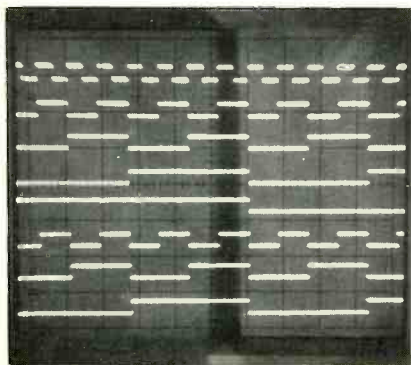


Fig. 6. A typical 8-trace display obtained with a single-channel scope (left) and 16-trace display obtained with a dual-channel scope.

The Xenon Flashtube

By Forrest M. Mims III

Though solid-state components have supplanted most gas-filled and evacuated glass tubes, there are still some applications that only a traditional electron tube can fill. An excellent example is the xenon-filled lamp.

Xenon flashtube systems that emit brilliant flashes of white light were first used to make stop-action photographs by Harold Edgerton in the late 1930s. Back then, a xenon flash-lamp system was a highly specialized laboratory device. Today, a pocket-size xenon photoflash unit can be purchased for as little as \$10.

Xenon lamps and flashtubes have dozens of additional uses beyond their role in photography. For instance, Fig. 1 shows the ACR/4G Firefly Rescue Light, a miniature xenon lamp beacon that emits 250,000 lumens per flash and can be seen at distances up to 15 miles away.

Many other applications for xenon lamps and technical details about the lamps themselves will be discussed in this column. In a future column, I will also describe several flashtube driver circuits.

Xenon Lamps

Though various gases can be used to make flash lamps, tubes filled with xenon gas are by far the most commonplace. Xenon is a member of the family of noble, or inert, gases. It is extracted from liquid air, which contains xenon in the ratio of one part in 20 million. This rarity explains the origin of its name, which means "stranger" in Greek. Some mineral springs emit gases that contain xenon in higher proportions. Xenon sells for about \$20 per liter. Though it was once thought that the inert gases cannot form compounds, since 1962 many xenon compounds have been produced. They include xenon hydrate, xenon deuterate and the highly explosive xenon trioxide.

There are two principal categories of xenon lamps: those designed for continuous operation and those designed to emit brief flashes.

Specially designed xenon lamps can be



Fig. 1. This ACR/4G Firefly strobolight beacon emits 250,000 lumens per flash. (Courtesy Chromalloy Electronics Div.)

operated continuously. These continuous-arc lamps will be discussed only briefly here, basically because there are far more uses for flashtubes designed to emit brief pulses of brilliant light.

The flashtube is a quartz or glass tube or bulb filled with xenon gas. (Flashtubes are also known as flash lamps and strobe lights.) When a suitable voltage is applied to electrodes installed in a flashtube, the resultant electrical discharge excites the

xenon and causes it to emit light. If the current flow is sufficiently great, a brilliant white burst of light is emitted. The duration of the flash, which can be as brief as a fraction of a microsecond, can be controlled by electronic means.

Specially designed xenon lamps fabricated as illustrated in Fig. 2 can be operated continuously. The xenon in these lamps is typically at a pressure of 20 to 40 atmospheres. Continuous-arc xenon

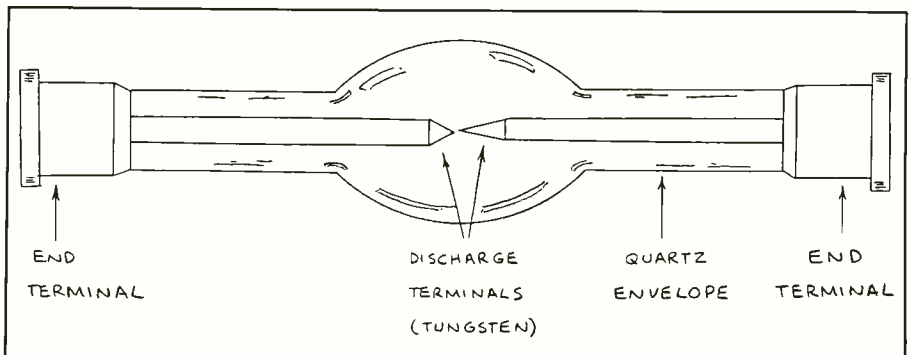


Fig. 2. Typical configuration of a xenon arc lamp designed for continuous operation.

lamps like these generate considerable heat. For this reason, tungsten electrodes are used to help dissipate the heat, and additional cooling can be provided by forced air or a water jacket.

An interesting feature of such lamps is that light is emitted both by the excited xenon gas and the tungsten electrodes. The electrodes emit light when they are heated to incandescence.

Even though continuous-arc lamps produce much more heat than pulsed lamps, their envelopes can be made from thinner materials. This is because a continuous-arc lamp doesn't produce the internal shock wave that accompanies each flash produced in a pulsed lamp.

Flash Lamps

Though many kinds of xenon flash lamps are available, the most commonly used is the flashtube. Construction of a typical flashtube is, in principle, no more complicated than that of a neon lamp or tube. However, since the current applied to xenon flashtubes is generally much greater than that applied to neon lamps, special attention must be paid to the design of internal electrodes and the seals between glass and metal.

Figure 3 shows construction details for a typical linear xenon flashtube. Though the tube shown is linear in construction, flashtubes can be formed into many shapes, including circles, helical coils and U-shaped tubes. Flash lamps are also constructed from glass bulbs that contain special probes that keep the arc discharge in a fixed position.

Xenon flashtubes range in size from a paper clip to a fence post. Small tubes are used in pocket cameras and personal warning strobes. Large tubes are used to excite various kinds of lasers and for nighttime aerial photography. Shown in Fig. 4(A) is an assortment of inexpensive miniature xenon flashtubes, while Fig. 4(B) shows a miniature xenon flashtube that measures only an inch in length. This size flashtube is used in compact cameras that have built-in electronic flash units.

Figure 5 compares, on a logarithmic

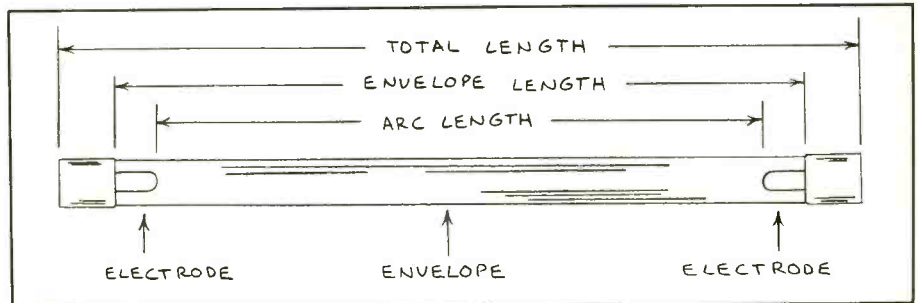


Fig. 3. Typical configuration of a linear xenon flashtube.

scale, the emission spectrum of a typical low-energy xenon flashtube with that of a tungsten lamp. Since the tungsten source is a blackbody radiator, its emission is a smooth curve. The irregular spectrum illustrated for the xenon source is due to the quantum electronic nature of the emission.

Note in Fig. 5 that the xenon emission is uniformly high across the entire visible spectrum. This is why the emission from xenon lamps appears so brilliantly white. Note also that the emission of xenon extends well into the ultraviolet portion of the spectrum.

The most important components of a flash lamp are its internal electrodes. These must be capable of withstanding an arc discharge without suffering appreciable deterioration or without sputtering, which can coat the interior wall of the discharge tube with a metal film that is opaque to the light flashes.

Figure 6 shows the most common methods of installing electrodes in a flashtube. Moderately-priced, low-power flashtubes are often made from borosilicate glass, a material well-suited for glass-to-metal seals necessary to attach electrodes. Quartz (fused silica) provides much better transmission of the ultraviolet light radiation produced by a xenon arc. It also permits operation at much higher power levels. Unfortunately for flashtube makers, quartz has an exceptionally low thermal expansion coefficient. This makes quartz-to-metal seals very difficult to achieve since, when heated, all metals expand more than quartz does. Therefore, special techniques, such as illustrated in Fig. 6, are used to install electrodes in a quartz tube.

Trigger Requirements

Xenon flash lamps are most often driven

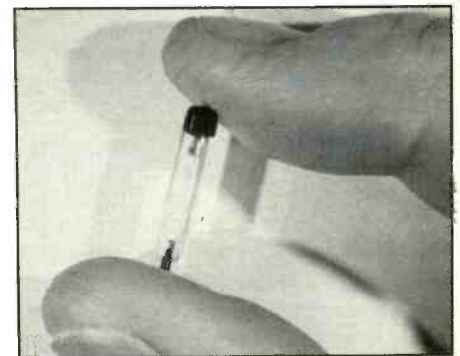
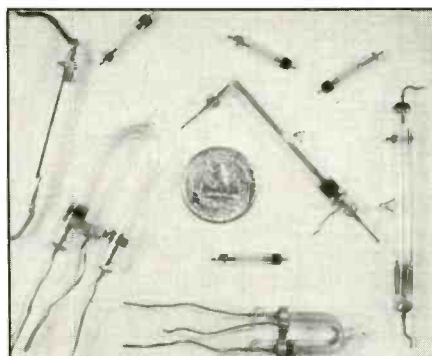


Fig. 4. Assorted miniature xenon flashtubes used in the author's lab (A). Miniature xenon flashtube used in miniature cameras with self-contained flash units (B).

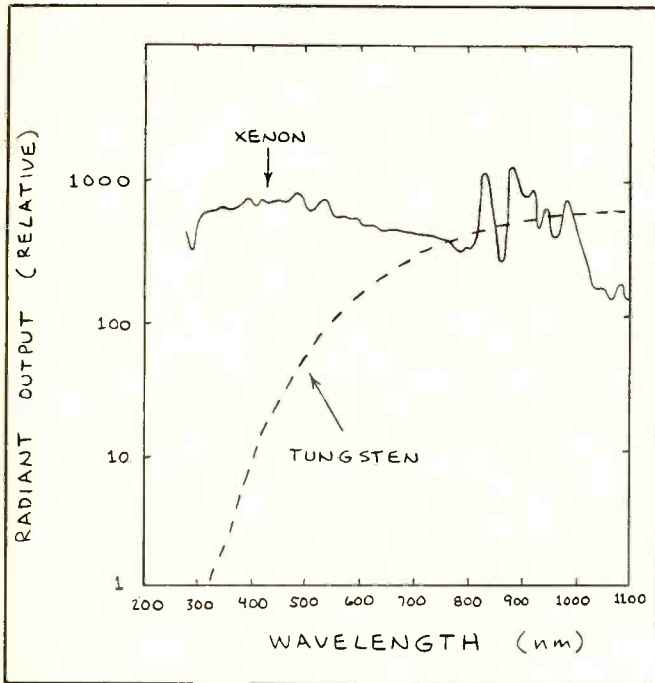


Fig. 5. Typical emission spectra of xenon flashtube compared with that of tungsten lamp.

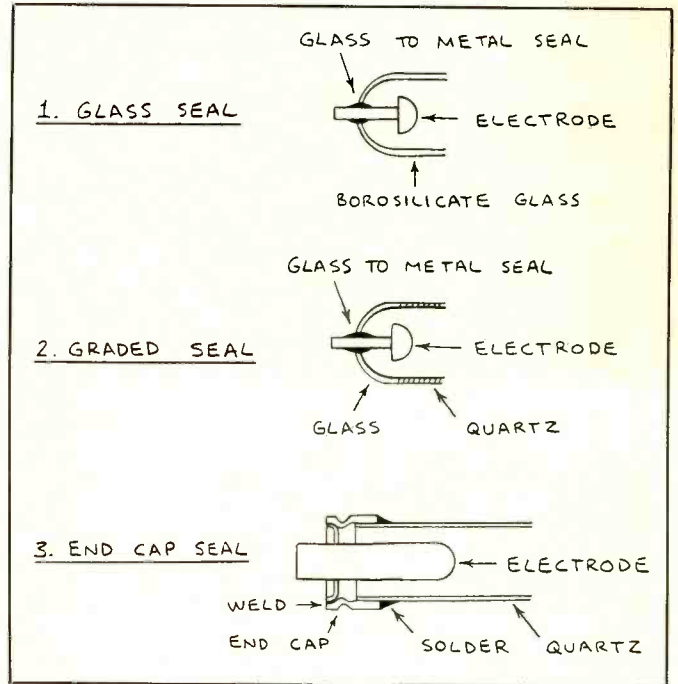


Fig. 6. Major electrode designs used in xenon flashtubes.

by a capacitor that has been charged to at least several hundred volts. This discharge capacitor is usually connected directly across the flashtube's terminals, perhaps through a pulse-forming inductor or network.

Breakdown voltage of the xenon gas in a flashtube is generally between 10,000 and 20,000 volts. Since this is usually far more than the charge on the discharge capacitor, it is necessary to temporarily ionize the xenon gas to provide a conductive discharge path for the capacitor. This is called "triggering" or "firing" the flash lamp.

At least five methods are used to trigger a flashtube:

- **External Trigger.** A basic externally triggered flashtube circuit is shown in Fig. 7. In operation, the high-voltage supply charges discharge capacitor $C1$ to several hundred volts or more through $R1$. Simultaneously, $C2$ is charged to several hundred volts (V_T) through $R2$. Though not shown in this circuit, $C2$ is

often charged by the same high-voltage supply that charges $C1$. Generally, $C1$ has a large capacitance, perhaps several hundred microfarads. Usually a small capacitance is used for $C2$, typically 0.1 microfarad or less. Because $C2$ has so small a value, it charges almost instantly.

After $C1$ is fully charged, the flashtube

is ready to be triggered. This is accomplished by applying a pulse to the SCR's gate. This switches on the SCR, thereby providing a discharge path for $C2$, which now discharges rapidly through the SCR and the primary of trigger transformer $T1$. This small transformer (see Fig. 8) has a high turns ratio. Therefore, the sev-

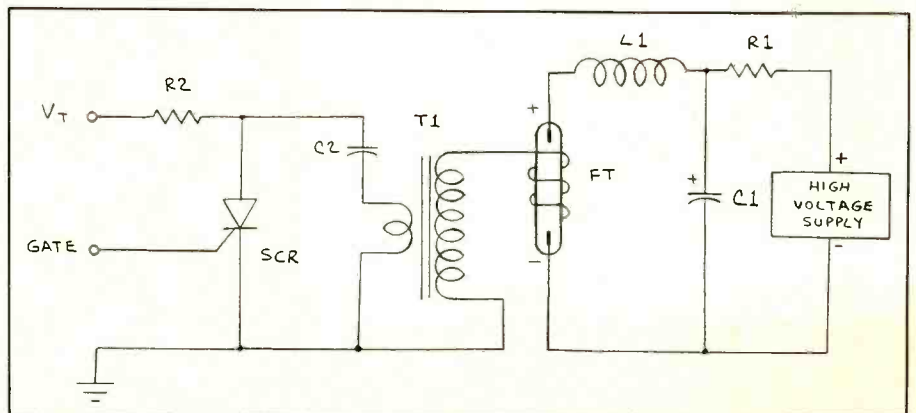


Fig. 7. Externally triggered xenon flashtube circuit.

eral-hundred-volt pulse across its primary appears as a 10,000- to 20,000-volt pulse across its secondary. This pulse of very-high voltage is applied to a conductor known as the trigger electrode, which is in close proximity to the flashtube.

The very-high-voltage pulse on the trigger electrode almost instantaneously ionizes the gas inside the flashtube. When the gas ionizes, a conductive path is provided for the charged capacitor, which then rapidly discharges through the flashtube. The result is a brilliant pulse, or flash, of white light.

Many kinds of trigger electrodes are used with flashtubes. The simplest is one or more loops of wire wrapped around the flashtube. A trigger electrode can also be made by painting a stripe of conductive ink on the flashtube. Flashtubes are often installed inside metal mountings or metalized reflectors that sometimes double as trigger electrodes.

• *Series Triggering.* Figure 9 shows a series-triggered flashtube circuit. Here the high-voltage pulse required to ionize the xenon inside the flashtube is applied directly to the tube's electrodes, not a separate trigger electrode.

As shown, the components are essentially identical to those in Fig. 7. The only significant difference is that trigger transformer *T1* must be more heavily constructed because its secondary winding carries *C1*'s full discharge current.

In operation, discharge capacitor *C1* is charged by the high-voltage supply through *R1*. As in the Fig. 7 circuit, *C2* is simultaneously charged by several hundred volts through *R2*. When *C1* is charged, the flashtube can be fired by applying a signal to the gate of the SCR. Switching on the SCR allows the charge on *C2* to discharge through it and the primary of *T1*, impressing a high-voltage pulse across *T1*'s secondary. This pulse is applied directly to the cathode terminal of the flashtube, thereby ionizing the xenon gas inside the tube. Now *C1* discharges through the secondary of *T1* and the flashtube.

• *Simmer Triggering.* In this trigger mode, a separate high-voltage supply is

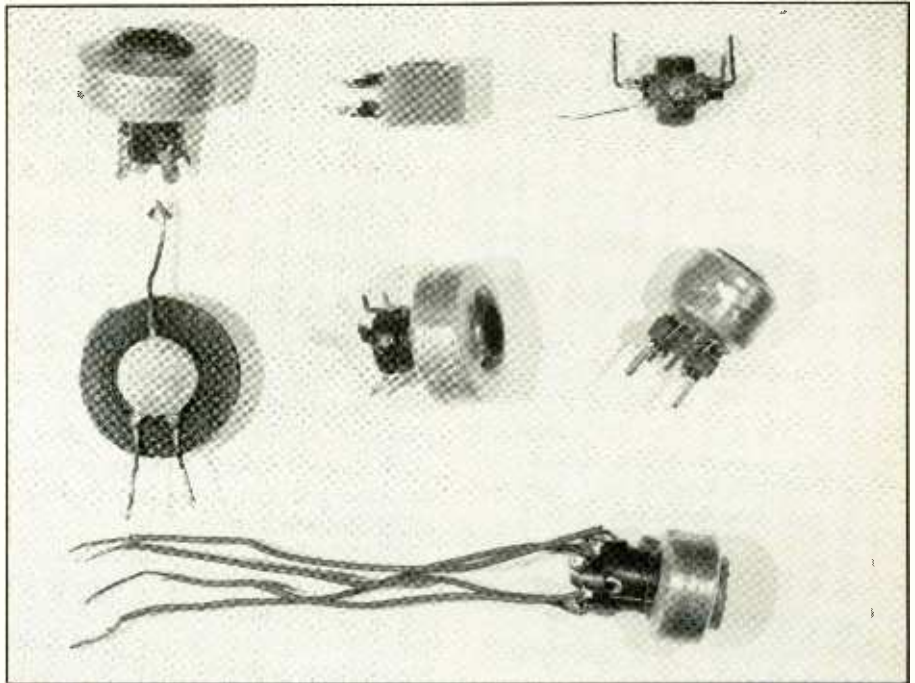


Fig. 8. Miniature xenon flashtube trigger transformers used by the author.

connected to the flashtube circuit shown in Fig. 7. This voltage keeps the tube's gas ionized continuously. The tube is then fired at any time by actuating a relay or solid-state switch connected between it and charging capacitor. Simmer triggering also requires an external trigger (see

Fig. 7) to ionize the flashtube prior to application of the simmer voltage.

• *Pseudo-Simmer Triggering.* Here the flash lamp is connected to a circuit much like the externally triggered Fig. 8 circuit. The chief difference is that, as in simmer triggering, a solid-state switch is inserted

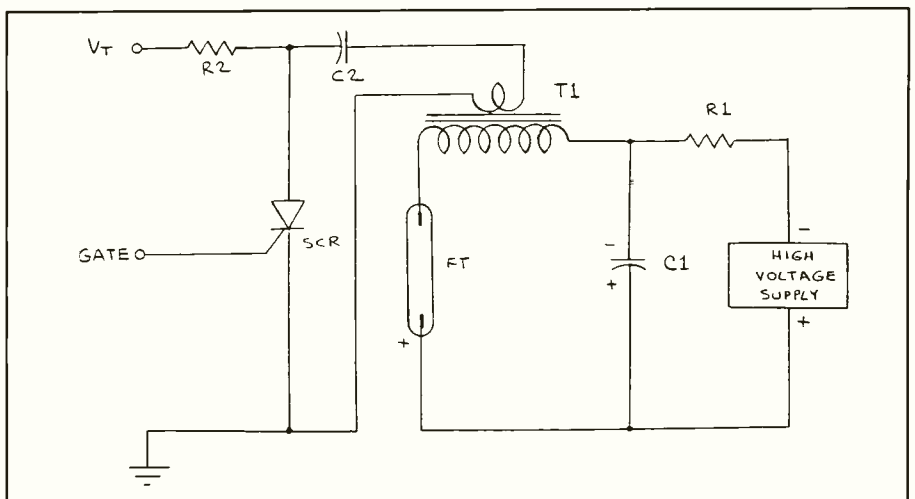


Fig. 9. Series-triggered xenon flashtube circuit.

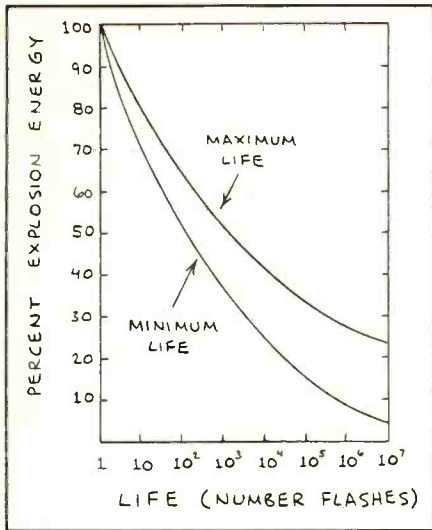


Fig. 10. Typical useful life of linear xenon flashtube.

between *C1* and the flashtube. This permits the flashtube to be ionized before *C1* is discharged.

- **Overvoltage Triggering.** This method eliminates the requirement for a separate trigger circuit by applying a voltage to the flashtube's terminals that is sufficiently great to ionize the xenon gas. In a typical circuit, the discharge capacitor is charged to at least 10,000 volts. An externally triggered spark gap or thyratron is connected between the discharge capacitor and flashtube. When the switch is actuated, the discharge capacitor is connected directly across the flashtube. The gas in the main tube is then almost instantly ionized and the capacitor discharges through the tube.

Driving Requirements

When a small current is applied to an ionized flashtube, a very thin violet or blue arc can be seen between the tube's electrodes. This effect can easily be seen by using a small discharge capacitor. As the current is increased (i.e. the value of the discharge capacitor is increased), the thin arc becomes wider. Eventually, the discharge becomes a plasma that fills the entire flashtube.

As the discharge current is increased, the flashtube's life is appreciably shortened. At some point, the life is shortened

to a single pulse and the wall of the flashtube is fractured. The tube might even explode. The point at which this occurs is called the "explosion energy."

The energy in the discharge current applied to the flashtube is half the product of the discharge capacitor's value and the square of the voltage on the discharge capacitor, or $E = CV^2$.

For both safety and economy, flashtubes are generally operated at less than 70 percent of their explosion energy. Figure 10, adapted from a graph produced by EG&G, Inc., shows the dependence of the life of a flashtube on the percentage of explosion energy at which the tube is operated. As this graph clearly shows, flashtube power-supply designers must pay close attention to the specifications of the flashtubes they use.

The life of high-energy flashtubes can be increased by increasing the risetime of the discharge current. For this reason, pulse-forming networks are often used between the discharge capacitor(s) and the flashtube. The simplest network is an inductor connected as shown in Fig. 7. More sophisticated networks incorporate several discharge capacitors and several inductors to provide an energy-storage network. Such networks can produce longer, nearly square-shaped pulses than simply discharging a capacitor alone through a flashtube.

Applications

Xenon flashtubes produce a brilliant burst of white light that is ideal for photography. Moreover, they can be repetitively flashed in quick sequence. This makes xenon flashtubes ideal as tracking beacons for small rockets, emergency lights and aircraft beacons.

Certainly the best-known application of the xenon flashtube is stop-action photography, a technique pioneered largely by Harold Edgerton. Though the flash from a xenon lamp is most often used to produce a single image on film, many of Dr. Edgerton's photographs have captured a sequence of motion on a single frame of film. To photograph a golfer striking a golfball, for example, the subject was placed in a dark room before a camera loaded with film and with

its shutter open. When the golfer began to swing his club, a xenon lamp emitted a sequence of brilliant bursts of white light. After the swing, the camera's shutter was closed and the film was developed. The result was a series of superimposed images showing the stance of the golfer and the swinging club at each burst of light.

Edgerton's spectacular photographs were made possible by the high level of radiant energy contained within a single flash of light from a xenon flashtube and the fact that the duration of the flash was only a microsecond or less. Conventional flashtubes can supply substantial radiant energy, but their flash duration is typically a very slow 0.02 second.

So much has been written about the use of xenon flashtubes in photography that it's impossible to do the subject justice in this report. For more information, refer to the references listed below.

Another well-known application for the xenon flashtube is its use as a source of "pump" light for various kinds of lasers. Indeed, Theodore Maiman made the very first laser by mounting a ruby inside the coils of a helical xenon flashtube.

Other, less exotic, applications include use of the xenon flashtube as light sources for photocopy machines, exposing photoresist patterns, exposing microfilm, flash photolysis and as beacons for aircraft and earth satellites. Xenon flashtubes are also used in stroboscopes and for aerial photography at night.

Safety Requirements

When working with or around xenon flashtubes, it's important that you observe several safety rules. These include:

- (1) Always mount xenon a flashtube behind a transparent explosion barrier because that xenon flashtubes can explode if operated above a particular energy threshold. Additional protection can be provided by wearing safety goggles.

- (2) Always advise persons who will be exposed to the light from xenon lamps to protect their eyes and skin from the radiation. The reason for this is that some xenon flashtubes, particularly those with quartz tubes, emit high levels of poten-

(Continued on page 78)



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Motorola's New 88000-Series RISC Processor Chip Set; Task-Specific Microprocessors; Random Notes

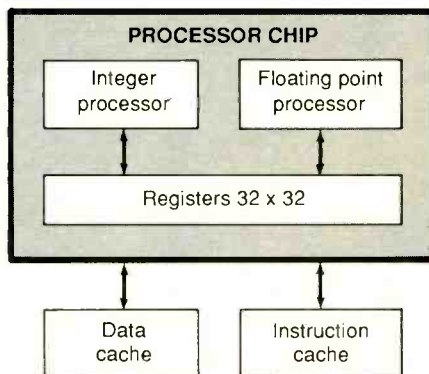
By Harry L. Helms

For years, Motorola has been a world leader in microprocessor technology. Its 6800-series family spawned perhaps the finest 8-bit processor ever, the 6809, and its 68000-series family became a *de facto* industry standard (along with Intel's 8086/186/286/386 family) in 16- and 32-bit microprocessors. Thus, when Motorola decides to embark on a radically different direction in processor technology, it's major news, and that's why we're going to depart from our usual format this month to discuss it.

Motorola recently introduced the 88000-series *reduced instruction set* (RISC) processor chip set. The result is a processor capable of much greater raw performance than conventional microprocessor designs—on the order of 50,000,000 instructions per second! How does a RISC processor manage to achieve such performance? One clue lies in the “reduced instruction set” part of its name.

You can get an idea of the staggering growth in the size and complexity of microprocessor instruction sets by comparing the instruction set of an early device, such as the Z80, with the instruction set of today's 80286 and 68020 units. Not only have the instruction sets grown in absolute number of supported instructions, but the individual instructions tend to be more complex. By contrast, the instruction sets for RISC processors are highly streamlined. This reduces the software “overhead” the processor must contend with. Moreover, the instructions are designed so that *all* can execute within a single clock cycle. (By contrast, many instructions used with conventional microprocessors require multiple clock cycles to execute.) Another trick used to enhance performance is to use fixed word lengths throughout the system.

Performance of the 88000 is enhanced by the fact that it is part of a three-chip system involving a processor unit, a data cache, and an instruction cache, as shown in the drawing. The processor unit contains separate integer and floating-



Block diagram of the Motorola 88000 three-chip RISC processor set.

point processing units along with a *register file* consisting of 32 32-bit registers.

The 88000 uses a novel technique known as “scoreboarding” to keep track of the states of the registers so that a programmer or the system's compiler doesn't have to. The result is a highly efficient use of the registers. Therefore, fewer are needed than might be expected. It takes less time to store information in any of the registers since there are fewer to go through. Another result is that the system compiler is more efficient since it doesn't have to handle the registers.

The data cache and instruction cache chips increase the system speed by reducing the number of times the processor unit must access the main system memory. Frequently used data and instructions are kept in the respective cache chips and can be directly stored from or fetched into the processor registers without having to pass through the main system memory. The processor doesn't have to “hunt” for these instructions and data in the main memory, either. All fetch and store operations take a single clock cycle.

Naturally, the extraordinary performance of the 88000 does not come without some costs, particularly on the software side. A reduced instruction set makes life easier for the processor, not programmers. Operations that often take a single instruction with conventional microprocessors make several RISC instructions

to perform. (This is somewhat analogous to the advantages and disadvantages of programming in a high-level language versus programming in assembly language.) For commercial customers, there is also the “loss” of the existing software base.

Both Motorola and Intel have stressed “upward compatibility” in software when introducing new microprocessors; for example, most software written for the 80286 will execute on the 80386 with no problems. Users who switch to the 88000 and similar RISC processors, however, will not be able to build upon their existing software bases and, in effect, will be discarding existing programs and have to write all new ones.

But marketing officials at Motorola don't see these as significant problems. Motorola will be offering software developers everything from software simulators to systems running Unix to help ease the software crunch. (In fact, the 88000 was designed to be used in systems running Unix environments.) Moreover, Motorola foresees the 88000 being used in applications in which speed is more important than maintaining software compatibility, such as image processing and digital switching. If software compatibility is important, Motorola expects designers to stick with the 68000 family and await future members (such as the expected 68040) with enhanced speed. Those for whom performance is paramount will likely gravitate toward the 88000 and develop their own software bases.

Motorola's announcement of the 88000 has given the entire concept of RISC immediate credibility. It is likely that other major semiconductor firms will announce their own RISC processors in the near future.

Task-Specific Microprocessors

A different approach to enhancing microprocessor performance was recently announced by Intel. Its approach is to

take existing microprocessor designs and alter and enhance them for specific applications. These are known as *task-specific* microprocessors and make use of "application-specific" instruction sets. Such microprocessors may share essentially the same hardware "platform." However, their instruction sets will be radically different, depending upon the intended applications. In essence, the microprocessors may be very similar to each other physically but be unable to run each other's software. The application-specific instruction sets are designed to allow the microprocessor to perform certain tasks with speeds significantly greater than general-purpose microprocessors (although not as great as RISC processing). The special instruction set also greatly simplifies developing software, since the instruction set supports the intended application.

Dr. Andrew Grove, Intel's president, has said that he feels such application-specific microprocessors may well become the dominant trend in future microprocessor designs. He said that Intel will be bringing out at least six task-specific microprocessors in the coming year, and that each will be separate and distinct from mainstays of the Intel line, such as the 80386. These new devices are expected to be used in applications such as embedded controllers, where high high-speed, real-time processing ability is required.

Random Notes

What's the dominant semiconductor technology? According to Integrated Circuit Engineering Corp., an Arizona-based industry research and marketing firm, it's CMOS. In 1982, CMOS held 12% of the market, and this has grown to 28% in 1987. By 1992, CMOS is expected to command over 50%.

CMOS's growth has come largely at the expense of NMOS, which saw its market share decline from 41% to 25% from 1982 to 1987. Bipolar device share shrank only slightly, from 22% to 21%.

TTL also fell from 19% to 11% in the same period. On the other hand, ECL, which is still tops for many high-speed applications, expected to slightly increase its share in the next five years.

The past few months have seen a crippling shortage of 256K dynamic RAMs. Some manufacturers have had to curtail some of their production due to the shortage of these devices, while others have had to pay premium prices on the "gray" and surplus markets. One obvious cause of the shortage has been an interruption in production as RAM makers change over facilities for the new generation of 1M RAMs.

Some people feel another cause is the U.S.-Japan semiconductor trade agreement, which was originally intended to protect the U.S. semiconductor industry by limiting imports. There has been speculation that Japanese DRAM manufacturers have deliberately curtailed shipments to the U.S. in an attempt to simultaneously comply with the accord and to give a forceful demonstration of the power they now have in the electronics industry. (At the time this was written, Texas Instruments and Micron Technology were the only domestic makers of 256K memories.) Whatever the cause, the shortage has been a clear warning of how the U.S. has become just as dangerously dependent upon foreign semicon-

ductors as it has upon foreign energy sources—and how in a trade dispute the Japanese could severely disrupt the American electronics and defense industries merely by shutting off supplies of a few essential components.

New Literature

Advanced CMOS logic (ACL) is the newest generation of CMOS logic devices, offering speed approaching that of the best TTL devices while retaining CMOS's low power consumption and other advantages. Texas Instruments has put together *Advanced CMOS Logic Designer's Handbook*, a comprehensive guide and applications techniques for such devices. You can find out how to get a copy by calling the Texas Instruments customer response center at 1-800-232-3200. . . . Not all Motorola news this month concerns RISC. It has released two new applications notes that describe the use of MOSFETs in radio-frequency power amplification. They are No. AR165S, "RF Power MOSFETs," and No. AR176, "New MOSFETs Simplify High Power RF Amplifier Design." You can get copies from your local Motorola sales office/representative or by writing on company or professional letterhead to Motorola Literature Distribution, P.O. Box 20912, Phoenix, AZ 85036. **ME**

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Advantages of Single-Sideband Communication

By David Sweeney

With ordinary amplitude modulation, good communication ceases when the distance between operators of radio equipment reaches a point where the audio signal seems to disappear from the r-f carrier. You can tell when this is happening because you say and hear "say again" a lot as you try to maintain communication. Mike keying may continue for a while, but soon you will have to yield to the laws of nature and end your conversation as you reach the limit of AM transmission range. So much for AM operators and hoped-for communication. However, you could have continued communicating long after maximum AM transmission range was exceeded if you were using single-sideband equipment.

For the same transmitting power, antenna efficiency and propagation characteristics, SSB offers a much farther communicating range than AM. Stated differently, for a given set of conditions, an SSB transmitter exhibits as much as four times the performance of an AM transmitter with the same peak output power.

Some Background

Single-sideband communications appeared as early as 1915, when John R. Carson filed a patent application for it (see box for more details). At that time, most scientists comprehended only the time-based technique of AM transmission in which a high-frequency sine wave (the carrier) is modulated with a low-frequency (usually audio) signal. An anten-

na field changing polarity at a high-frequency rate but with its strength varying at a lower audio-frequency rate was easy to visualize. Few technical people in those radio pioneering days suspected the existence of additional components called "side frequencies."

Carson and others discovered the bands of side frequencies in a mathematical analysis of amplitude modulation. Arithmetic terms identified the side frequencies as being separate from the carrier but necessary to maintaining the modulation waveshape. Although scientists put the side frequencies to work and demonstrated the advantages of SSB communication, the additional expense for transmitter filters and precision low-frequency oscillator crystals delayed large-scale development of the technol-

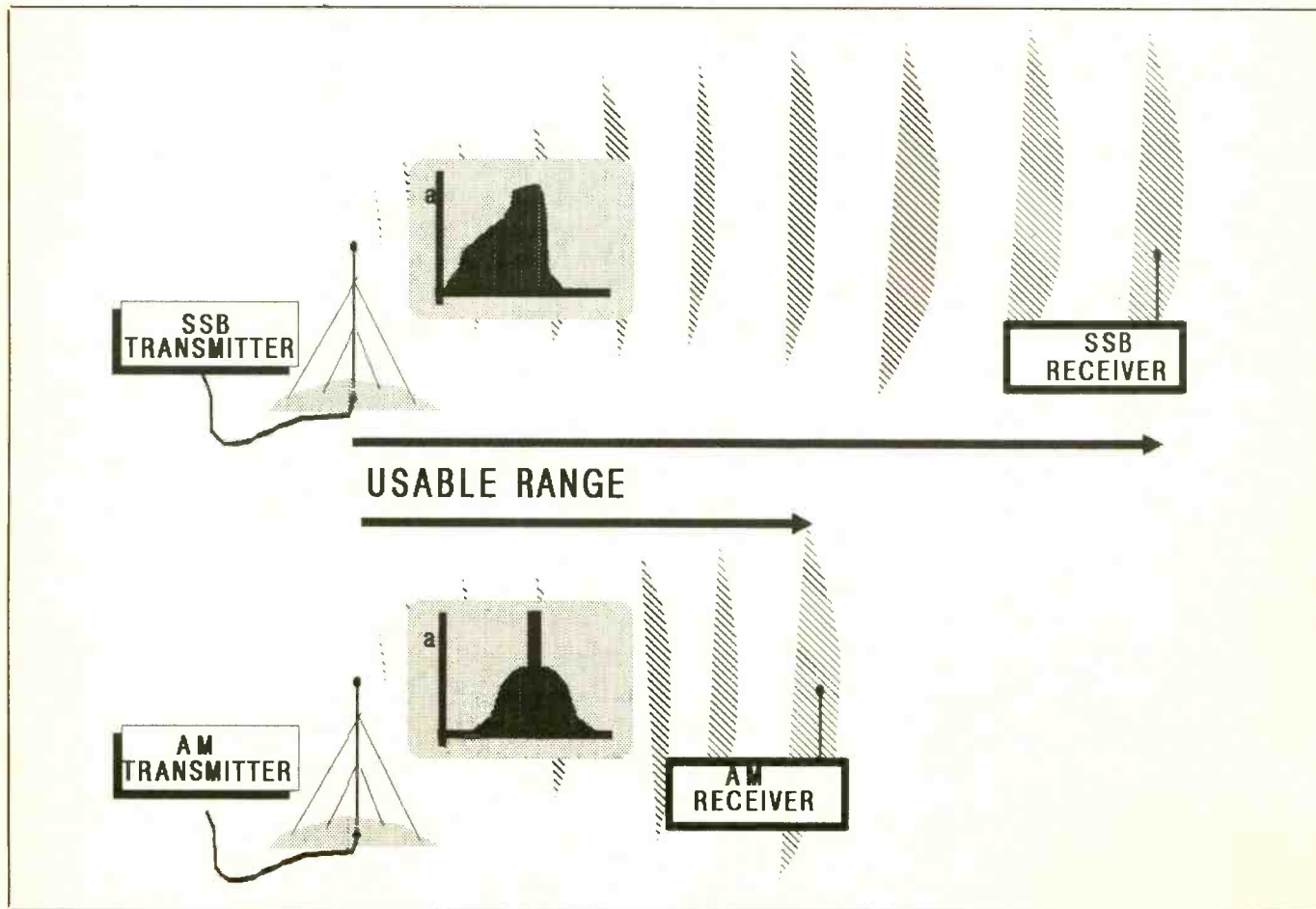


Fig. 1. When AM transmission range (upper) has reached its limit, SSB range (lower) is still going strong. For the same peak output power from the transmitters, SSB has up to four times the performance of AM.

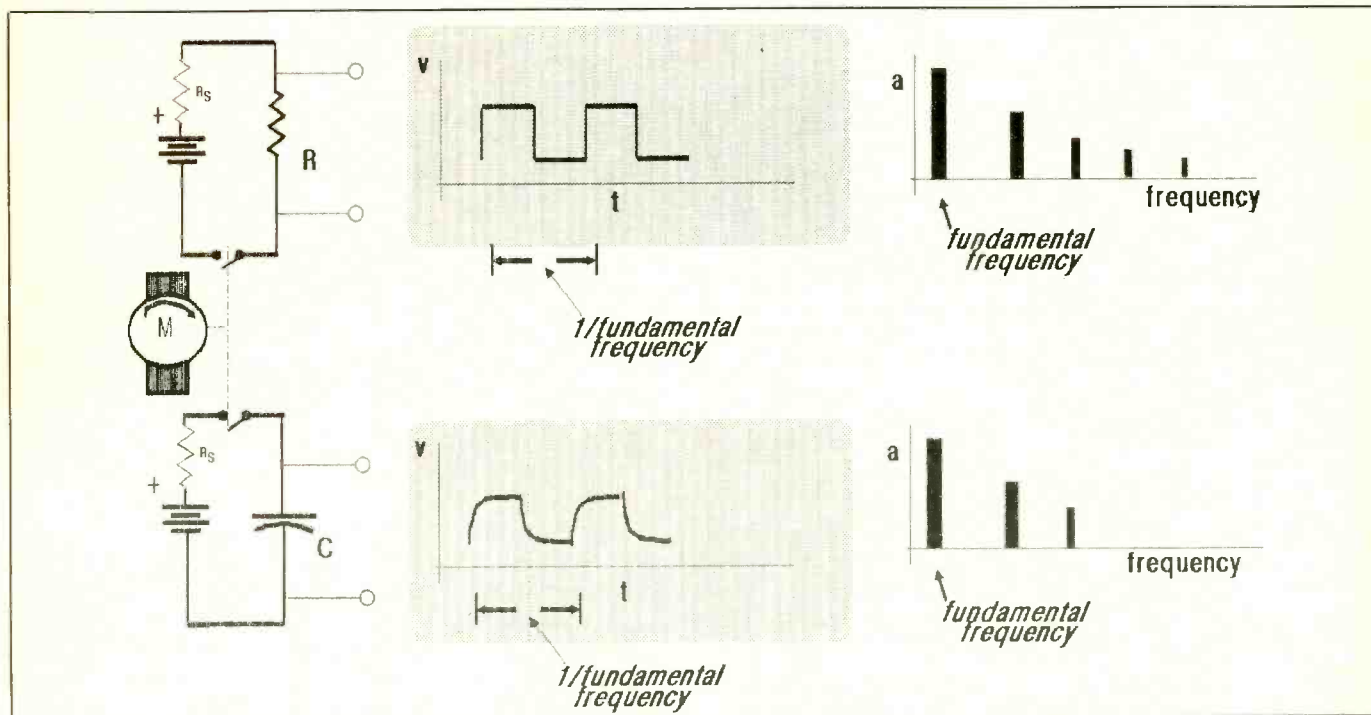


Fig. 2. Motor-driven switch circuits illustrate the principles of component frequencies.

Moments in Single-Sideband History

The basic principles of single sideband have been recognized for more than 70 years. In 1915, John R. Carson mathematically analyzed amplitude modulation and concluded that one sideband and the carrier could be removed from an AM signal but that the information content would remain. Back then, much of the technical community doubted the existence of sidebands. However, a small number of engineers and scientists experimented with filtering sidebands by detuning antennas, though the transmissions still included the carrier.

Carson filed the basic U.S. patent (No. 1,449,382) relating to SSB transmission. He was the first to advocate suppression of both carrier and one sideband. Within three years of his application for a patent, the first commercial SSB system for wire service began operating.

For radio waves, experiments with SSB were described in various *Proceedings of the Institute of Radio Engineers* in 1923. Much of the information con-

tained in these articles was based on communication using 55 kHz between Rocky Point, NY and London, England. To generate the power required for sending voice signals across the Atlantic ocean, the transmitting equipment contained 20 vacuum tubes in its final amplifier.

Later experiments with carrier frequencies greater than 2 MHz required automatic frequency control (afc), which is a far more difficult task for SSB because a small percentage of change in the higher carrier frequency resulted in a large change in the audio signal. The need for a frequency reference at the receiver became apparent, and the carrier was transmitted at a low level for use as a pilot signal.

Since the mid-1930s, many shortwave international radiotelephone circuits have been placed into service. These links generally have used pilot-carrier (SSB with a small percentage of the carrier signal present in the transmitted signal) with afc in manually tuned receivers.

The high precision needed for SSB required expensive lattice filters at the transmitter and receiver. Lack of compact, inexpensive high-precision components delayed large-scale development of single-sideband equipment for decades. Then, during the 1950s, SSB equipment began to appear in force among radio amateurs and in military installations. From then until now, SSB has risen in popularity, thanks to advances in electronics technology and the development of microcircuits, especially digital frequency synthesizers for carrier production.

At the present time, very reasonably priced SSB equipment is available to the general radio public. Though this equipment is more expensive than conventional AM gear, it is not prohibitively so as was the case throughout most of the years SSB has been in existence. Moderate prices now make it possible for radio enthusiasts to afford this superior gear.

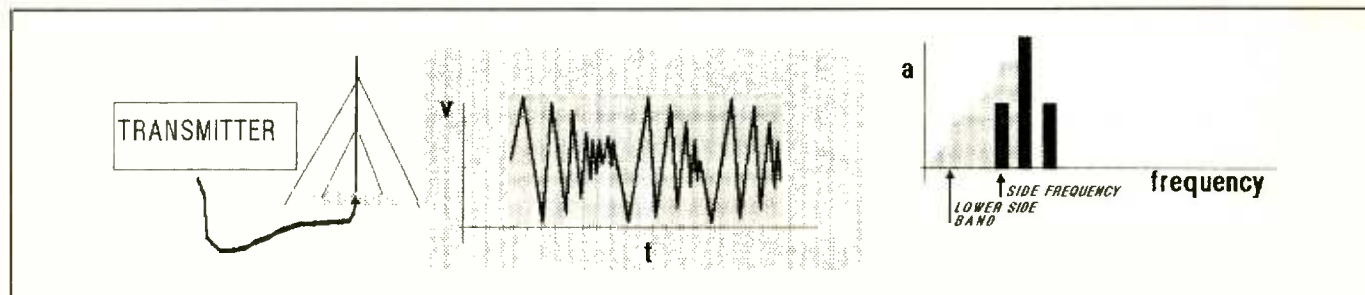


Fig. 3. In an SSB transmitter (left), the carrier and one sideband are filtered out so that only the selected sideband is radiated by the antenna (center). Note how in the spectrum diagram (right) two upper and lower-sideband "channels" occupy the same spectrum space of a single AM channel.

ogy. Fortunately, constant research and development in electronics technology, especially during the past 15 years or so, have made it possible for amateur radio operators and others to presently afford single-sideband equipment.

These days, ham radio operators routinely use SSB for long-range voice communication on licensed frequencies. In addition, the government has opened more frequencies to the public as new rules permit SSB operation on a portion of the 10-meter band. Holders of Novice and Technician ham licenses can use the 28.3-to-28.5-MHz portion of the band for SSB operations. Previously, operators who wanted to use the high-frequency (hf) band were limited to carrier-wave-only operation. Now, a lot of people who do not want to learn Morse code for operating CW have obtained SSB licenses.

Of course, you need not be a ham radio operator to be able to take advantage of SSB communication. For example, Citizens Band SSB-type receivers have been around for years, offering all the advantages of this method of communicating hams enjoy. The special capabilities provided by SSB have even resulted in the formation of SSB CB users clubs, of which the SSB "Network" is just a part. Many of these clubs publish interesting newsletters for their members and others who express an interest in their operations. Members of such clubs have a lot of fun with their SSB rigs and frequently perform vital public service in times of emergency.

Besides permitting longer communi-

cating range (see Fig. 1), SSB offers a bit of privacy. Users of equipment that is not capable of handling SSB transmissions hear garbled "duck talk" when they tune in a "sidebander." Obviously, then, to have a complete SSB link, both the transmitter and the receiver must be SSB devices. The SSB receiver generates its own carrier signal and has detector circuitry specifically designed to demodulate SSB signals.

The transmitted SSB signal appears as a complex waveform that operates near the AM carrier frequency and contains amplitude and frequency variations. With SSB, there is no carrier and, as a result, no transmission until there is a modulating signal. Also, SSB receivers have some peculiar controls that are absent on AM receivers. These include: USB/LSB (upper sideband and lower sideband) switches, a CLARIFIER control and an SSB/AM mode selector switch.

Component Frequencies

While an understanding of electronics principles often requires the use of mathematics, it is more fun to pursue an intuitive analysis of SSB. With this in mind, let's take a look at the frequency components in time-variant signals.

Shown in Fig. 1 are two motor-driven switching circuits. The upper circuit's motor-driven switch alternately connects and disconnects a voltage to and from a resistor, while the other circuit's switch does the same for a capacitor.

As expected, a square wave exists at

the resistor in the first circuit, as illustrated by the center drawing at the top in Fig. 2. Now notice how much different is the waveform at the capacitor in the drawing immediately below. Here, capacitive action rounds the edges of the square wave on the charge and discharge edges of the cycle.

Capacitive reactance (X_c) decreases with increasing frequency. Hence, the capacitor can be said to short out the high-frequency component of a waveform. At the edges of the square wave, the voltage changes rapidly with respect to time, which is a high-frequency phenomenon. Note also that in the flat region of the square wave, the rate of change is zero, which is a low-frequency characteristic. The capacitor rounds the edges of the square wave as the higher frequencies find a low-impedance circuit-return path.

Just as subtracting frequencies with a capacitor changes the shape of the waveform, adding frequencies can restore the square shape of the waveform.

Instead of using a motor and switch, a square wave can be assembled using sine waves of different frequencies from a number of oscillators. You simply add together the outputs of the oscillators to produce the square wave, provided each oscillator's signal frequency is harmonically related to the other oscillator frequencies.

Contained in Fig. 2 are also plots of amplitude for each frequency, illustrated here as spectrums shown at the right in the upper and lower drawing sequences. As you can readily see, some of the high

frequencies present for the resistor circuit are absent for the capacitor circuit.

Sideband Defined

Maintaining the waveshape of any signal requires a transmission system that does not filter out component frequencies. For an AM carrier wave, component frequencies are the result of the audio modulating the r-f carrier. These components change with the audio.

An AM signal can be simplified if you consider a single audio tone of, say, 1,000 Hz modulating the r-f carrier. With a steady audio frequency, only three component frequencies establish the shape of the signal: the r-f carrier and the two low-frequency side signals. The difference between the carrier and audio frequencies defines the lower side frequency, while their sum defines the upper side frequency.

Figure 3 illustrates what happens when the audio varies. The frequencies spanned by the AM carrier with audio modulation determine the bandwidth necessary to keep the original waveshape. If most of the carrier and one of the sidebands are filtered out, the shape of the wave will be changed. However, a single side frequency (sideband) will be transmitted. This is the basis of single-sideband transmission.

To maintain the original waveshape, AM communication requires sending and receiving *all* of the frequencies—carrier, upper sideband and lower sideband. As the receiver of this AM signal is moved farther and farther away from the transmitter, the receiver may be able to sense the carrier, but the side frequencies, being lower in power, will continue

to fade until they ultimately become too weak to hear.

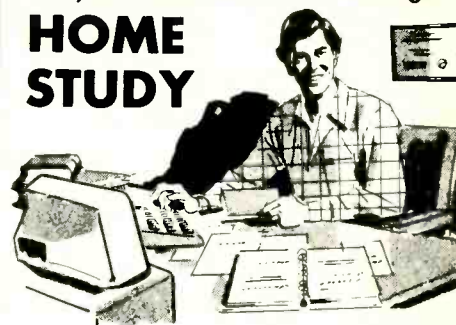
As fading occurs, the waveshape of the original modulated signal fails to be maintained. The result is that the receiver will be amplifying an unmodulated carrier as the distance between the transmitter and receiver becomes so great that side-frequency attenuation results in complete loss of information being received.

SSB transmission takes advantage of the differences in amplitudes between the carrier and side frequencies. At the transmitter, special circuits remove the carrier and one of the side frequencies before transmission. The resultant transmitted signal contains only one sideband of frequencies that ride a modulation "envelope" from which the carrier has been removed. Obviously, then, since the sideband frequencies result from the audio, no transmission occurs until the operator keys and speaks into the microphone.

Going further, if not amplified, this single band of frequencies would use only half the power originally used in the AM transmission. However, the single-sideband signal can be amplified and transmitted at *full* transmitter power. As a consequence, sideband output power increases to twice what it would be with AM transmission, which gives a theoretically four times power boost over AM transmission. (If the carrier were present, amplification would have exceeded the transmitter's capabilities!)

A local oscillator at the receiver generates the carrier and adds it to the received SSB signal. This produces a detector input that is much stronger than was available with the original AM signal. The detector extracts the received SSB signal

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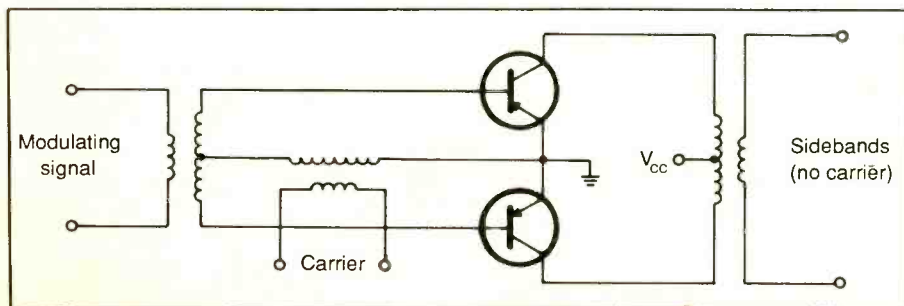


Fig. 4. A simplified schematic diagram of a typical SSB modulator.

COMMUNICATIONS . . .

from the carrier to restore the original audio intelligence.

By locally generating the carrier (instead of receiving it as in AM), effective signal strength at the SSB receiver's detector exceeds the strength of a comparable AM signal. The frequency spectrum diagrams in Fig. 1 relate the AM signal levels to the single-sideband levels and graphically illustrate the advantage of the latter over the former.

Besides providing greater range, some other benefits are derived from single-sideband operation. For example, transmitter antenna tuning is sharper and receiver noise filtering produces improved signal-to-noise ratio (S/N) figures because tighter filters can be used. Also, signal loss from sideband fading is less likely to occur. In AM, when one of the sidebands fades, the result is audio distortion. Such losses occur when atmospheric disturbances impact one frequency region more than another.

A final benefit of SSB is that it doubles the number of available "channels" in a

given band of frequencies. The reason for this is that where a single AM transmission supports only one communicating "channel," the SSB transmission supports two because both its upper and lower sidebands can be in use separately but simultaneously.

SSB Controls

An SSB receiver contains many of the same types of circuits used in AM models. However, it does require a different kind of detector and some additional controls. With regard to the latter, you will typically find AM/SSB and USB/LSB switches and a CLARIFIER control.

The AM/SSB switch provides a convenient means for selecting between the two types of reception media. The USB/LSB switch is used to select either upper-sideband or lower-sideband reception according to which sideband the current transmission is on. The CLARIFIER control permits fine tuning of the receiver's local oscillator for clear, intelligible audio re-

ception. Obtaining clear audio reception requires that the carrier from the receiver's oscillator be tuned to the identical frequency used by the transmitter to produce sidebands. You can diddle with the CLARIFIER control to minimize distortion.

About SSB Circuits

Figure 4 is a simplified schematic diagram of a typical SSB modulator. It shows the carrier being applied in-phase to both transistors. The carrier signal at the output transformer is also in-phase and cancels in the output. The modulating signal is applied to the transistors in opposing phase such that a modulated output occurs only when a modulating signal is present.

With the carrier canceling out but modulation applied to the circuit, the output contains the sidebands. Filter circuits following the modulator select either the upper or the lower sideband for transmission.

SSB receivers use a detector that performs the same as a typical frequency mixer. The circuit mixes the received SSB signal with a locally generated carrier, which must be at least twice the amplitude of the received signal. The difference-frequency output from the mixer is the audio signal.

Automatic gain control (agc) in an SSB receiver differs from that in an AM receiver in that there is essentially no carrier when there is no audio. An AM receiver bases agc feedback on the received carrier. With no carrier available in an SSB transmission, traditional agc action is not possible. Instead, agc in SSB is averaged and stored for the interval when the signal is present.

Summing up

As you can see, there are more than enough advantages to be gained by using SSB equipment for radio communication—more than sufficient to offset the additional cost of such equipment when compared to AM equipment. Increased range for more reliable communication is only one of the benefits offered by SSB. Doubling the number of available channels of communication can be an important consideration, too, on the crowded airwaves. **ME**

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Computer Communications

By Curt Phillips

Last month, I reviewed two 2,400-bps (bits per second) modems that are available from several mail-order sources for around \$200. The same sources sell 1,200-bps modems for around \$100. Despite the widespread availability of modems at reasonable prices, however, the vast majority of computer owners do not yet own a modem [45.4 percent of *Modern Electronics* readers own one—Ed.]. Many people who do own modems use them rarely or not at all.

Since most people who have microcomputers aren't active in computer communications, why should you be interested in telecomputing? The reason is that there is a vast amount of information and services available to you and your computer via the convenient phone.

As one person expressed it to me, "Before I got involved in computer communications, the only information in my computer was that which I had either purchased or typed myself. Now I can directly access programs and information I would have never known about before."

"Free" Software

People being introduced to computer communications are usually surprised by the number of free and low-cost programs available. You may have seen advertisements from organizations like PC SIG, which provide diskettes of software for about \$6 per disk. Most of this software can be obtained for free from computer bulletin boards (BBSes).

There is a wide variety of software distributed by this method, and the quality and level of sophistication is sometimes as good as that of expensive commercial packages. Interestingly, most of the active modem users I know use a shareware terminal program (discussed in more detail later), even if they own a commercial program. Spreadsheet, database and word-processing programs are all available, as well as a seemingly endless supply of games. The quality of this software varies widely, but you get the chance to give it a thorough tryout before you pay for it.

In some cases, the software author has released it into the public domain and gives the right of usage freely. Because of the number of computer users interested in electronics, there are a significant number of public-domain programs for doing electronics and amateur radio-related calculations.

Other authors consider shareware an alternative method of distributing and selling their commercial software. They ask a modest payment to "register" it if you decide to use the program regularly, which typically entitles you to upgrade information and a printed user's manual. A typical shareware communications program costs about \$50 to become a registered user, payable only after you have tried the program. Compare this to the popular terminal programs distributed conventionally that cost over \$200, and shareware might be a bargain even after you pay.

Shareware is far from the only reason to get involved in telecomputing. Through the commercial database services and computer bulletin-board networks, you have access to a vast amount of technical expertise from all over the country. Moreover, there is plenty of truly free software available for downloading, including a bevy of utilities that are not commonly sold.

No matter how knowledgeable you are about electronics, on occasion you will be confronted with a seemingly insurmountable problem. Several months ago, I was attempting to interface two pieces of computer equipment with some software that didn't want to work with them. Neither the equipment manufacturers nor the software house was very familiar with the other's products, so they couldn't help. I figured that someone somewhere must have used these products in combination; so I left a message stating the problem on a couple of national commercial data networks. Within a few days, I had several messages sent to me suggesting possible solutions. One of the suggestions put me on the right track, and soon I had solved the problem.

Through a concept known as "echoing," many of the private BBSes relay

messages regionally or nationally. Two popular echo networks are FIDONET and ALTERNET, both of which transmit their messages nationwide.

Discussions on both types of services cover not only the expected electronic, computer and technical topics, but such diverse subjects as photography, real estate, genealogy and many others. Even discussions on politics and religion can be found on both the free and commercial services. Most of these discussions take place in public posting areas (where anyone can read them), but if you have a private message, you can send it confidentially via E-mail (Electronic mail).

Through the commercial services, you can plug into a level of financial and business information formerly available to only large corporations or brokerage firms. You can get current (15-minute delay) stock quotations and historical information on thousands of companies, as well as search the business and popular press for any information of interest. Even if you aren't a stock-market investor, this information can be valuable.

If you get a job offer or are considering doing business with an unfamiliar company, you can use your computer to do research on them. Some pay services also allow shopping and banking online, as well as access to airline schedules. Also available via phone are reference sources such as *Thomas Register* and encyclopedias, all of which can be searched with the speed and accuracy of the computer.

Getting Started

So now that you're interested in going online, how do you do it? The basic tools needed for telecomputing are a computer with a serial interface, communications software, a modem and a telephone line.

Your computer will likely already have a serial interface, also called a serial port and an RS-232 port. Some computers include them as standard equipment and most multifunction memory cards for IBM-type computers include a serial port. A serial port most often has a 25-pin (DB-25) connector; on PC machines it is usually male. Some machines are using a 9-pin (DB-9) connector (also usual-

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ly male). On machines like the lower-priced Ataris and Commodores, a plug-in module provides the serial interface.

The heart of the serial interface board is the Universal Asynchronous Receiver/Transmitter (UART) chip, which regulates the conversion of data from parallel to serial. Of most concern to the user is not the mechanics of UART operation, but the configuration of the output pins. The RS-232 (actually, RS-232C) "standard" defines pin functions in one of two ways: as DTE (Data Terminal Equipment) or DCE (Data Communications Equipment). The serial card should be configured as DTE, because most modems will be set as DCE, and the DTE-to-DCE connection is a "mated" pair. If your serial port is incorrectly configured, it can usually be changed by moving jumpers or resetting DIP switches.

The modem (MODulator-DEModulator) is the circuitry that converts (modulates) the serial digital signal from the computer into audio tones for the telephone line. In receiving data, it demodulates and reverses the process. Modems have different operating speeds. The most common are 300, 1,200 and 2,400 bits per second (bps). The speed of information flow is directly proportional to the bps, and as with cars, the faster, the better (usually).

The Bell 103 protocol is the standard for 300-bps modems, and it controls which tones are used for transmit and receive as well as specifying frequency modulation. The Bell 212A protocol is a standard for 1,200 bps and specifies phase modulation. Another 1,200-bps standard is the CITT Recommendation V.22, while the CITT Recommendation V.22 is a 2,400-bps standard. Most modems being marketed for microcomputers will handle whichever of these standards is required; the two modems reviewed last month support all of the foregoing standards.

For some types of computers (IBM and compatibles, Apples, etc.), a serial interface and modem can be combined into one card (circuit board) called an internal modem. Internal modems typically cost a little less than external modems. If you don't already have a serial port,

purchasing an internal modem will save you this cost as well. However, if you have more than one computer or later upgrade to an incompatible computer, the versatility of an external modem is worth the extra cost.

Many modems are listed as "Hayes compatible." Hayes compatibility refers to the set of commands that software uses to access the advanced features of the modem, like changing speed, dialing in pulse or tone, automatic redialing, etc. Lower-priced modems that don't offer these features do not need to be Hayes compatible. On modems with advanced features, Hayes compatibility is a desirable quality because most of the terminal software will automatically support it. Thus, the less you know about connecting computers and modems, the more useful is Hayes compatibility.

Terminal software is the program that allows your computer to talk to the modem and phone line and, through them, other computers. Sometimes terminal software is included when you buy the modem. If you have to purchase a program, you might get one from a \$6-per-program vendor, because you will have access to many terminal programs. Three popular programs available from these sources for IBM PCs and compatibles are ProComm, QModem and Telix.

One feature that the program needs to have is the ability to download or transfer binary data files, using a common protocol. The protocol is simply a set of rules that the computers use to check for errors in transmission. The most common of these is XMODEM. Most terminal programs have this feature (including the three listed above), but check the manual (or READ.ME file in the program itself) if you have any doubts. This will also tell you how to set the parity and other parameters. For most purposes, use 8 bits, no parity, 1 stop bit, full duplex, and set your modem to originate.

With your modem connected to the phone line, your modem connected to the computer (either internally or via a cable purchased from your modem vendor) and your terminal program loaded into your computer, you're ready to begin communicating.

Going Online

Very often, the terminal package will include introductory packages for free or reduced-cost access to commercial data services, such as CompuServe and The Source. If not, you can get information on CompuServe by dialing 1-800-848-8990 and The Source by dialing 1-800-336-3330.

These are good places to start. The information packet for the commercial services contains detailed information about how to sign-on and navigate around their features. When you call a commercial service, use 300 bps; the higher speeds cost more per minute and you will be browsing anyway.

Phone numbers for free BBSes can be found on the commercial services or from your local computer store or computer users group. Once you've logged onto the BBS, you should be able to find the phone numbers of several other BBSes. Most BBSes have files of other BBS numbers in their general vicinity; so at this point, you will have plenty of numbers to call.

Commercial services have many incoming phone lines, but many BBSes have just one line. Consequently, you may often get a busy signal when dialing up a BBS. One solution to this is to use the auto-redial function of your terminal program and/or modem if it features this (check the manual). Another solution is to try again late at night, when activity drops off. However, you should call a number late at night only if you're *sure* it is a BBS. By "sure" I mean that you or a friend has called it recently.

Once you get through, the first letters that appear on your computer's video screen may be garbled, as the BBS tries to determine at what speed you're operating. If more than one or two lines are garbled, hang up and change the settings to 7 bits, even parity and 1 stop bit. A bad phone line can cause garbling even with the parity correctly set, but this is rarely a problem with local calls.

Once the parity is correctly set and you are connected to the BBS, you should obtain a screen that tells you the name of the BBS, the name of the System Operator

(SysOp) and other words of welcome and information.

Next, it will ask you for your first name and then your last name. In some cases, it will ask you to type "NEW" if you are new to the BBS. Most BBSes expect you to use your real name and do not permit "handles." Recognizing you as being new to the board (either by checking your name against those of registered users or by your having typed NEW), it will ask you for registration information.

You will be asked to input your city, state and street address, as well as your telephone number and, perhaps, your age. Most likely, you won't be allowed to leave messages or download files until you have been verified and registered by the SysOp, and perhaps pay a membership fee. Sometimes, verification consists of the SysOp only scanning your information for the obviously phony (e.g., the Mad Hacker from Smallville) and sometimes he or she will telephone you to verify the information given.

The information you enter should be seen only by the SysOp, but privacy is not ensured. I don't know of anyone who has had problems with information given to SysOps, but you should at least be aware of the possibility.

After registration, you will see a menu of things you can do on the BBS. Choose one that appeals to you to explore the board and learn about its features. On most BBSes, typing "?" or /HELP will provide a detailed explanation of the menu options. When you are ready to quit or log off, don't just hang up the phone. The menu should list a command to tell the board you are terminating contact. Typically, it will be "G" for good-bye or "O" for off.

Keep in mind that using a BBS is a privilege, not a right. The SysOp has spent a sizable amount of money on equipment for your enjoyment and you are electronically (often quite literally) a guest in someone else's home. Behave with the courtesy you would show if you were actually there in person. It is true that some SysOps behave like tyrants; if you encounter one, the solution is to simply not to call that BBS again. **ME**

Your comments and suggestions are welcome. You can contact me at P.O. Box 678, Garner, NC 27529 or by computer on Delphi (CURTPHIL), CompuServe (73167,2050) or The Source (BDK887).



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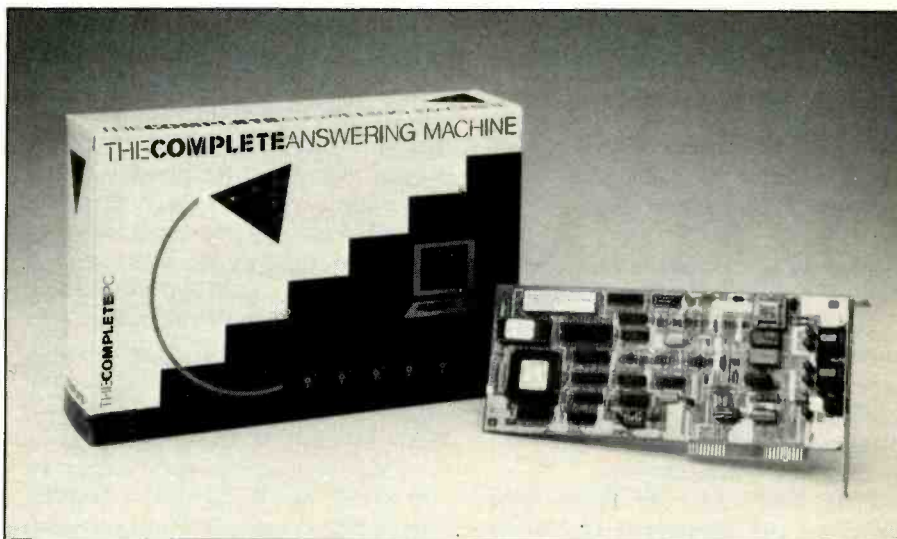
By Ted Needleman

Last column, I discussed The Complete PC's Fax board and Hand Scanner. This time around, I'm covering the third product mentioned in their line—The Complete Answering Machine (CAM). CAM was actually the first product this small company introduced and has been on the market for about a year. In some ways, it is also the most sophisticated (and complex) of the products the company offers.

At its simplest, CAM is a three-quarter size printed circuit board which turns your PC or compatible into a telephone answering machine. It allows you to store a digitized message, in your own voice, on your hard disk. When the phone rings, CAM will answer after a predetermined number of rings, play the message, and record the caller's reply. Luckily, this is not really the best way to use CAM. After all, it doesn't make a whole lot of sense to use a \$349 add-in board and a \$1500 or more PC to do the job that a \$50 dedicated answering machine performs just as well (not to mention needing to leave your PC on 24 hours a day to accomplish this).

The Complete Answering Machine's usefulness is in the advanced features it makes available. Although some of these depend on the particular phone system you are hooking up to, CAM provides the equivalent of a sophisticated voice mail system, at a price that's a fraction of the cost of most of these systems. And, working in the background, it does not require the dedicated use of your PC. You can still perform your day-to-day application work while CAM handles your phone.

Most of you will already be familiar with voice mail systems, even if you haven't realized that is what you've been dealing with. Many larger companies have installed them and more are doing so every day. If you've ever had your call answered by a pre-recorded message instructing you to "Press the number one button to talk to Customer Service, the two button to get information on the new



doohickey, or the three button to talk to Fred," you've already had your introduction to voice mail. And, if like myself, you have ever spent 15 minutes pressing phone buttons just to find out that you need to dial a completely different phone number, you might begin to wonder if some of these voice mail systems aren't the next generation's answer to Dungeons and Dragons.

A voice mail system, however, is not at all dissimilar to the hierarchical directory system most of us use on our hard disks. Many hard disks are organized so that there is a main directory (the root directory) at the top, followed by several layers of subdirectories. Each of these subdirectories can (and often do) have multiple layers of subdirectories. If you graph out the structure and turn your graph upside down, it resembles a tree (hence the name "tree-structured" directory).

Voice-mail, whether from The Complete PC or AT&T, operates in a similar manner. The first message you receive when the line is answered is a generic one. You are either routed directly to the individual you need to reach or to a department. At this point, depending on how the system is structured, you may either be asked to leave your message or to travel further down the tree. If your phone

system has the ability to transfer a call between stations, you can even move from branch to branch (horizontally rather than vertically). Specific callers can be assigned a code to retrieve messages left for them alone (this is done by assigning them their own mailbox), and CAM can be set up to forward messages left in certain (or all) mailboxes to another number.

CAM is a complex product if one is to use it effectively. I've had mine for about a month and discover new features every so often. At its simplest, it can be installed and setup, using a menu driven install program, in less than half an hour. But installing multiple greetings, mailboxes, different layers of message routing, and outgoing message capability takes both careful reading of the documentation and some experimentation. Sitting down and plotting out your system hierarchy is also a good idea. The documentation is well written and quite understandable, but this is a sophisticated application and some uses are not immediately apparent. The manual calls for one person to be a "System Administrator" who will not only set up the system, but will also maintain it by setting up new mailboxes and features.

You can use up to four CAM boards in a PC. With multi-line phone systems,

this is the only way to provide coverage of more than one line. A single CAM can be used with a multi-line system, but will only pick up the specific line to which it is attached. Another consideration, with multi-line setups, is the type of PC the CAM boards are to be installed in. The manual gives these guidelines: an 8088 or 8086 based system will support a single CAM operating in the background, an 80286 computer running at 8 MHz with a slow hard disk will support up to three CAMs if you dedicate the computer to this purpose, while a 10-MHz 80286 or 80386 system can support up to four CAMs. Both you and your callers will need "Touch-Tone" phones to make use of CAM. The package includes both a keypad template and plastic reference card giving the various commands. Callers without Touch-Tone phones will be able to leave a message at the first greeting, but won't be able to give the command to move to a specific person's mailbox.

The best use for CAM is in a small- to medium-size office. You can use it at home, but unless you really want to do a fair amount of interactive messaging (leaving messages for specific callers) CAM is probably overkill. I'd also like to see The Complete PC add a data modem to this card. A similar product, Watson (from Natural Microsystems), offers many of CAM's features, but can also be used as a standard 300/1200 baud modem, saving a slot and some money.

All things considered, though, The Complete PC is giving you a lot for the \$349 price. If you have a need for it, The Complete Answering Machine provides many of the features of a multi-thousand-dollar voice messaging system for a fraction of the price. In last month's column, I mentioned how impressed I was with the Complete FAX Board and Complete Hand Scanner. The Complete Answering Machine is also an impressive product and good value. As I write this, spring Comdex is coming up in a few

weeks. Maybe if I'm lucky, The Complete PC will be introducing another terrific product!

LapLink

Laptop and other "portable" computers are finally starting to have an impact on the industry. Long favored by reporters and other journalists, businessmen and others who must move from place to place are beginning to appreciate the convenience of having a computer along on their travels. They can be unexpectedly useful, especially as a second computer. This month's column is an example. It is being written on an Epson Equity LT, mostly at the bedside of one of my year-and-a-half old twins who had to spend the night in the hospital. Not wanting him to be by himself in unfamiliar surroundings, I elected to stay overnight also. Having the Equity LT along accomplishes two things. First, it permits me to make good use of time which otherwise would be spent on non-work related subjects. Second, it gives me something useful to do to take my mind away from where I am.

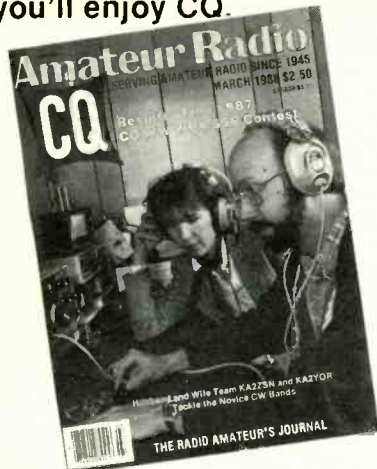
The only problem I've run into using a laptop (and for that matter an IBM PS/2) is the 3.5-inch disks they use. I usually submit my columns (and writing I perform for others) on standard IBM-compatible 5.25-inch floppies. For that matter, all of the other PC systems I work with have the larger disks. While the 3.5-inch units offer some significant advantages, such as greater capacity (720K compared to 360K) and protection of the media with the hard shell, it will still be quite a while before they are as widely accepted as the 5.25-inch disks are.

The Epson LT came with a copy of the newest version of LapLink, a program I had used several times before. You don't have to buy an Epson Equity LT to get LapLink; it is available by itself from the developer, Traveling Software. It is just as useful for transferring information between a standard PC or compatible and a

LAP-LINK (2.16) Copyright 1986, 87 Traveling Software Inc. 5406911		Remote Drive (C:)\17131520 Free	
Local Drive (D:)\17985536 Free			
(DIR) 12-09-85 12:43a	(DIR) 4-06-88 6:12p	(DIR) 4-06-88 6:12p	
..	
MLPLUS	BOX	BOX	384 2-23-87 12:00p
BOX	CAPERS#7.ART	CAPERS#7.ART	5888 4-09-88 11:02a
CAPERS#7.ART	CAPERS#7.BAK	CAPERS#7.BAK	5376 4-09-88 10:55a
CAPERS#7.BAK	CHAPTER1.DOC	CHAPTER1.DOC	128 2-23-87 12:00p
CHAPTER1.DOC	CHAPTER2.DOC	CHAPTER2.DOC	128 2-23-87 12:00p
CHAPTER2.DOC	CHAPTER3.DOC	CHAPTER3.DOC	128 2-23-87 12:00p
CHAPTER3.DOC	COMPLTPC.BAK	COMPLTPC.BAK	1280 12-09-85 1:17a
CIACONVE.BAK	COMPLTPC.REV	COMPLTPC.REV	1280 12-09-85 1:41a
CIACONVE.WS	DIARY.DOC	DIARY.DOC	3584 2-23-87 12:00p
COMPLTPC.BAK	FM.EXE	FM.EXE	33024 5-30-85 9:45p
COMPLTPC.REV	INTERNAL.DCT	INTERNAL.DCT	25600 12-30-86 1:04p
DIARY.DOC	LASER1.DOC	LASER1.DOC	8448 2-23-87 12:00p
FM.EXE	LASER2.DOC	LASER2.DOC	3200 2-23-87 12:00p
INTERNAL.DCT	MAIN.DCT	MAIN.DCT	277504 12-30-86 1:04p
LASER1.DOC	MOVEPRN.EXE	MOVEPRN.EXE	3204 9-30-87 1:54p
LASER2.DOC	PATCH.LST	PATCH.LST	82560 9-30-87 1:54p
MAIN.DCT	PERSONAL.DCT	PERSONAL.DCT	10 12-30-86 1:04p
MOVEPRN.EXE	PRINT.TST	PRINT.TST	5632 2-16-87 12:00p
= D:\WS4	C:\WS4		
			COM1: 115200
COMMANDS: Help [C] Tree Copy Wildcopy Group Options View Erase Rename Dos Quit			

A typical screen dump of LapLink's local drive (D:) and remote drive (C:) directories.

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PC CAPERS...

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LAP-LINK (2.16) Copyright 1986, 87   Traveling Software Inc.   S406911
== Local Drive (D:)17985536 Free ==   Remote Drive (:)   0 Free ==
<DIR> 12-09-85 12:43a
.. <DIR> 12-09-85 12:43a
.. <DIR> 12-09-85 12:02a
MLPLUS <DIR> 12-09-85 12:02a
BOX 384 2-23-87 12:00p
CAPERS#7.ART 2432 12-09-85 12:27a
CAPERS#7.BAK 1792 12-09-85 12:22a
CHAPTER1.DOC 128 2-23-87 12:00p
CHAPTER2.DOC 128 2-23-87 12:00p
CHAPTER3.DOC 128 2-23-87 12:00p
CIACONVE.BAK 15749 12-09-85 12:27a
CIACONVE.WS 14464 12-09-85 1:06a
COMPLTPC.BAK 1280 12-09-85 1:17a
COMPLTPC.REV 1280 12-09-85 1:41a
DIARY.DOC 3584 2-23-87 12:00p
FM.EXE 33024 5-30-85 9:45p
INTERNAL.DCT 25600 12-30-86 1:04p
LASER1.DOC 8448 2-23-87 12:00p
LASER2.DOC 3200 2-23-87 12:00p
MAIN.DCT 277504 12-30-86 1:04p
MOVEPRN.EXE 3204 9-30-87 1:54p
= D:\WS4

COM1: 115200
COMMANDS: Help [F1] Tree Copy Wildcopy Group Options View Erase Rename Dos Quit
    
```

Attempting link to remote system...
Remote system not active...
Press →

A screen dump of LapLink's display when an attempt is made to link to a remote system and the latter is not active.

PS/2 as it is for performing the file transfer between a laptop and a larger system.

The LapLink package consists of the program on both 3.5- and 5.25-inch diskettes, and a "universal cable." This is a serial cable with both 9-pin and 25-pin serial connectors on both sides of the cable. Most laptops, AT compatibles, and IBM's new PS/2 systems now use DB-9 connectors on their serial ports, while PC and XT compatible machines use the larger 25-pin DB-25 connectors.

Having this 4-headed cable allows you to connect any combination of these systems together. Once the two computers are cabled, the LapLink software is run on each system. The two screen dumps reproduced here illustrate what you see when the software is run on the first system, and then both (although, of course, the list of files will be different). The split screen can be a little confusing. The determination of which drive (i.e., system)

is local and which is remote is made upon running the software. The machine on which you first execute the LapLink program is the local system. The second computer to run the software becomes the remote. I generally place the laptop on the right of my main system and make sure to run LapLink on the left-hand machine first. That way, the physical location of each computer corresponds to the screen display.

The operations that are available to you appear in a bar menu at the bottom of the screen, and can be executed from either the remote or local system. The Help command provides a brief explanation of each of the other commands, as well as defining the various key functions. Log allows you to move to various subdirectories on the two systems, while Tree (as in DOS) will display the subdirectory structure on a disk. Copy, Wildcopy, and Group are the actual file trans-

fer commands. Copy will move a single file between the systems, while Wildcopy uses DOS wildcard characters to copy multiple files meeting the wildcard specifications. Group also copies more than one file. In this case you mark the files to be copied by moving the cursor bar up and down the file list display and pressing the "r" key to choose those you wish to include in the group.

The Options selection allows you to specify communications parameters such as COMM port and speed. LapLink can operate at 115 Kilobaud, with faster throughput achieved through a compression scheme that Traveling Software calls its "Turbo" option. At 115KB, file transfers are accomplished rapidly. This surprised me a bit, since another manufacturer's 115KB serial LAN I reviewed a few issues back, had much slower file transfers. Maybe LapLink's "Turbo" really does add some pizzazz. If the serial port in your system is not able to operate reliably at 115K, you can use the Option command to reset the port to a slower speed (though you must use the same speed on *both* machines).

The View command operates similarly to DOS' TYPE command. If the file is ASCII text, it will be displayed on the screen. Erase and Rename also function the same as the DOS commands, while DOS allows you to temporarily exit LapLink, run a program, and re-enter LapLink. If you are familiar with WordStar, this command operates the same as WordStar's "R" command. Quit does just that, returning you to DOS.

LapLink comes with sufficient documentation to do the job, but it's nothing special. A short primer on communications would be helpful to those who run into problems, as would a more complete troubleshooting guide. The lack of these, though, is not a major strike against the software. The program is almost intuitive in use, and the on-line help, while not context sensitive, is sufficient to answer many of your questions while using LapLink.

The one time I ran into a problem with

an earlier version of LapLink, and was unable to find the answer in the manual, I received a quick answer with a call to Traveling Software. It didn't solve the problem (an incompatibility with the IBM Convertible I was using at the time, since fixed in the program), but saved me from wasting any more time.

LapLink is not for everyone—if you don't need to move files between systems using different media you can find plenty of other things to spend \$129.95 on. But if you do need this capability, the money will be well spent. The software works and performs well without fanfare or any great amount of setup effort. And when I have work to get done, and limited time to do it, this is exactly what I

want from a piece of software. Traveling Software also has a full line of lap-top oriented products. Give them a call for their catalog. **ME**

COMPANY ADDRESSES

The Complete PC
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Mavis Beacon Teaches Typing

By Art Salsberg

There's been no dearth of computer typing programs. Nevertheless, learning how to type has such a wide, ongoing appeal, that new instructional software continually emerges in the hopes of reaching the ready, wide audience. "Mavis Beacon Teaches Typing" from Software Toolworks Inc. (Sherman Oaks, CA), which produced the hit program, "The Chessmaster 2000," is a refreshing, new challenger in this important self-help software field.

Unlike Evelyn Wood in the speed-reading area, Mavis is a fictional character. But how "she" teaches typing is real and exceptionally good, as I'll describe later.

The program is priced at \$44.95 for an IBM, Apple IIGS and Macintosh version; \$39.95 for Apple II, Atari 8-bit and Commodore C-64/128 computers. The IBM one comes with 5¼" and 3½" disks. The IBM PC/XT/AT program requires DOS 2.0 or later, 256K of memory and dual drives, whether two floppy ones or a hard-disk drive and a floppy drive. To get graphics on a Hercules Graphics Adapter, you're advised that you should have 512K memory. Mavis is copy-protected, and requires a key disk to operate, but an unprotected copy is available for \$10 more.

Mavis comes with a spartan installation and program-running guide. In fact, it's only a four-page brochure. An accompanying 62-page booklet about the program, typing history, and typing guidance, however, makes up for this apparent shortfall with a witty, informative presentation of information that's supplemented by historical photographs and various drawings.

Description

Mavis has multiple learning centers. Basically, the user works in either the "classroom," "workshop" or "arcade." A teaching plan on a "chalkboard" precedes each lesson. This describes the typing problem being addressed, the reme-



Screen display of Mavis Beacon's "Road-Racer" typing game.

dy, an explanation of the recommendation and the option to choose some alternative action.

The program analyzes the student's problems and continually customizes lessons to strengthen weaknesses. This progressive tailoring of lessons to a user's typing proficiency is at the core of the program. Mavis begins with prepared lessons, but soon builds new lessons that reflect needed practice toward greater speed and accuracy. Using statistical analysis, it focuses on keys that are giving the user the most trouble. Moreover, its practice sentences are interesting, whether jokes and riddles for younger typing students or extracts from the *Guinness Book of World Records* for adults.

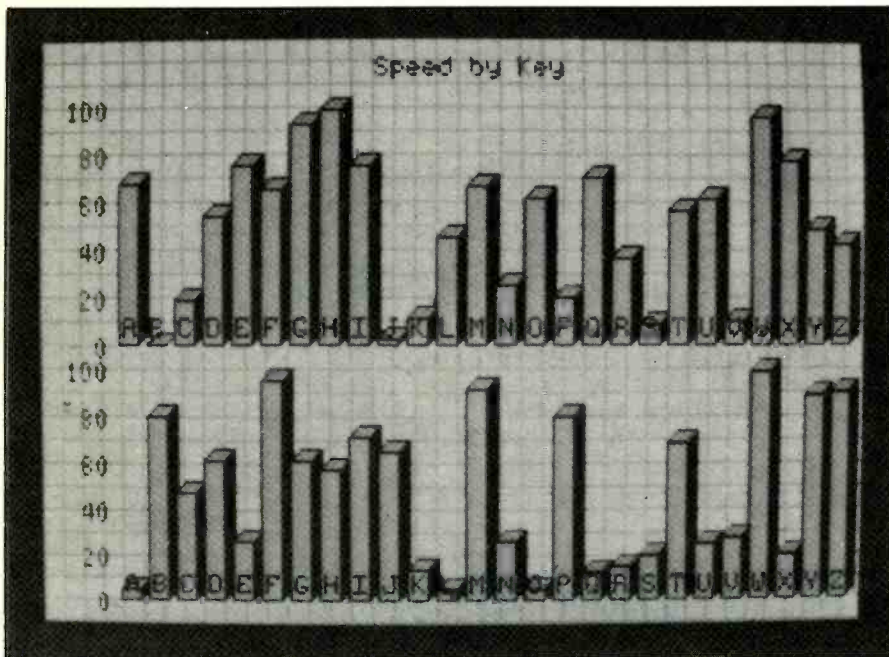
A rich variety of progress charts can be displayed anytime one wishes to see how they're doing. Also, a "Help" key brings up explanations. There's lots of other graphics plus sounds and tunes. These include a keyboard with moving finger-guide hands, racing car dashboard, moving metronome clock pendulum and tick-tock sound, and "meters" that indicate your speed, accuracy and progress. You

can also create customized lessons and change the default QWERTY keyboard that virtually everyone uses to the Dvorak keyboard that promises better speed (though hardly anyone uses it). Furthermore, the user can call up "Keys and Fingers" to find out which key was just pressed and what finger you should have used.

So now that we've gone through the program's basics, let's see how it works out in practice.

In-Use Comments

After giving your personal history—name, age (5-8, 9-14 or adult) and your typing experience (beginner, intermediate, advanced)—you're set to start the lessons. The typing matter on the screen is framed at the left with a meter, at the right with a metronome clock, and at the bottom with a keyboard and guide hands. Choosing "advanced" typist, as I did, eliminated guide-hand movement. ("Advanced," by the way, means a 60 words-per-minute typist.)



Program provides detailed 2D and 3D (shown) graphics on-screen.

Taking the first lesson, I was marked at 44 wpm with 96 percent accuracy, leaving me with 40 wpm when adjusted for errors. I went on to other types of lessons. These included a simulated stock-car race to see if my typing speed could exceed a previous 46 wpm (it did), a Sherlock Holmes Mystery text typing exam, where I hit 50 wpm, with an adjusted score of 45 wpm; a Freewheeling Race, which is a three-minute challenge, where I scored a terrible 39 wpm. I found the letters on the latter, not to make excuses, difficult to follow well.

Then I was given text to give me practice with keyboard rows that were computed to be giving me more trouble than others. All through with the lessons, my typing speed reached 67 wpm with 98 percent accuracy, for an adjusted score of 65 wpm. This was the highest score I got as I moved ahead for a go-around that included pattern-type testing where I had to type a word completely correct before the computer program would let me go forward, practicing with a steady metronome tick sound to develop a regular typing rhythm, working on a group of prob-

lem words set up by the computer where words are typed at a glance before more words suddenly appeared, and so on. The "so on" included special video shades for troublesome letters determined by the computer program. A host of capitalized and lower-case letters, all intermixed, really fouled up my score (45 wpm with an adjusted 42 wpm reading).

Examining graphs of the current lesson and combined lessons truly gives you a good overview of where your weaknesses are and how you're progressing. You can choose graphs by key speed, key accuracy, problem keys, errors by row, etc., making a graph selection with convenient pull-down menus.


"Mavis Beacon Teaches Typing" is a superlative all-around typing improvement program. Its artificial intelligence system shows the user where his problem areas are and sets up future lessons to correct them. If you've ever tried to learn how to type or improve your typing with the boring rote system of different letters of the alphabet, then you'll really appreciate the real words and meaningful sentences employed by Mavis. It's all spiced

up by races, metronome clocks and tunes, all of which are designed to hold your interest. With more than 20 progress graphs at hand, it's a pleasure to analyze your own aptitudes, too. All this combines to promise a better chance than usual to stick with the lessons and continue to improve your typing, stroke by stroke. That's half the battle right there.

Rounding it all out, are the availability of the Mavis typing programs for a wide variety of computers, at a truly modest price. And for a bonus, the program includes a Resume Writer Program that let's you fill in information, with screen guidance, and automatically print it out as a finished employment resume. Having examined a handful of such programs, I find Mavis to be a winning package at the head of a crowded pack. **ME**

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LETTERS... (from page 5)

milliamperes. I hope you pay more attention if someone tells you the building is on fire.

Henry Ariail
Sewanee, TN

Panning the Audio Panner

• A couple of corrections are necessary in my April article, "Automatic Audio Panner." In Fig. 2, the lower end of R28 should go to -12V, NOT ground. And in the second paragraph of "Test & Calibration," substitute C13 for C1 and C14 for C2 throughout the paragraph.

Charles R. Fischer

• There are some errors in the Automatic Audio Panner project of the April 1988 issue. The (-) output of the bridge rectifier should connect to the input (pin 2) of

the lower voltage regulator. The lower voltage regulator should be a 7912 instead of a 7812 as printed.

I buy and read your magazine monthly. As an electronics instructor, it helps me to keep abreast of the constant changes in the electronics field. I also enjoy studying the projects and have learned a lot from them.

Barney Lejeune
Carencro, LA

Author Says . . .

• There are some corrections needed in my "Semianalyzer" article featured in the April and May 1988 issues. One is that *no* sockets are supplied for the ICs and *no* cabinet is supplied at the kit price given. The cabinet is available only as an extra-cost option. The other is that

neither sockets nor the Soldercons suggested as replacements for them in the article are recommended for either the ICs or the displays.

David Miga
Electronic Design Specialists
N. Lauderdale, FL

• Readers who order the printed-circuit board for my "Multi-Channel TTL Logic Tracer" (May 1988) should be advised that they will not be filled at the present time. The reason is that R&R Associates, the pc-board supplier, has ceased operations because the owner had a severe heart attack. All orders already received are being returned with explanation. I am presently trying to find another supplier for this board.

Peter A. Lovelock

ELECTRONICS NOTEBOOK (from page 58)

tially dangerous ultraviolet radiation.

(3) Avoid observing a xenon flashtube at close range. High-energy tubes can produce a sufficient radiant energy to produce a lesion or even a burn.

(4) *Never* assume a capacitor in the power supply of a xenon lamp is discharged! The power supplies used to operate xenon flashtubes operate at potentially dangerous or even fatal voltage levels. The discharge capacitor(s) are particularly dangerous. Before attempting to work on *any* xenon flashtube circuit, no matter how small, *always* disconnect the power source from it and discharge the flash capacitor by several times shorting together its terminals with an insulated-handled screwdriver. If possible, first partially discharge the capacitor by allowing it to fire the flashtube to which it is connected. Then remove the power and short its terminals. Use extreme caution! Even experienced engineers and technicians have been killed by accidentally touching the high-voltage terminals of xenon-flashtube power supplies.

Going Further

The photographic applications of xenon flashtubes have been described in many articles and books. The two leading names in this field are Harold Edgerton and Edward Farber. Edgerton pioneered

xenon flashtube photography and Farber invented the portable xenon flashtube photoflash unit and has published a monthly column ("Lights and Lighting") for *Photomethods* between 1958 and his death in 1982. He also wrote articles on xenon flashtube photography for *Popular Photography*, *Modern Photography* and other periodicals.

For additional information on triggering flashtubes, see "Flashtube Triggering Review" in *Lasers & Applications*, March 1984, pages 92 and 93.

For additional information about the design of flashtube power supplies, see "Flashtube Circuit Program" by Eamon Murphy (*Electro-Optical System Design*, April 1982, pages 41 through 44). This paper includes a good list of additional references.

Manufacturers of xenon flashtubes publish excellent information about triggering and driving their products. Some of the best information is published by EG&G Electro-Optics (35 Congress St., Salem, MA 01970). Besides technical information about its line of flashtubes, EG&G has reprinted some of Harold Edgerton's classic papers on the subject. These papers are an invaluable source of information and ideas.

Finally, additional information about xenon flashtubes can be obtained by consulting a good technical library. **ME**

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CIRCLE 22 ON FREE INFORMATION CARD

Complete Guide to VHS Camcorder Troubleshooting and Repair by John D. Lenk (Prentice-Hall. Hard cover. 317 pages. \$38.)

The growing popularity of combined color camera and videocassette recorder in one package—a Camcorder—promises expanding repair work. This book focuses on one of the two types of camcorder on the market: VHS. The competitive 8-mm camcorder is not addressed here, which leaves room for another book.

This book details a practical approach to troubleshooting and repairing VHS camcorders. Thus, it is not a substitute for servicing information for a specific camcorder model, but rather presents typical details to foster an in-depth understanding of the electronic and mechanical aspects of VHS camcorders, both videocassette recorder and camera sections.

The text divides the equipment into orderly subsections within nine chapters that address specific sections, such as Camera Circuits, Tape Transport and Servo System, Video/Audio Signal-Processing Circuits, etc. The initial three chapters explore camcorder features and operations, followed by test equipment and routine maintenance procedures. The author then moves into how-it-works information, detailing circuit operation right down to specific components that are referenced to actual schematics, waveforms and block diagrams. Following the signal paths described and illustrated actually makes up a superb educational course in consumer video equipment. The same is true for mechanical transport aspects.

After full circuit descriptions, an especially helpful focus on basic troubleshooting approaches stamps the end of the chapter. Actual schematic diagrams are used here, with the troubleshooting method noting voltages expected and what to check next if they do not pass muster.

In the final two chapters, a host of typical problems, including electrical and mechanical adjustments, and troubleshooting and repair notes based on symptoms are given for a cross-section of VHS camcorders.

The book should serve well as an educational course that combines theory and

practice that one will be hard-pressed to find elsewhere and as a shop manual for VHS camcorder service technicians. Anyone involved professionally in videocassette repairs should get this book quickly and devour its contents.

Learning Electronics by R. Jesse Phagan & William Spaulding. (Tab Books. Soft cover. 346 pages. \$16.95.)

Subtitled "Theory and Experiments With Computer-Aided Instruction for the Commodore 64/128," this book is basically an introduction to dc and ac theory and practices as they apply to electronics. Its main strength is that it stresses mathematical solutions to design problems and, through end-of-chapter "Hands-On" procedures, direct reader involvement. The object is not only to teach the student what he must know, but to motivate him into wanting to learn. To the latter end, 16 programs (listings for which are given in an appendix) have to be keyed into the computer, saved to disk and recalled as needed to complete chapter-closing and "exam" questions. Choice of Commodore 64 and 128 computers for these programs is good, since these low-cost computers are in general circulation.

As with most such books, this one takes the traditional approach. In the first chapter, it puts electronics opportunities into perspective, discusses electrical safety and, briefly, computer-assisted instruction (CAI). The second chapter deals with the basic tools of the trade, while the third and fourth chapters deal with "Shop Math," which keeps things within manageable bounds by not going beyond elementary algebra and trigonometry, and engineering notation. The remainder of book follows the traditional sequence of dc and ac topic introductions. At the points where they become germane to the subject matter, the usual flow of the theory sections is interrupted by chapters on specific test instruments. For example, use of an ohmmeter is sandwiched between chapters on dc components and dc circuits, while use of an oscilloscope comes just before the chapter on dc circuit analysis.

This book provides a well-rounded and nice approach to learning dc and ac fundamentals. Its text is well-written and

nice supported by meaningful illustrations and schematics. Too, emphasis on hands-on experience and inclusion of program listings that should prove useful even after the student has completed an included "Final Exam" go a long way toward easing the learning task and even making it a fun experience.

Illustrated WordStar Professional Release 4 by Russell A. Stultz & Dianne Stultz. (Wordware Publishing, Inc., 1506 Capital Ave., Plano, TX 75074. Soft cover. 247 pages. \$19.95.)

New and experienced users of WordStar Release 4 should appreciate the way this book details the features, functions and commands of this popular software package. The operative word in this book's title is "Illustrated," which means a profusion of sample screen illustrations that greatly simplify explanations of this word processor's functions and commands. In addition to speeding the learning process through clearly written text and supporting screen illustrations, the book contains a series of 80 "modules." These are actually individual chapters arranged in alphabetical order for quick location of any topic.

Most modules detail the correct format and use of a specific function. For example, if you want to protect a file, you would find this in Module 58 on page 153, sandwiched between print underlined text in Module 57 and quick math in Module 59. Initial Modules first tell you how the book is organized and detail the hardware and software requirements for its use; give an overview of WordStar, including details on its control keys, menu network and program files; and, to get the ball rolling, present a sample session with the word processor.

As befits a book that emphasizes heavily activity at the keyboard, this book's text material is brief but to the point. As such, along with its illustrations, it serves as a quick look-up guide to get the user moving at a fast pace, with little wasted effort. In sum, then, this book is an excellent companion to the fine manuals provided by MicroPro with the WordStar Professional Release 4 package and is more likely to be referred to when a question arises.

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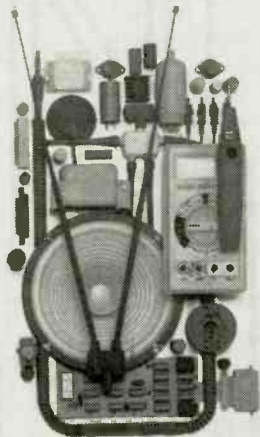
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Live Well Timer (from page 35)

this scheme when wiring the free ends of the wires coming from the S1,1, S1,4 and S1,6 holes in the board.

Strip ¼ inch of insulation from both ends of two 5-inch-long stranded hookup wires. Tightly twist together the fine conductors at all four wire ends and sparingly tin with solder. Crimp and solder one end of each wire to the center lugs of the switch (labeled 2 and 5 in Fig. 1). Crimp but do not solder the free end of the wire coming from lug 2 to the MOTOR+ terminal-strip lug. Crimp and solder the free end of the lug 5 wire to the MOTOR - lug.

Trim to length a hookup wire, strip ¼ inch of insulation from both ends, and crimp and solder one end to the MOTOR+ and the other end to the +12V lugs on the terminal strip. Locate the free end of the wire coming from the hole labeled GND in the circuit-board assembly and solder it to the GND terminal-strip lug.

Finish construction of the Live-Well Timer by preparing the cable for connection of the pump motor and dc power source to the project. Use medium-duty zip cord for the cables, making them as long as needed to do the job. Separate the conductors at both ends of the cables a distance of 2 inches. Strip from all conductors ¼ inch of insulation, tightly twist together the fine wires in each and tin with solder.

Terminate the ends of the cables that go to the project in crimp-on spade lugs. If possible use red-coded lugs for "hot" or positive (+) conductors and black- or green-coded lugs for the ground or negative (-) conductors. If the connections at the motor and boat's electrical system are via screw-type terminal blocks, terminate the other ends of the cables in like manner, but make certain that you observe the same polarity scheme at both ends of each cable. Affix to the cables permanent tags that identify one as POWER and the other as MOTOR.

Checkout & Use

With its switch set to OFF, connect the project to your boat's 12-volt electrical system and live-well pump motor via the POWER and MOTOR cables. Observe polarity! Setting the switch to MANUAL should cause the pump motor to turn on and remain running until the switch is set to OFF.

Place a control knob on the potentiometer's shaft and rotate it fully counterclockwise. Set the switch to AUTOMATIC and observe pump action. Initially, the pump motor should run for about 50 seconds and then settle down to about 32 seconds, repeating again about every 1.5 minutes thereafter. If you should note that the time between turn-on and turn-off is more like 6 minutes, the potentiometer is wired backward. To correct this, disconnect power from the project, desolder the outer-lug wire (do *not* disturb the center wire) on the potentiometer and crimp and solder it to the other outer lug on the pot. Reassemble the project.

Reconnect power to the Live-Well Timer and set its switch once again to AUTOMATIC. Let the project run for a half hour or so, trying various settings of the potentiometer. Make panel marks at various settings to indicate times. You can make these permanent legends if you wish. To do so, remove the control knob from the potentiometer's shaft and use a dry-transfer lettering kit to apply appropriate legends. Wrap the pot's shaft and mounting hardware in masking tape and spray several coats of clear acrylic as needed to protect the legends. Again, wait until each coat dries before spraying on the next. Remove the masking tape and replace the control knob.

Mount the project near the live-well pump in your boat. The easiest way to do this is with Velcro strips, but you can use metal clamps and suitable hardware if you wish to make the installation permanent. **ME**

PARTS LIST

- C1—47-pF, 50-volt disc capacitor
- C2—100-pF, 50-volt disc capacitor
- C3,C4,C5—0.01- μ F, 50-volt disc capacitor
- L1—2.2-mH inductor (J. W. Miller No. M7222ND from Digi-Key for \$1.71 or Radio Shack Cat. No. 273-1601 inductor assortment—see text)
- P1—Phono or phone plug (to suit auxiliary speaker output of scanner or headphone output of vhf receiver)
- Q1—2N2222 general-purpose silicon npn transistor
(Resistors are $\frac{1}{4}$ -watt, 5% tolerance)
- R1—15,000 ohms
- R2—10,000 ohms
- R3—1,800 ohms
- R4—100 ohms
- T1—8 ohms: 1,000 ohms audio coupling transformer (Radio Shack Cat. No. 273-1380 or similar)
- XTAL—1,000-kHz crystal (Digi-Key Cat. No. X066, \$6.45, or similar)
- Misc.—Printed-circuit board or perforated board with suitable Wire Wrap or soldering hardware; suitable enclosure; 12-volt dc power source (see text); small rubber grommet (see text); wire for antenna (see text); machine hardware; hookup wire; solder; etc.

you have a choice of either powering scheme.

Construction

Wiring of the circuit is not critical. Therefore, you can design and fabricate a printed-circuit board for the simple circuit or use perforated board with suitable Wire Wrap or soldering hardware. In fact, if you wish the convenience of printed-circuit construction but do not want to design and fabricate your own board, you can use Radio Shack's Cat. No. 276-168 universal pc board. Follow the schematic diagram as you install and wire together the components. The only items that require special attention are transistor Q1 and coupling transformer T1. You must make sure the emitter, base and collector leads of the transistor tie in to the appropriate points in the cir-

Weather Frequencies (MHz)

- 162.400
- 162.425
- 162.450
- 162.475
- 162.500
- 162.525
- 162.550

Note: All transmissions are NBFM on these vhf frequencies.

cuit and that the primary and secondary sides of the transformer are not transposed.

A 6-foot-long piece of wire is sufficient as an antenna for the project. This antenna will transmit a signal that can be received throughout a normal-size home.

You can house the project inside any enclosure that is large enough to accommodate the circuit-board assembly and any powering scheme you choose. If you use a metal enclosure, be sure to line the antenna's exit hole in a rubber grommet.

Using the Rebroadcaster

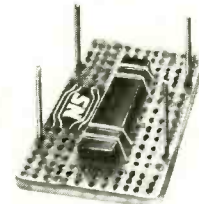
Using this project is quite simple. Start by plugging P1 into the auxiliary speaker jack on your scanner or headphones jack on your vhf FM receiver. Apply power to the rebroadcaster project and tune the scanner or receiver to the desired weather channel. When the signal is clear, use an ordinary AM broadcast-band radio to search for the rebroadcast weather signal on about 1,000 kHz.

Turn up the scanner's or receiver's audio level control until the received signal in the AM broadcast-band radio begins to distort. Then back off on the scanner's or receiver's volume control just a little to eliminate the distortion. That is all there is to it.

Now you can receive government weather broadcasts on any AM broadcast-band radio or receiver in your home. The rebroadcaster has an effective oscillator input power of less than 24 milliwatts, which is enough strength to assure good reception in a typical home. **ME**

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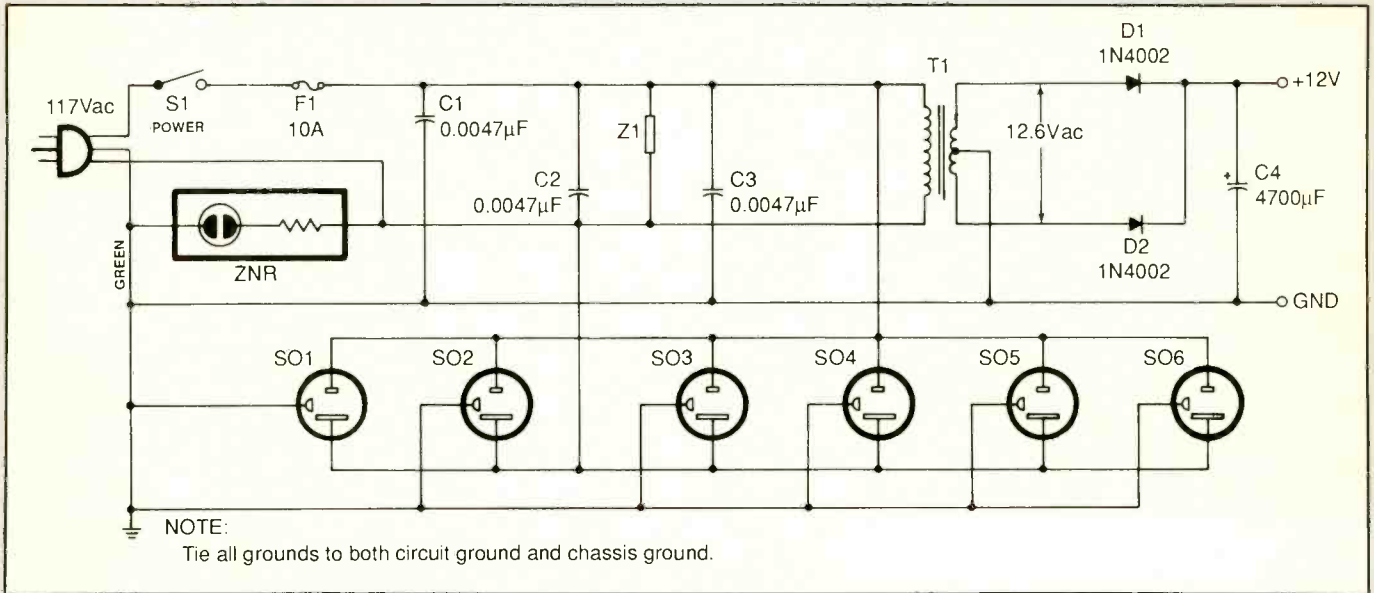


Fig. 2. Complete schematic diagram of an optional power strip/surge protection system you can build. Use as many (up to a maximum of six) ac receptacles as are needed for your particular computer system.

justment slots for *R5* in the front panel and *R4* in the side panel. Drill suitably sized holes in each location.

Next, machine the enclosure as needed for the switches, light-emitting diode, power jack and buzzer. Decide now where you want to mount the solid-state buzzer. If you elect to mount it on the circuit-board assembly as shown in Fig. 4, plug its black-insulated negative (–) lead into the indicated hole in the board and solder it into place. Then use suitable machine hardware to mount the buzzer directly on the board. In this case, you must drill a series of small holes in the front panel in the vicinity of the buzzer's mounting location (see lead photo) so that its sound can escape and be heard. Otherwise, drill the mounting holes for the buzzer through the front panel and a third hole for the buzzer's leads. Route the leads back into the enclosure and mount the buzzer on the panel. If you wish to avoid having to fashion rectangular slots for the toggles and mounting holes for slide switches, you can substitute miniature toggle switches, which require a single round hole for each, for *S1* and *S2*.

PARTS LIST (Outlet box)

Semiconductors

D1, D2—1N4002 silicon rectifier diode

Capacitors

C1, C2, C3—0.0047-µF, 250-volt metallized-film (Digi-Key Part No. P4600)

C4—4,700-µF, 50-volt electrolytic

Miscellaneous

F1—10-ampere, 250-volt fast-action fuse

S1—Spst 15-ampere (at 120 volts ac) power rocker, toggle or slide switch

SO1 thru SO6—Chassis-mount, three-socket ac receptacle (use as many as needed for system, up to a maximum of six)

T1—12.6-volt center-tapped power transformer

Z1—140-volt ac ZNR (Digi-Key Part No. P7069)

ZNR—Laser-cut spark-gap surge absorber (Heath Part No. 9-159; optional—see text)

Heavy-duty 3-conductor ac line cord with plug; suitable enclosure; bayonet-type holder for F1; 16-gauge or larger stranded hookup wire; plastic strain relief or small rubber grommet for line cord; terminal strips; machine hardware; solder; etc.

Note: Z1 is available as Part No. 9-159 for \$4.60 only from the Heath Company, Benton Harbor, MI 49022 (Attn.: Parts Replacement) or by calling 616-982-3571. This component is used in Heath's Model GD-1495 Smart Outlet Box. Digi-Key is located at P.O. Box 677, Thief River Falls, MN 56701, tel.: 1-800-344-4539.

Slide a 1-inch length of small-diameter heat-shrinkable or other insulating plastic tubing over the free ends of both wires coming from the LED1 holes in the circuit-board assembly. Identify the cathode lead of the LED and cut it to ½ inch long. Form a small hook in the cut end and crimp and solder it to the free end of the LED1 cathode (identified by a K

in Fig. 4). Then do the same with the anode lead and the free end of the other LED1 wire. Push the tubing up flush with the bottom of the LED's case and shrink into place.

As noted in Fig. 1, you can use 9 to 12 volts dc for the B1 battery. Therefore, decide now if you want to use a 9-volt transistor battery or eight 1.5-volt AA cells to provide 12 volts

dc. Depending on which arrangement you use, drill a mounting hole for the 9-volt battery clip or as many holes as needed to mount the two 4-cell AA holders through the rear panel of the enclosure.

Once the enclosure has been completely machined, label the various switches (and their positions), control-access holes and power jack with appropriate legends. A typical labeling scheme is illustrated in the lead photo. If you use a dry-transfer lettering kit, spray two or more *light* coats of clear acrylic over them to protect from scratching in use. Allow each coat to completely dry before spraying on the next.

When the acrylic spray has completely dried, mount the switches and power jack in their respective holes in the enclosure. If you mounted the buzzer on the outside of the front panel, use hookup wire to extend its leads as needed to route the red-insulated one to one lug of *S2* and the black-insulated one to the indicated hole in Fig. 4. Solder both connections.

As you connect into the circuit the switches and power jack, cut to length hookup wires as need. Connect and solder one wire between the other lug of *S2* and the indicated *S2* hole in the board. Do the same for the center-contact lug on the power jack and the *J1* CENTER CONTACT hole in the board and between the jack's shell contact and one of the holes labeled GROUND and the lugs of pushbutton switch *S3* and the *S3* and another GROUND holes in the board. Repeat for *S1*. Plug the active conductor of the AM radio's earphone jack into the EARPHONE JACK CENTER CONTACT hole and solder it into place.

Finish wiring the circuit board assembly by soldering 6-inch lengths of hookup wire into the holes labeled *B1+* and GROUND. If possible, use a red-insulated wire for the *B1+* connection and a black-insulated wire for the GROUND connection. Con-

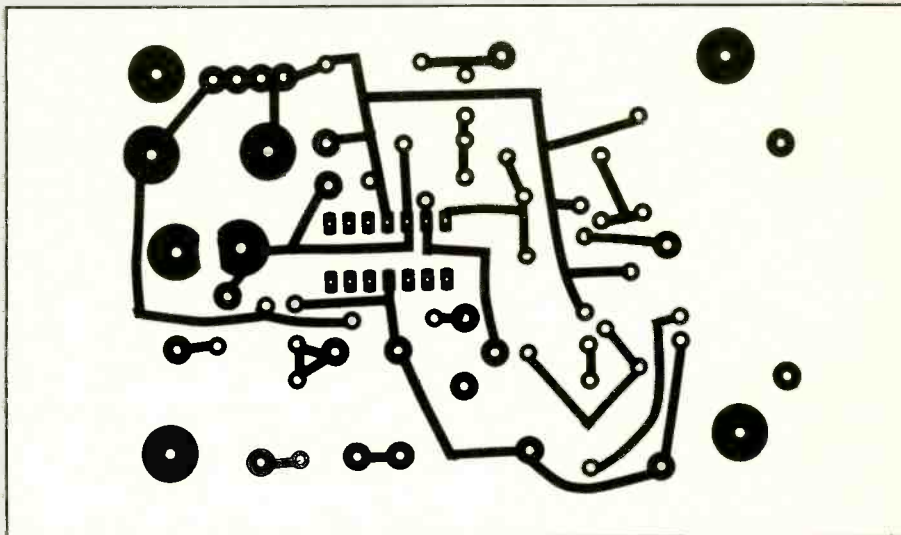


Fig. 3. Actual-size etching-and-drilling guide for the LEW project.

nect and solder the free end of the GROUND wire to the negative (-) lug on one AA-cell holder and the *B1+* wire to the positive (+) lug on the other AA-cell holder. Then connect and solder a short length of hookup wire between the + lug on the first holder and - lug on the second holder to place all eight cell holders in series.

If you are using a 9-volt transistor battery instead of the AA-cell arrangement, eliminate the hookup wires. Instead, plug the black-insulated wire from a battery-snap connector into a GROUND hole and the red-insulated wire into the *B1+* hole in the board and solder both into place.

Once the circuit-board assembly has been fully wired, use an ohmmeter or continuity tester to determine if the power rails have been correctly wired. To do this, connect one lead of the meter or tester to the pin 4 contact on the *IC1* socket and the other to the center-contact lug on the power jack. Set *S1* to ON. If you do not obtain a roughly zero-ohm meter reading or continuity tone, try reversing the meter or tester leads. If the circuit is wired properly, you should obtain a low-resistance reading (due to forward resistance of *D2*) or a tone that indicates continuity.

If you do not obtain the proper result with the meter's or tester's leads connected to the indicated points in either direction, recheck your wiring and correct it as needed. Next, check with the ohmmeter or continuity tester connected on one side to circuit ground and on the other to pin 11 of the *IC1* socket. You should obtain the same indication as before. When you are sure of your wiring, plug *IC1* into the socket, taking care to orient it as shown in Fig. 4. Also, make sure that no pins overhang the socket or fold under between IC and socket.

Now mount the circuit-board assembly inside the enclosure with component side facing the inside surface of the front panel. Use the same spacers and machine hardware you used before. Plug the light-emitting diode into its hole and, if necessary, apply a drop or two of clear, fast-setting epoxy cement or plastic cement to keep it in place.

Make sure POWER switch *S1* is set to OFF. Then, taking care to observe proper polarity, insert eight AA cells into the battery holders (or snap a 9-volt battery into the connector and slide the battery into its clip holder).

Note that there are several ways of connecting power to the AM radio

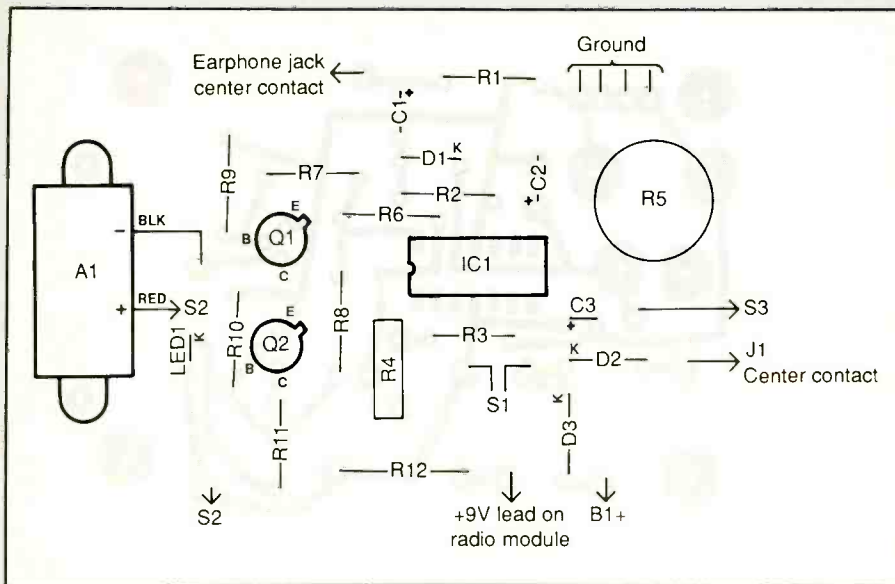


Fig. 4. Wiring diagram for LEW's printed-circuit board. Use this as a rough guide to component layout if you wire the circuit on perforated board.

used with the LEW system. Perhaps the simplest is to use a 9-volt battery snap connector that directly mates with the snap connector that already exists in the radio. Keep in mind, however, that this *reverses* the color coding of the insulation on the add-on connector. That is, its black-insulated wire now becomes the positive conductor and its red-insulated lead becomes the negative conductor. This is the opposite of the conventional color coding used on such connectors. So use extreme care when connecting the power cable to the LEW device. If there is any doubt in your mind, check with a dc voltmeter or a multimeter set to dc volts.

If you decide to build the combination power strip/surge protector, refer back to Fig. 2 for wiring details. If you need up to six ac receptacles, you can modify an existing six-outlet strip by adding to it the circuitry shown along the top of the schematic. If you need only four or less receptacles, you can build this accessory into a standard four-outlet electrical box and use standard three-contact receptacles.

Another approach is to use a large heavy-duty metal chassis box into

which you can build the entire circuitry from scratch. For this, be prepared to do a lot of chassis work, cutting or punching the holes into which to fit the receptacles, heavy-duty power switch and fuse holder. You will also have to drill a number of holes in the enclosure to accommodate mounting hardware for the various capacitors and other components via terminal strips and mounting the power transformer.

If you decide to modify an existing multiple-outlet power strip, use all existing components but substitute a bayonet-type fuse holder and fast-blow fuse for the built-in circuit breaker if it has one. Also, use a separate metal utility box, which can be mechanically fastened to the power strip with machine hardware, to house the power transformer and filter capacitor C4. If you prefer, you can simply mount the transformer to an outside surface of the power strip with machine hardware and have its primary and secondary leads enter the strip's enclosure through rubber-grommet-lined holes, assuming that there is enough space inside the strip to accommodate the rest of the add-in components. If you do this, make

certain that there is no possibility for the primary leads of the power transformer to become electrically exposed and create a shock hazard.

Should you build the accessory from scratch, use only 16-gauge or heavier insulated conductors for all wiring, a heavy-duty three-conductor ac line cord with integral plug and a switch rated at not less than 15 amperes at 125 volts ac. Also, make sure that all wiring is both electrically and mechanically secure before placing the power strip/surge protector into service.

The power cable between the accessory and main project can be any medium-weight two-conductor cable, such as speaker or lamp zip cord. Drill a hole in the accessory's housing and deburr it to remove the sharp, ragged edge. Line the hole with a rubber grommet or use a plastic strain relief when you install the cable. Separate the conductors of the cable, which should be between 3 and 6 feet long, a distance of 2 inches at one end and 1 inch at the other end. Strip ¼ inch of insulation from both conductors at both ends. Tightly twist together the fine wires in each conductor and sparingly tin with solder.

Pass the end of the cable that has the conductors separated by 2 inches through the rubber grommet and tie a knot in the cable inside the accessory's housing, leaving enough length plus some slack to reach to the points in the circuit to which they are to connect. If you are using zip cord, one conductor should be ribbed or otherwise identifiable. Connect and solder this one to the junction formed by the cathodes of D1 and D2 and the positive (+) lead of C4. Then connect and solder the unidentified conductor to circuit ground. If you use a plastic strain relief to insulate the cable from the metal enclosure, eliminate the rubber grommet and knot.

Terminate the other end of the cable in a plug that mates with the POWER jack on the LEW project. Make

sure the identified conductor goes to the plug's "hot" contact lug and the other goes to the plug's ground or reference lug. If in doubt, use an ohmmeter or continuity tester to make sure.

Checkout, Adjustment & Use

Set both the GAIN and DISCHARGE RATE trimmer controls to approximately mid-rotation. (Use a nonmetallic tuning tool to access the adjustment slots of these controls through the holes in the front and side panels of the LEW's enclosure.) Set the AM radio's VOLUME control to a quarter-turn from minimum. Then tune the radio to a spot on the dial near 550 kHz where no station is transmitting.

Plug the modified earphone cable into the radio's EARPHONE jack. If you are using an ac adapter instead of the power supply in the accessory power strip/surge protector, plug its output cable into the POWER jack on the LEW's front panel and turn on the power. At this point, the project's LED should light and the buzzer may also sound, assuming the BUZZER switch is set to ON. Press and release the RESET pushbutton switch. The LED should extinguish and the buzzer should silence if it was on.

As a preliminary operational test, position a soldering gun—not an iron—near the project and press the trigger. The LED should turn on and the buzzer may sound. If everything appears to be okay, place the LEW project near your computer, but no closer than 1 foot away from any computer equipment.

For maximum sensitivity, set the GAIN control to a position where the LED just barely remains off when there is definitely no electrical-storm activity in your vicinity. If possible, make this setting on a bright, sunny day. If in an 8-hour period you note false alarms, reduce the sensitivity of the project a bit by readjusting the GAIN control. Sensitivity can also be changed by readjusting the radio's VOLUME control for lower-level

output. You might also want to readjust the setting of the DISCHARGE RATE control.

You can easily simulate a distant electrical storm with your room's light switch. First, however, use another AM radio tuned to a weak station to ascertain that you can indeed hear the light switch "clicks." If your adjustments of *R4*, *R5* and the VOLUME control of the AM radio used with the project are correct, the LED should light but the alarm should remain silent when you turn on and off the lights in rapid succession 10 to 15 times.

After pressing and releasing the RESET switch, the LED should not light when the light is switched on and off only once. Of course, the only way to be absolutely certain that that the LEW system is operating properly is to try it out under actual electrical-storm conditions. When this occurs, you will probably want to make further adjustments of the GAIN and DISCHARGE RATE controls to optimize performance of the project.

If the project is to be used to protect a computer system, plug the ac adapter into the same surge-protected power strip you use for your computer. Also, keep the LEW system at least a foot away from any computer equipment because, if you do not do this, frequent false alarms are likely to occur.

After initial power-up, always press and release the RESET switch. The LED normally turns on on power-up to serve as a visual indicator that the project is operating as it should.

When the project signals that an electrical storm is approaching, turn on a separate AM broadcast-band radio and listen for the sound of static. If it sounds like an electrical storm may be approaching, start saving your current work to disk, make backups as necessary and perform an orderly power-down procedure. Then pull the plug of the power strip

from the ac wall receptacle.

If you note several false alarms in a short period of time, due to an unusually noisy electrical environment, set the BUZZER switch to OFF. The LED is sufficient to alert you to an approaching electrical storm. Of course, make a mental note to periodically glance at the project to see if the LED is on. If false alarms continue for a long period of time, make appropriate readjustments of the LEW's controls or/and move the project to a less-noisy location.

LEW's circuit is designed so that the LED and buzzer automatically turn off slowly after receiving a spheric pulse from a lightning strike. This allows you to gauge the intensity of an approaching storm. During an intense storm, the LED and buzzer should remain on almost continuously. With a weak storm, the LED and buzzer should turn on only intermittently.

With some solid-state buzzers, a feedback effect might sometimes occur when the LEW's AM radio is located close to the buzzer. This feedback is the result of the buzzer remaining on once it is triggered (though it can be silenced at any time by pressing and releasing the RESET switch). To reduce feedback, mount the buzzer on the outside and place the radio inside of the project's enclosure.

For portable operation, use the project's built-in battery supply. While ac operation can be conducted with the battery attached with no harmful effects, it may be wise to remove the battery if you use mainly ac power and install it on those occasions when you want portable operation.

You will likely want to readjust the GAIN and DISCHARGE RATE controls and the radio's VOLUME control several times during a season. At their optimum settings, the LEW system should sound an alert only when an electrical storm is fairly close, say, 10 to 30 miles away. **ME**

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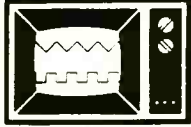


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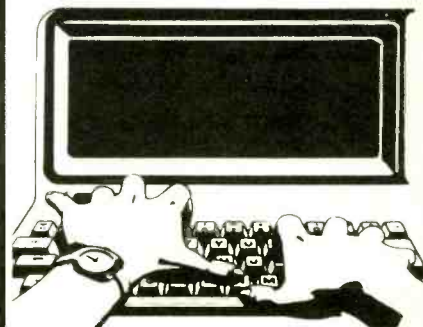
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In short, any time a function affects only some of the signals in a logic function, dependency notation can concisely specify which signals are affected.

Decoding Other Symbols

These examples illustrate how to interpret the new logic symbols. In practice such relatively simple and familiar functions really don't require the new symbols to portray them clearly. In general, the more complicated the device, the more likely it is that a logic symbol will help.

Any logic symbol can be decoded using the same techniques as were used with these three ICs. First, examine the blocks that make up the symbol and look for a common control block. Then determine how the qualifying and dependency symbols affect the inputs and outputs. Many,

and hopefully most, of the symbols used in the standard are already familiar or are easy to guess the meanings of. Once you've mastered the system, the specifics aren't difficult to pick up.

Learning a new language always involves some effort in learning the rules and a new vocabulary, but your reward is being able to communicate in new and often improved ways. This new language is no exception.

ME

512K Hardware RAMdisk (from page 26)

range. Once again, connect the meter's common lead to the circuit-ground point and, while observing the display, touch the "hot" probe to all socket pins shown in the schematics connected to ground. In all cases, you should obtain a 0-ohm reading.

If you fail to obtain the proper voltage or resistance reading at any point in the circuit, carefully check your wiring. Correct the problem before proceeding.

When you are sure that your wiring is correct, power down the computer and unplug the RAMdisk board. Then install the ICs in their respective sockets, making certain each plugs into the correct socket in the proper orientations (see Fig. 3). Take care to prevent any IC pins from overhanging the sockets or folding under between ICs and sockets.

To have the Hardware RAMdisk respond to the address assumed in the device-driver code, set the toggles on the *S1* DIP switch assembly as follows:

Position	Controls	Status
1	N.A.	N.A.
2	A9	Off
3	A8	Off
4	A7	On
5	A6	Off
6	A5	Off
7	A4	Off
8	A3	On

To set the board to another address, change the switch settings and device driver. An open (off) switch position corresponds to a logic 1, a

closed (on) position to a logic 0. Simply set the switches to the binary value of the desired address range. Do not forget to change the device-driver and diagnostic source code!

If you build only a 256K RAMdisk, modify the device driver as described. Then install RAM chips into the U21 through U28 sockets to fill bank 0 in Fig. 3.

The RAMdisk device driver has been written to initialize ("format") the disk each time the system is rebooted. This includes power-up and any time a reset or ALT/CTRL/DEL key combination is executed. Initializing the RAMdisk erases any data previously written to the device. If you wish to be able to reboot the system without altering the RAMdisk, the easiest method of doing so is to remove the initialization code from the device driver and make it a separate executable file. Then each time the Hardware RAMdisk is to be "formatted," simply run the initialization program.

In addition to serving as a fast "disk," the Hardware RAMdisk has other uses. For example, it can serve as a debugger that can store system status, or you can store in it a map of the system's memory before executing a new program. Since the RAMdisk is protected from random memory writes by the computer's microprocessor, data in it can be used to restore system status after a "crash." The RAMdisk could also be used as a print spooler, which can buffer large files without taking up system memory.

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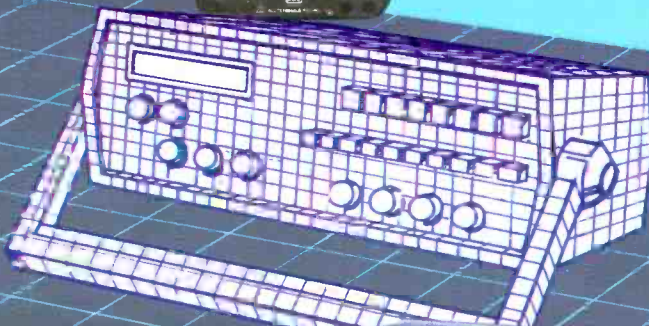
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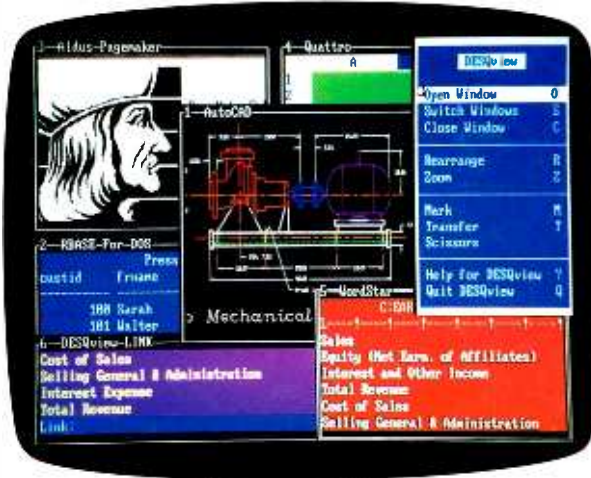
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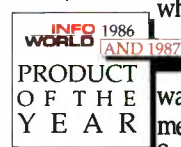
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