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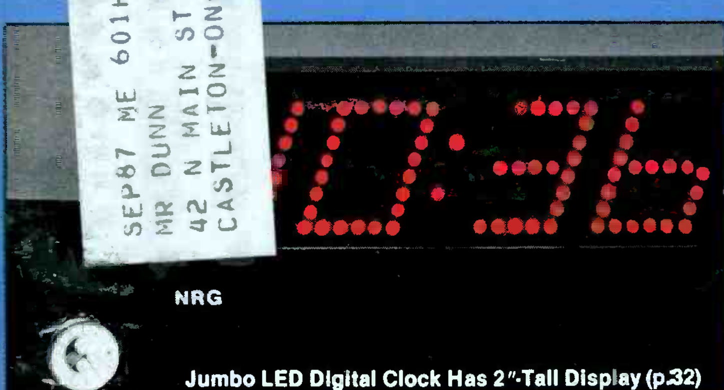
THE MAGAZINE FOR ELECTRONICS & COMPUTER ENTHUSIASTS

- COMPUTER-CONTROLLED LASER LIGHT SHOW
- HOW TO USE THYRISTORS TO SWITCH AC VOLTAGES
- A JUMBO LED DIGITAL CLOCK

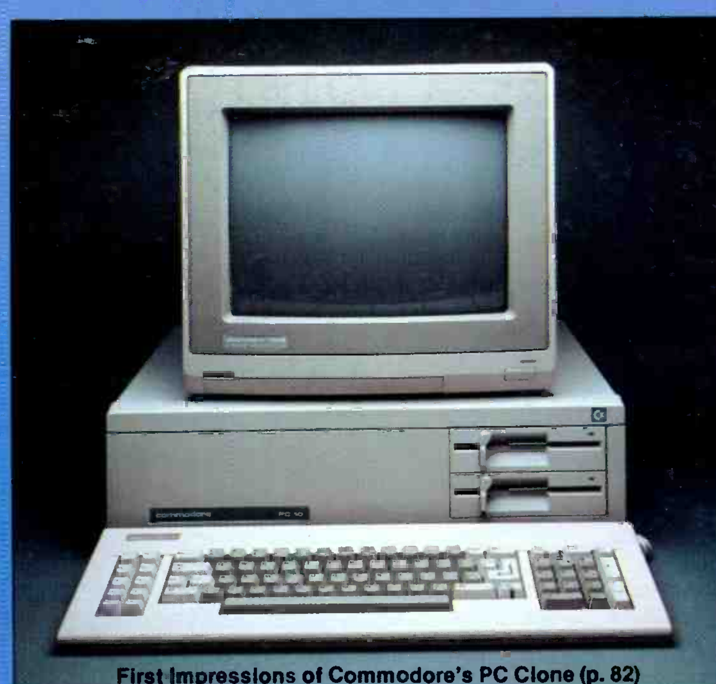
Computer-Controlled Laser Light Show (p. 48)

Full Construction Plans:

- Automatic Redialer for ... phone Numbers
- ... Component Tester ... ith Oscilloscopes
- ... nclair-Timex Computers ... tile Programmable ... ffers



Jumbo LED Digital Clock Has 2"-Tall Display (p.32)



First Impressions of Commodore's PC Clone (p. 82)

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Also: Forrest Mims' Low-Power Radio Transmitters • Eric Grevstad on More Clones, Smart Spelling, Cheap Writing • Don Lancaster on an Apple IIGS Disk-Drive Adapter & Current Mirrors • The "Disk Optimizer" Program to Increase Disk-Access Speed • Electronic & Computer News . . . and more.

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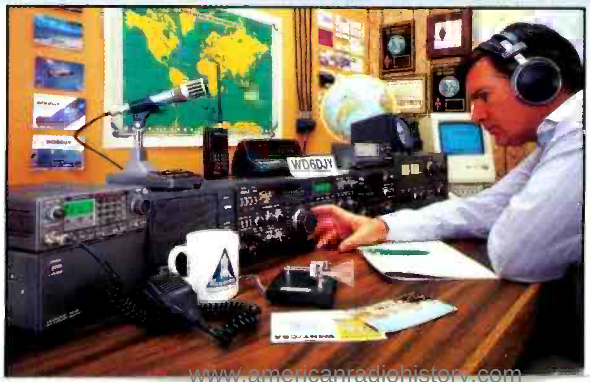
Interface IF-232C/IF-10B



Complete service manuals are available for all Trio-Kenwood transceivers and most accessories.
Specifications and prices are subject to change without notice or obligation.

More TS-940S information is available from authorized Kenwood dealers.

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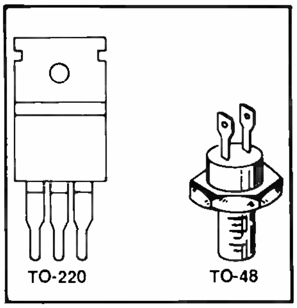
MODERN ELECTRONICS

THE MAGAZINE FOR ELECTRONICS & COMPUTER ENTHUSIASTS

APRIL 1987 **VOLUME 4, NUMBER 4**



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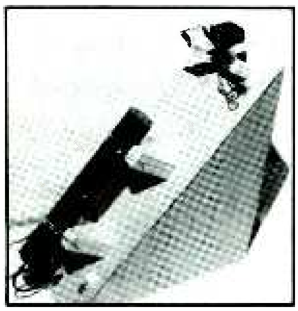

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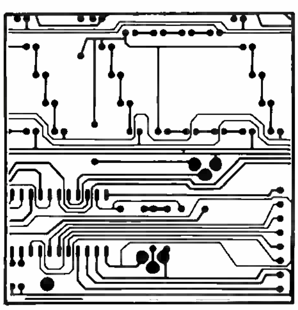

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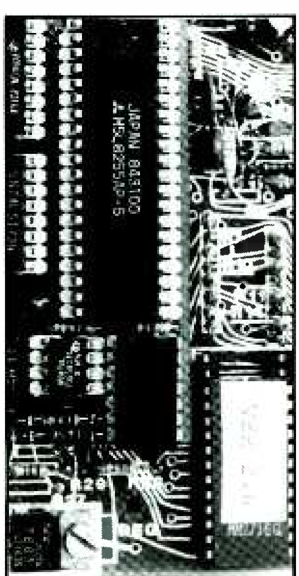

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EDITORIAL

Promises, Promises

Editors are beleagured by news releases that relate to new developments in the lab. Most do not reach the marketplace, though. When they do, it's generally a few years later and the development has been greatly modified. It's exciting to see what's churning, nonetheless, and to watch for winners that emerge.

Last year we waited for the other shoe to drop after receiving some of these interesting announcements. For example, there was a new TV technology that promised to significantly increase picture definition through a new broadcast system that required only minimal circuit changes in an existing TV receiver. Chapter two of this saga provides more details. Seems that CBS and NBC are testing the system, developed by Charles Faroudja, that's claimed to provide up to a two-thirds improvement in picture clarity. This comes close to RGB (red-green-blue direct connections) quality. Called "enhanced NTSC," this could be the picture equivalent of what the Dolby noise-reduction system is to audio. Let's wait and see.

The multiuser operating system, Unix, has been around so long now in terms of micro life that one wonders when it really will take off, as predicted year after year. Now a bevy of computer companies are supporting a new "window" system, X Window, that's said to make Unix interfacing friendlier. Let's wait and see.

We've all heard how wonderful personal computers are for automatic control purposes. Listen to the reports, year after year, and it's a wonder that the whole country isn't on automatic computer control by now. It's not so, as we know. Nevertheless, strides in computer control are continually advanced, and in the programmable controller field, new inroads have been announced. The one that piqued my imagination most recently was the introduction of LabVIEW, a software development that opens new possibilities for automation.

The problem faced by the industry in using PCs as programmable controllers is that the users are not computer programmers. And even when programs are written for them, they're still generally unfamiliar with the ins and outs of applying them. After all, the basic work in this area has been electro-mechanical, with the relay being the foundation. As a result, a relay language system was developed using relay contacts as the basic element of programming. This led to relay ladder programming and a PC keyboard layout that emulates relay logic as well as a front-panel on instrument controllers that uses relay symbology.

LabVIEW, in turn, takes another approach to programming for control purposes. It provides graphic tools for programming by block diagrams, each one of which represents a complete program. As a consequence, pages of code to not have to be written. A mouse is used to wire up the blocks. If wire routing is invalid, the computer automatically shows it as a broken line. Instruments are created on the screen for programming purposes, and the results can be executed through the computer. On paper, it's certainly impressive. In essence, the user creates an instrument's front panel, configures its operation by using only block diagrams, and gets all manner of real-time strip charts, histograms, etc., to boot. All without conventional programming! (For more information, contact National Instruments, 12109 Technology Blvd., Austin, TX 78727.)

Changes for the better don't necessarily make life immediately easier. For example, chip packaging modifications can make it difficult to find a replacement part, though the new package may allow overall equipment to have less bulk. A new, expanded spreadsheet program may be great, but if you don't have a faster computer with lots more memory, you might have to take a coffee-break while waiting for it to do its calculations. Faster chips often exhibit higher failure rates.

Some things seem to never change, though. Just think, the familiar TO-3 package (now named TO-204A) is over 20 years old.

We'll keep you posted on more promises, as well as reporting on those that have come to fruition.

Art Salsberg

Erratum

• The projects in *Modern Electronics* and other electronics magazines have helped my fellow students and me win prizes in our industrial arts shows. But out of all the magazines dealing with electronics, I find yours to be the *best*! Thank you. Incidentally, I spotted a slight error in the schematic of "The (Car) Thief Chaser" in the October 1986 issue. Pins 1 and 3 of the 555 timer should be transposed.

John Hiett
Flagstaff, AZ

Connections to pins 1 and 3 should indeed be transposed.—Ed

Authors' Updates

• My "$20 Drum Synthesizer" that appeared in the January 1987 issue looks good. Since a reader telephoned me to ask about a source for the SN76477 chip used in the project, I figured other readers might be experiencing difficulties. If any are, I suggest they try Anchor Electronics, 2040 Walsh Ave., Santa Clara, CA 95050 or Jameco Electronics, 1355 Shoreway Rd., Belmont, CA 94002. Anchor's price is $3.82 and Jameco's price is $5.95 each. Both companies carry the other semiconductors used in the project, so there should be no problem with the minimum-order charge of $20.00.

This aside, I noted in "How to Design Ultra-Long Delay Timers" in the January 1987 issue that Fig. 7 will not work as shown. To function, pin 7 of IC2 must be grounded. In addition, pins 3 through 6 and 8 through 12 should be grounded to prevent accidental damage to the chip from static discharge.

C.R. Fischer

• Great magazine! However, there are a lot of unanswered questions with regard to the Digital Amplifier featured in the December 1986 issue:

1.)If one were to use an ac power supply, how much current and maximum supply voltage need it supply?

2.) I can see how to modify the input stage for home use (eliminate C7 and R46), but how much input signal do I need for full output?

3.) Exactly what is the output power from the amplifier at a given frequency, load impedance and distortion?

4.) All the p-channel power MOSFETs I can find prefixed with "IRF" have four digits. Is the IRF953 specified for Q1 and Q3 correct?

Greg Woolard
Antioch, TN

The author replies: Your best bet for an ac-line-operated power supply is to keep the positive and negative supplies to between 32 and 35 volts at 5 amperes or more. The input stage is designed to provide full output with a signal of 5 volts peak, the maximum delivered by most car radios. With the radio at full output, the amplifier will be at a level near clipping. To use the amplifier with a home stereo system, you need a preamplifier. This can be built around the LM381N with good results. Several good circuits are provided in the National Semiconductor data books. The output power

(Continued on page 91)

MODERN ELECTRONICS NEWS

THE #1 CLONE. Radio Shack ranks as the No. 1 PC-DOS clone manufacturer with 272,000 units sold through retail channels in 1986, ahead of all others such as Compaq, Leading Edge, etc. Normally reserved about its sales numbers, and ignored in all studies of who sells how many, RS is now telling what was an untold story. Moreover, its total of 668,000 computers sold in 1986 places them in a dead heat with Apple Computer for the overall No. 1 spot on a unit basis.

AUDIO/VIDEO SERVICE EDUCATION. Another company hiding its light seems to be RCA Consumer Electronics. It's been producing fine technical material to support its products for many years. Among its offerings in this area are a host of RCA VCR workshop training manuals, a technical reference library, unitized chassis color TV service education manual and tech library, RCA color TV workshop manuals for step-by-step color TV operation and troubleshooting, and more. Write to RCA Consumer Electronics, Technical Training Dept. 1-450, P.O. Box 1976, Indianapolis, IN 46206, and request its 1986 Technical Training Publications Catalog.

E-MAIL WHITE PAGES. Computer electronic mail services are great--if someone knows how to reach you. Moreover, each commercial E-Mail service has its own addressing scheme. Now an equivalent of the telephone company's "White Pages" for home phone numbers and addresses has been started, called the National E-Mail White Pages. It's free to anyone with a modem; initially, that is. Registrants will be included in a searchable on-line directory, with calls received via modem at 203-245-7720. Only those who registered their own addresses can search for other E-Mail addresses in the White Pages. New registrants get 50 free searches. After this, users with credit cards can buy blocks of 50 additional searches for $10, with unlimited searching for high-volume users for $95/year. In addition to listing a registrant's various "addresses," the preferred one can be noted, too. For more information, call 800-843-6088 or send MCI Mail to RHERFF (for Ron Herff) for a reply. To register, call 800-622-0505 with a 300-, 1200- or 2400-baud modem.

YES, NOVICES MAY NOW TALK. At long last, after much pressure and cajoling, the FCC has officially expanded entry-level privileges for amateur (ham) radio operators to include operating modes beyond the traditional Morse Code. Now hams with Novice licenses will be able to communicate by voice and between home computers linked by radio without having to pass more difficult tests in order to do so. The new opportunity includes single-sideband voice and digital communications at 28 MHz as well as all modes in parts of the 220-225-MHz band and the 1240-1300-MHz band. So Novices can now transmit data by radio that's independent of the public telephone systems, and join over 20,000 packet-radio operators as part of a growing worldwide network.

STEALING TV SATELLITE ANTENNAS? Guess this happens, too, since Pico Products, Inc., Liverpool, NY just introduced the PAL-100 "Picoalarm" home satellite feed system security alarm. The security device emits a high pitch from a piezo buzzer when the cable connecting to the feed electronics is severed or disconnected. Pico says that some insurance companies offer reduced liability rates on satellite systems that have such a security device installed. Only one question here: who's gonna hear (and respond to) the alarm?

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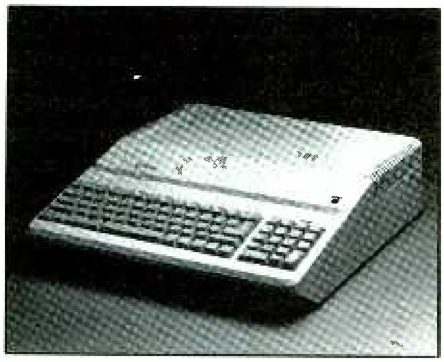
NEW PRODUCTS

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.

A New Apple IIe

Apple Computer has announced an updated version of its Apple IIe personal computer. The new IIe has an expanded keyboard with built-in numeric keypad and features Apple's new "platinum" color scheme. It comes with 128K of user RAM, which is expandable to 1.2 megabytes, eight expansion slots, with an Apple 80-Column card already installed in one, and graphics in three resolutions in up to 16 colors on a wide variety of monitors.



New features include the 18-key numeric keypad, two programmable function keys and cursor-control keys. To facilitate upgrading the new computer to IIGS status (optional), the IIe's keyboard is functionally equivalent to the IIGS's .

Built around the low-power 65C02 microprocessor operating at a clock frequency of 1.02 MHz, the updated computer's standard features include video output (monochrome and NTSC-compatible color) and game I/O interfaces and a built-in speaker. It handles both text and graphics, the latter in three resolutions. Low resolution offers 16 colors with 40 × 48-block display, high resolution offers six colors with 280 × 192-dot display, and double-high resolution offers 16 colors with 560 × 192-dot display.

The computer measures 18"D × 15.13"W × 4.5"H and weighs 12 lbs. $828. The IIGS Upgrade is $499 (plus installation).

CIRCLE 1 ON FREE INFORMATION CARD

Preprogrammed vhf/uhf Police Scanner

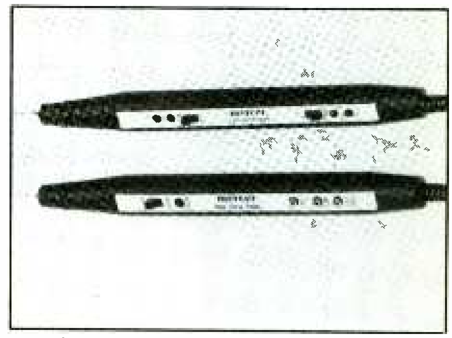
Regency Electronics' new "Informant" is a special mobile vhf/uhf receiver that comes already preprogrammed with national police and key state and local law-enforcement frequencies for all 50 states. It also has a built-in weather function that, when activated, automatically causes the radio to search for the closest active frequency from the National Weather Service. Unlike the case with scanners, the Informant never has to be programmed with the desired frequencies. With a single touch, its patented "TurboScan" system seaches out preprogrammed frequencies for a particular state at a rate of 50 channels per second, which is four times the speed of conventional scanners.

Features include a digital display that shows the state and type of transmission (state police, county police, etc.) being monitored; a highway/city switch for monitoring local or statewide police frequencies; a "hold" switch to keep the receiver on a single frequency; and a top-mounted speaker. It comes with a telescoping antenna. It can be used with a dc cigarette lighter cord or wired directly to a vehicle's dc system. $369.95.

CIRCLE 2 ON FREE INFORMATION CARD

Digital Probes

Two new logic probes and a pulser probe have been announced by Mercer Electronics, a Division of Simpson Electric Co. The 20-MHz Model 9604 and 50-MHz Model 9605 logic probes are handy troubleshooting tools for various types of TTL and CMOS (switch selectable) logic families. Their slim, compact design makes them easy to use in densely populated printed-circuit assemblies. Levels and pulses can be viewed easily from two front-mounted LEDs and can even be stored by means of a convenient switch. Two more LEDs in the base of the units indicate when an improper connection has been made or when an over-voltage condition exists.



The Model 9606 multifunction pulser can inject up to 50-microsecond pulses into a logic circuit without having to isolate the ICs when in the pulse mode. It also has a sync input that permits use of an external synchronizing signal. It is ideal for isolating opens, shorts and malfunctioning ICs in logic circuits.

CIRCLE 3 ON FREE INFORMATION CARD

Shirtpocket DMM

A new, miniature digital multimeter has been announced by A.W. Sperry Instruments (Hauppauge, NY). The Model DM-1 "Pocket Pro" miniature 3½-digit DMM combines the measurement capabilities of a 14-range digital instrument with the simplicity and size of a pocket calculator. It features autoranging, manual ranging, electronic overload protection on all ranges, automatic-po-

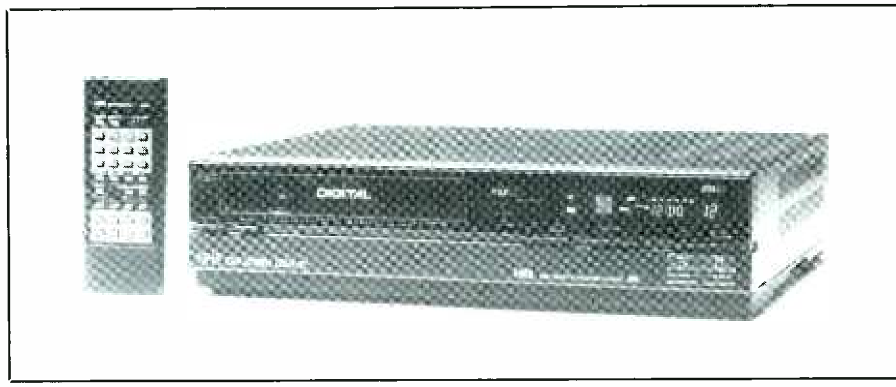
larity selection, audible continuity indication and more.

Pocket Pro can measure ac and dc volts to 200 mV, 20 V, 200 V and 450 V full-scale and resistance to 200, 2K, 20K, 200K and 2M ohms full-scale. Continuity indication is via a built-in buzzer; it sounds when the resistance between the probe tips is less than 200 ohms.

The DM-1 is supplied with two 1.5-volt LR-44 button-type cells, carrying case, built-in test leads and operating manual. Dimensions are 4.2"H × 2"W × 0.4"D, and weight is only 3.5 oz. $29.95.

CIRCLE 4 ON FREE INFORMATION CARD

Digital Hi-Fi Videocassette Recorder



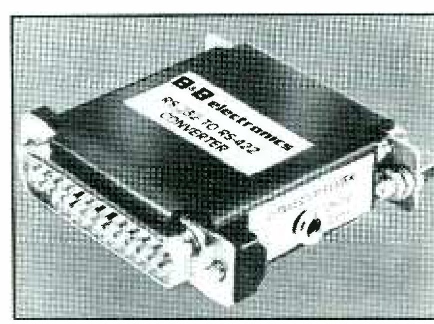
NEC Home Electronics' Model DX-2000U VHS videocassette recorder offers just about the entire catalog of advances in video recording technology. HQ recording is provided for improved video recording and hi-fi capability for full-spectrum audio recording in stereo. Added to this are true MTS stereo and SAP sound decoding, digital video processing and dual-purpose wireless remote control.

High-quality (HQ) recording adds sharpness and improves the color of recorded pictures for a 20% improvement in picture quality, while Hi-Fi recording provides an extended audio frequency response from 20 Hz to 20 kHz with more than 90 dB dynamic range and more than 60 dB channel separation. The 110-channel cable-capable synthesized tuner has 40 channel presets, with channels accessible via up/down scanning or randomly. Digital noise reduction improves video S/N by up to 9 dB, and digital playback yields noiseless stop-action and slow motion. Digital picture memory freezes live pictures.

Features include on-screen status/programming display; 4-event/21-day timer; a "unified" remote controller that operates both the VCR and NEC TV receiver/monitors; "Jet Search" for quickly reviewing the tape at 8 or 21 times normal speed; single-button recording in 30-minute increments up to 5 hours total; automatic power-on when a cassette is loaded; cassette eject with power off; picture sharpness control; multifunction display that gives error messages; 10-minute battery backup for the timer and memory settings; and a mirror system that visually confirms tape movement. The dual-purpose remote controller duplicates virtually all front-panel controls, including counter/timer setting and cassette eject. The VCR measures 17"W × 14¾"D × 4^{5}/$_{32}$"H and weighs 19.4 lbs. $819.

CIRCLE 5 ON FREE INFORMATION CARD

RS232C-to-RS422A Converter



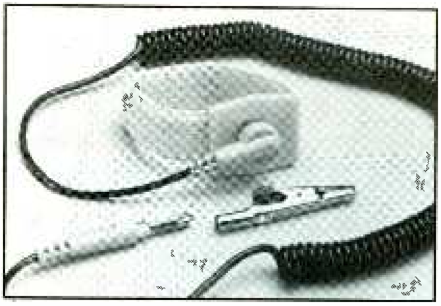
B&B Electronics' (Ottawa, IL) Model RS232C-to-RS422A converter uses balanced differential signals to permit cable communications at distances up to 4,000 feet, at transmission rates up to 93,000 baud. For users who require multiple-drop systems, the converter permits as many as 10 receivers to be simultaneously connected to a single driver.

Featured in the converter are a male DB25 connector for RS232C and a female DB25 connector for RS422A hookups. RS232C transmit data is converted to RS422A and RS422A receive data is converted to RS232C. No handshaking lines are connected. Also available is a reversed converter, Model 422COR, with female DB25 connector for RS232C interfacing and a male DB25 connector for RS422A interfacing. Both models require 12 volts dc at 100 milliamperes, for which a power supply is available as an option. $49.95 for converter; $14.95 for power supply.

CIRCLE 6 ON FREE INFORMATION CARD

Antistatic Wrist Strap

Davle Tech's Model WRS-3 antistatic wrist strap is designed to allow the user to work safely on sensitive electronic assemblies. It has a retracting coiled cord that is claimed to prevent any possible tangling or user inconvenience as it discharges harmful static electricity to earth. An elastic band that the user wears on his wrist is made up of a non-irritating fabric



and has a 6″ circumference to fit a wide range of wrist sizes. A 360-degree swivel dot-type stud connects the cord to the wristband. The cord mating stud is enclosed in a molding that also houses a 1-megohm resistor that protects the user. A banana plug/alligator clip arrangment at the opposite end of the coiled cord provides for connecting the strap to a wide variety of conductive surfaces.

CIRCLE 7 ON FREE INFORMATION CARD

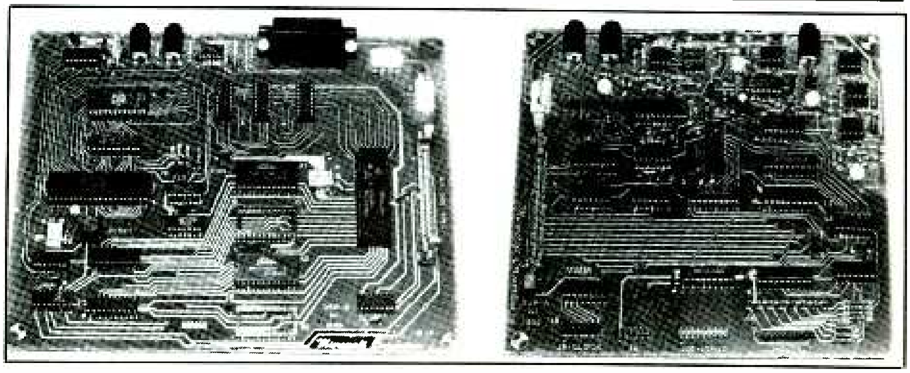
Professional CD Player

Technics' Model SL-P1200 "professional" compact-disc player offers search dial cueing that lets you "spin" the disc to any desired point anywhere on the disc just as with a conventional turntable. Forward/backward cueing is in 0.1-second increments and can be performed at two speeds. Slow mode goes through one second, while fast mode goes through 30 seconds of program material per revolution. A rocker control permits real-time manual control of the timing of the start of selections, performing digitally a function similar to manually controlling the speed of the platter of an analog turntable when mixing.

Auto cue automatically positions the laser pickup precisely at the start of the first note of each track, which is confirmed by a "standby" indicator. A long-stroke fader controls pitch over a range of ±8%. Pressing the on/off key instantly restores standard quartz-locked pitch.

Features include: numeric 10-key pad for direct access and 20-step random-access programming by selection number and index number; 4-pin DIN jack for connection of a momentary contact switch to control start/stop or start/pause functions; 9-digit display that shows track number, index number, and minutes, seconds and tenths of seconds; repeat and skip keys; double-oversampling digital filter; headphone jack with level control; subcode output; and remote controller. $1,295.

CIRCLE 8 ON FREE INFORMATION CARD



Digital Signal Processing Development Systems

Microcraft Corp. (Thiensville, WI) has announced a cost-effective pc-board system for digital signal processing (DSP) research, development and experimentation based on the Texas Instruments TMS32010. The complete system consists of Model DSP-D digital and Model DSP-A analog processing boards that can be used with personal computers equipped with RS-232C serial ports. A comprehensive manual comes with each board. Communication with the DSP-D via an RS-232C interface uses TX, RX and GND connections to permit the widest possible variety of terminals and computers to be used.

The DSP-D digital board loads and runs TMS32010 programs and features: TMS32010 DSP processor running at 20 MHz; 8039 microcomputer for local control of the TMS 32010 and RAM; software in ROM for RS-232 communication with the host computer; up to 4K of RAM for TMS32010 programs; tape storage of DSP programs; and 40-pin connector for linking with analog subsystem. The DSP-A analog board, which provides peripherals for the TMS32010, features: 8-bit A/D converter with sample and hold; 8-bit D/A converter; selectable sample clock rates to 20 kHz; analog filters for antialiasing and reconstruction; 8-bit digital I/O ports with LED indicators; and internal/external sample clocks. $299 DSP-D; $199 DSP-A.

CIRCLE 9 ON FREE INFORMATION CARD

(Continued on page 90)

NRI Trains You At Home—As You Build Your Own IBM PC Compatible Computer

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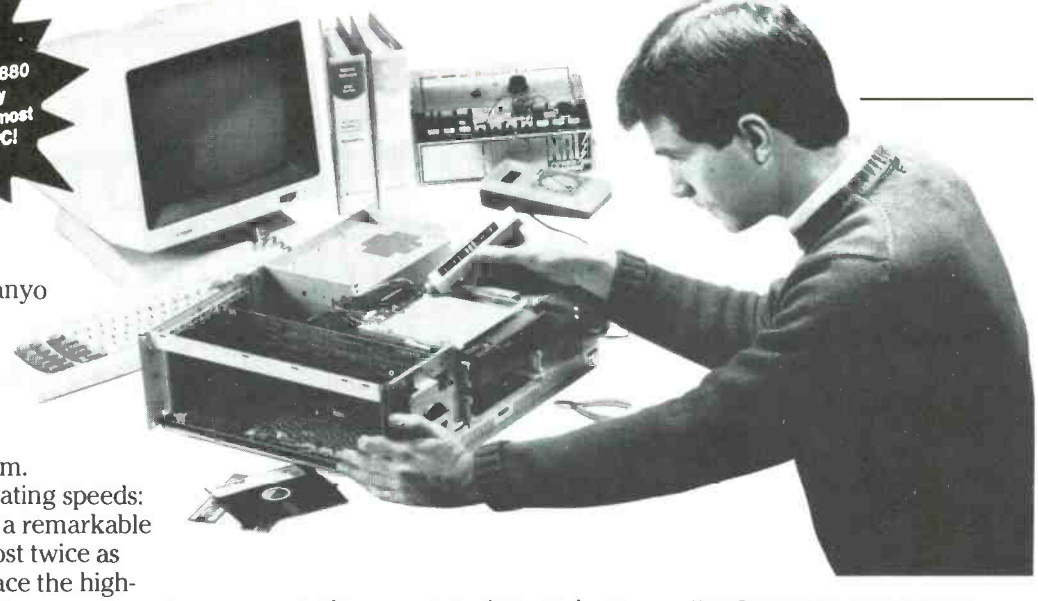

'ou start with he step-by-step ıssembly of the new, highly-rated, Sanyo :omputer. You install and trouble-hoot the "intelligent" key-ıoard. Then you assemble the ıower supply, install the disk lrive, and add extra memory to ;ive you a powerful 256K RAM system. 'he new 880 computer has two operating speeds: tandard IBM speed of 4.77 MHz and a remarkable urbo speed of 8 MHz, making it almost twice as ast as the IBM PC. Next, you'll interface the high-esolution monitor and begin to use the valuable software ılso included with your complete computer system.

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4-047

Introduction to Thyristors

How to use diacs, SCRs and triacs to switch and control ac voltages to resistive and reactive loads

By Dan Becker

Thyristors provide an efficient, low-cost method of controlling power to a load. For many applications, small size and high current capacity—as much as 4,000 amperes—make them more attractive than mechanical relays. The three most common types of thyristors are the diac, the silicon controlled rectifier (SCR) and the triac. Although these devices are primarily used with ac line voltages, the SCR is also extensively used in dc pulse applications. All are bistable semiconductor devices that can be switched from a high-impedance off state to a low-impedance on state.

Once triggered, a thyristor remains on until its forward current drops below the level necessary to maintain the on condition, which is called holding current I_h. Because ac line voltage falls to zero at the end of each half-cycle, thyristor current drops below the I_h level and reverts to the off state every half-cycle.

Thyristor Basics

•*Diac.* A diac, shown schematically in Fig. 1(A), has two terminals. When off, it is equivalent to an open circuit. It stays in the off state until a positive or negative voltage of sufficient amplitude—called the breakover voltage V_{BO} (or switching voltage V_s)—is placed across the terminals. The diac then turns on and the current through it is limited only by load resistance.

Figures 1(B) and 1(C) illustrate the single-pole, single-throw switch-like action of a diac. A typical diac has a breakover potential of 24 to 32 volts.

Diacs are primarily used with triacs in power control circuits, such as light-dimmers. We will go into more applications detail and the effect they have on circuit performance later.

•*SCR.* Similar to the diac, the SCR has two stable states, defined as on and off. The schematic symbol is shown in Fig. 2(A). Unlike the diac, however, current can flow in only one direction. In addition, the voltage at which breakover (switching) occurs is adjustable and is controlled by the third, gate, terminal.

Breakover voltage of an SCR is specified by the manufacturer for zero gate current. When designing a circuit, you must select a thyristor that is rated higher than the maximum voltage anticipated. For example, for ac-line operation, you would select an SCR with a 600-volt V_{DRM} rating. This ensures that the reverse-blocking voltage rating will also be adequate. Typically, it is 100 volts greater than the V_{BO} rating and is equivalent to the peak reverse voltage rating of a rectifier diode.

Cathode-to-anode action of an SCR is similar to that of a diode in series with a single-pole, single-throw switch. The "switch" closes under gate control. That is, to switch on an SCR, a small current must be passed to the gate terminal. Figures

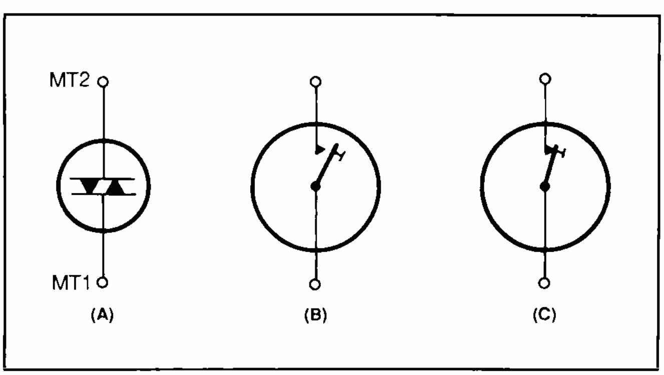


Fig. 1. Schematic symbol of diac (A) and simplified models of on (B) and off (C) states.

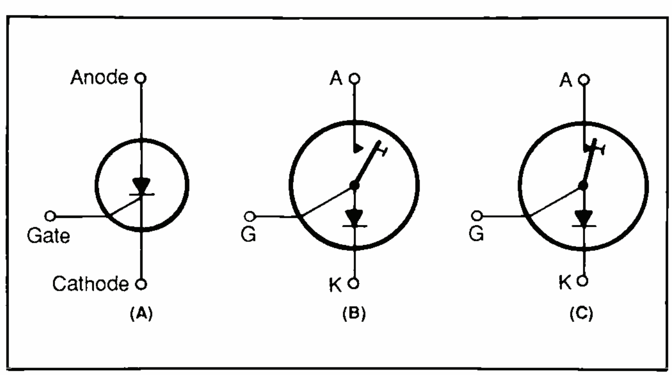


Fig. 2. Schematic symbol of SCR (A) and simplifed models of on (B) and off (C) states.

2(B) and 2(C) show the on and off states of this simplified model.

How gate current can be applied to an SCR is illustrated in Fig. 3. Here, an external switch in series with a current-limiting resistor is used to open and close the gate current path. The series gate resistor assures that the gate current will decrease to a safe value after the SCR is triggered. In addition, a 1N4004 rectifier diode is installed in series with the gate. This prevents the negative half of the ac line-voltage cycle from damaging the cathode-gate semiconductor junction of the device.

With an open gate switch, the SCR remains off, due to the high breakover voltage rating. If the gate switch is closed, the breakover voltage point is lowered through the action of gate current. Thus, the SCR would switch on during the positive half of the line voltage.

When on, forward current through an SCR is limited only by the load resistance. The SCR will remain on until forward current drops below holding current I_h.

When the line voltage alternates to the negative half of the cycle, forward current drops below holding current, forcing the SCR into the off state. Thus, the SCR must be retriggered (switched on) once every cycle, while the polarity of the cathode to anode voltage is in the forward direction (cathode negative and anode positive).

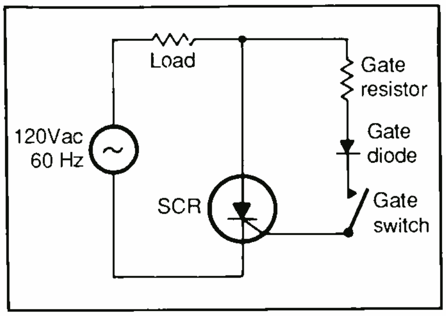


Fig. 3. An SCR test circuit.

By making the gate resistor variable, the breakover-voltage point can be controlled. As gate current increases, breakover voltage is lowered. This controls the point during the positive half-cycle at which the SCR fires, thereby controlling the amount of power fed to the load. At maximum gate current, this device operates like a half-wave rectifier in series with the load.

• *Triac.* To obtain control over both positive and negative halves of the line-voltage cycle, a more versatile device than the SCR is required. This brings us to the bidirectional triac.

Shown schematically in Fig. 4(A), the triac combines the bidirectional properties of the diac with the breakover-voltage gate-control mechanism of the SCR. The three terminals of the triac are identified as main terminal one (MT1), main terminal two (MT2) and gate (G).

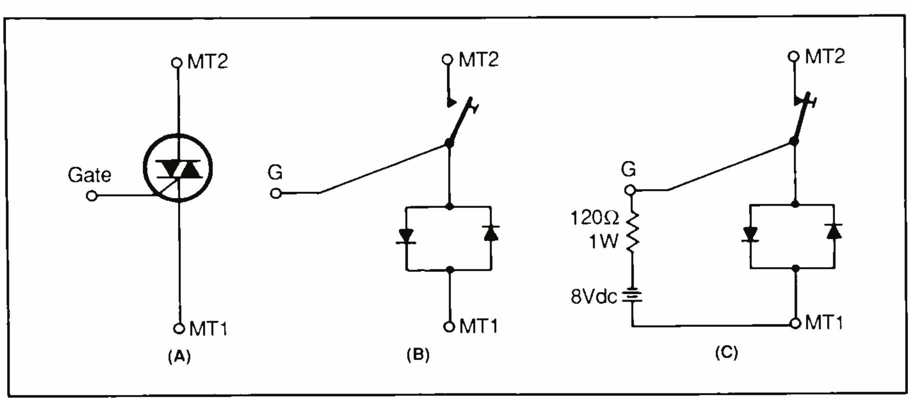


Fig. 4. Schematic symbol of triac (A) and simplified on (B) and off (C) models.

A triac can be switched on during both positive and negative halves of the 360-degree ac cycle, making the complete voltage cycle available to the load, instead of only the 180 degrees afforded by the SCR.

Gate current in a triac is always referenced to MT1 and can flow in either direction. In addition, it can be applied continuously or in pulses. The manufacturer's data sheet specifies the value of gate current I_{GT} necessary to trigger on the device. Often, this refers to the dc current required to trigger the device with 12 volts ac applied between MT1 and MT2. As the temperature of the triac increases, the required amount of gate current decreases.

Continuous gate current is easily accomplished with a dc voltage (with a current-limiting series resistor) applied between the gate and MT1. This triggers the thyristor on for both halves of the ac line voltage. It permits the triac to function as an electronically controlled switch. Figures 4(B) and 4(C) illustrate the on and off circuit characteristics, respectively.

Unlike the SCR, gate current of a triac can flow in either direction. This is convenient because it allows the ac line voltage to be used to supply the gate control circuit. Typically, pulses of gate current are generated, one for each half of the ac cycle. The polarity of each pulse corresponds to the instantaneous polarity of the voltage across the main terminals. Pulsed gate current allows triggering of the device at nearly any convenient point in the line-voltage cycle. This method is used in the light-dimmer circuit to be described shortly.

Some of the symbols manufacturers use to specify the characteristics of a thyristor are detailed in the thyristor characteristics table.

Thyristors are available in a variety of case styles. Examples of the more common types are given in Fig. 5. Case style and size are related to the power-handling capacity of the device. Because of the high efficiency associated with thyristors, even small packages like the TO-92 can handle rms currents in excess of 1 ampere and peak (nonrepetitive) currents of 15 amperes. Larger case styles, like the TO-48 stud mount, typically feature a current ratings of 40 amperes.

Because a thyristor is less than an ideal switch, 1 to 2 volts is dropped whenever current flows. This generates heat that must be dissipated by a heat sink. In an application like the light dimmer shown in Fig. 6, where the thyristor controls a 60-watt load, power dissipation is about 1 watt and requires only a small heat sink.

When a control circuit operates directly from the ac line, mounting a thyristor to a heat sink should be given careful consideration. The reason for this is that the metal tab on the case of the device is usually not electrically insulated from MT2. Therefore, you should install a Teflon or mica washer between the thyristor and the heat sink before fastening them together. This keeps the "hot" side of the ac line isolated from the heat sink and the enclosure and maintains good transfer of heat.

Some thyristors feature an isolated mounting stud. This lets you forget about the washer, since MT2 (or the anode of an SCR) is internally insulated from the case of the device.

Phase-Control Circuit

Illustrated in Fig. 6 is a typical application for thyristors—a light-dimmer control. Potentiometer *R1* lets you adjust the brightness of the lamp over a range from a weak flicker up to full on. Three different settings, shown as A, B and C, are indicated for *R1*, corresponding to the three pairs of points indicated on the ac line-voltage curve in Fig. 7.

Thyristor Characteristics.

V_{ORM}	Peak Off Voltage—exceeding this value switches on the device.
V_{BO} or V_S	Breakover or Switching Voltage—must exist across terminals before device switches on.
V_{TM}	On Voltage—voltage dropped across device by forward current.
V_{GT}	Gate Trigger Voltage—forward biases the gate terminal.
I_{GT}	Gate Trigger Current—value to use to ensure positive device triggering.
I_h	Holding Current—minimum current required to maintain the on state; often specified in milliamperes (mA).
$I_{T(RMS)}$	Rms Current—maximum rms on-state current without device failure.
$I_{T(AV)}$	Average Current—maximum average on current without device failure.
I_{TSM}	Surge Current—maximum peak on current (nonrepetitive) without device failure.

With *R1* set near maximum resistance (A), the triac switches on at point A on the time/voltage curve. This corresponds to minimum light brightness. At the opposite extreme, if *R1* is set toward minimum resistance (C), the triac fires at the beginning of each half-cycle, delivering maximum power to the lamp.

Following Fig. 6, potentiometer *R1* and capacitor *C1* form a voltage divider with a time constant of up to 5 milliseconds. Therefore, the voltage across *C1* lags the voltage across the main terminals of the triac. A second RC circuit consisting of *R2* and *C2* is connected in parallel with *C1*. The voltage across *C2* lags still further behind the terminal voltage of the triac. In addition, the voltage is now reduced to a fraction of the ac line voltage.

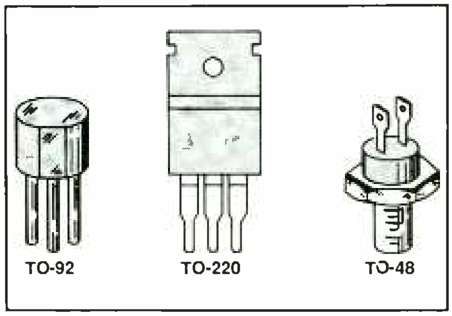


Fig. 5. Typical thyristor package configurations.

As the value of *R1* is reduced, the voltage across *C2* increases. A point is reached at which the peak voltage across *C2* exceeds the breakover voltage of the diac. At this point, the diac switches on and capacitor *C2*

(Continued on page 96)

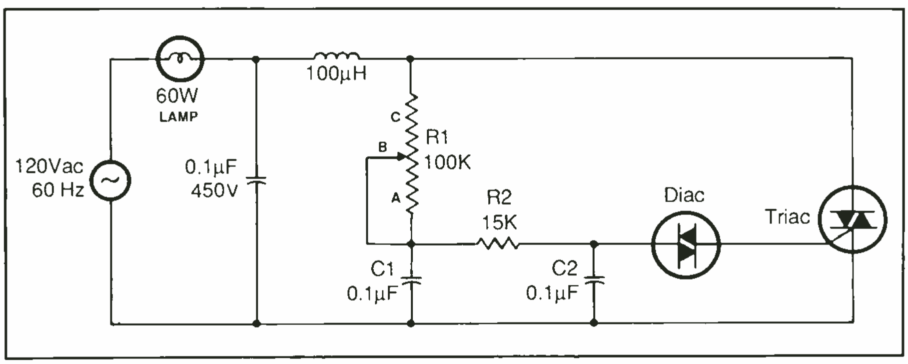


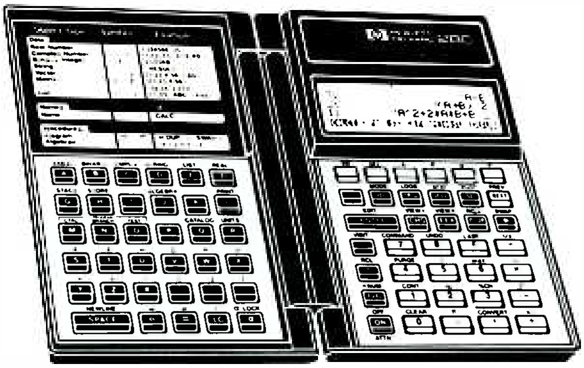
Fig. 6. A diac/SCR light-dimmer circuit with rfi suppression.

The UnExpected HP-28C— is this your next calculator?

HEWLETT PACKARD

A first report:

If you're at all like me, this is what you've been holding your breath for (in the calculator direction, of course). Just a few years back, calculators were exciting. Maybe once a year there was a new model that could do startlingly more. Not recently, though.



The HP-28C is first in a new generation. I don't have room here to do it justice, there are so many interesting features and specs for it. I'll sketch it for you, though . . .

You'll have ON-SCREEN MENUS and SOFT-KEYS, just like a PC—sensible access to hundreds of functions (128K ROM!) and high-level problem solving. Gamma function, random numbers, . . .

Complex numbers, matrices, vectors, lists, and algebraic expressions can be viewed, edited, and then used in calculations just as easily as ordinary numbers. Dot and cross products, determinant, . . .

You can choose RPN LOGIC for calculations OR use the built-in ALGEBRAIC LOGIC—with RPN its 4-line display shows your stack OR you'll see your equation displayed just as you would write it. You choose.

You'll do no programming to get solutions, either—it will solve for any unknown variable anywhere in your equation.

It will convert between different unit systems, too. The values of 120 units are built-in, and you can add your own. Are you ready for all this right now? (I have them in stock.)

You'll use SEPARATE KEYBOARDS, the right hand one for NUMBERS and the left for LETTERS. Later, you can fold it to pop into your shirt pocket.

You can plot graphs of your functions, even two at a time. Then place the cursor near where the graphs cross and press a key to calculate the x-value of the crossing, correct to 12 digits. I was amazed.

Scatter plots of your statistical data are easy too. Imagine showing all this to your colleagues!

Plotting. Plot mathematical functions and statistical data; set plot scales, axes, and center; display graphics.

Statistics. Single- or multi-variable statistics: summation, deletion, mean, standard deviation, total, maximum, minimum, variance, covariance, correlation. Linear regression and predicted value. Normal, Students t, F, and Chi-square distributions.

A major leap in technology—you'll do SYMBOLIC ALGEBRA, even SYMBOLIC CALCULUS. You'll manipulate unknowns and letters as well as numbers, even differentiate functions to get their derivative functions. This is the first small machine that can do symbolic mathematics, like MACSYMA on a mainframe, and it can be yours right now.

Symbolic Algebra. All real and complex number functions; expand, collect terms; expression editor; subexpression recall and substitution, symbolic solve; quadratic equations.

Calculus. Symbolic differentiation of arbitrary expressions; symbolic integration of polynomials; numerical integration of arbitrary expressions; Taylor series.

Programmability is enormous—You can use all of the built-in functions with your own menus and softkeys, plus sophisticated utilities.

Binary Integer Operations. Decimal, octal, hexadecimal, and binary bases; arithmetic; variable wordsize; bit shift and rotate, byte shift and rotate, arithmetic shift; logical operators; floating-point/ integer conversion.

Programming Features. User-defined functions, local variables, indefinite nesting and recursion, IF . . . THEN . . . ELSE, FOR . . . NEXT, DO . . . UNTIL, WHILE . . . REPEAT; halt, continue, abort, single-step, pause, read key, beep, display, error message, error number; set/ clear/test 64 user flags; conditionals, logical operators; object type.

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CIRCLE 28 ON FREE INFORMATION CARD

A New Life for Sinclair/Timex Computers

How to convert a Sinclair ZX81 or Timex-Sinclair TS1000 into a programmable printer buffer

By R.L.L. Hu & J.J. Chang

Not too many years ago, more than a million very-low-cost Sinclair ZX81 and Timex-Sinclair TS1000 computers were sold to consumers who wanted a taste of working with the new devices. Most of these computers are now stored away, just gathering dust due to obsolescence. If you're lucky enough to have one of these tiny mites but haven't used it in years and don't know what to do with it, here's a way to convert it into a Centronics-compatible parallel printer buffer that can free up your present computer during printing operations.

As an example of how effective the modification is, this manuscript tied up my computer for 11 minutes while printing. In contrast, using the ZX81/TS1000 as a printer buffer reduced this to 12 *seconds*!

You can do the conversion at a fraction of what it would cost you to buy a commercial buffer or build one from scratch. Converting a ZX81 or TS1000, as described here, offers a number of advantages not normally obtained with commercial or home-built buffers. Among these are: a power-on memory test/size-determination feature; a Multi-Copy Mode that lets you select up to 255 copies of a document to be printed; continuous display of buffer filled or copies remaining to be printed; a pause function for suspending printing; a clear key to reset the Buffer; and automatic cancelation of Multi-Copy Mode on buffer size overrun.

This project makes *permanent* hardware modifications to the computer to make it possible for all the printer buffer interfacing logic to be contained in the computer's original case. Once the modifications are made, you will no longer be able to run any of the computer's original software, of course.

About the Circuit

To transform the ZX81 and TS1000 from computer into Printer Buffer, the original r-f modulator and ULA

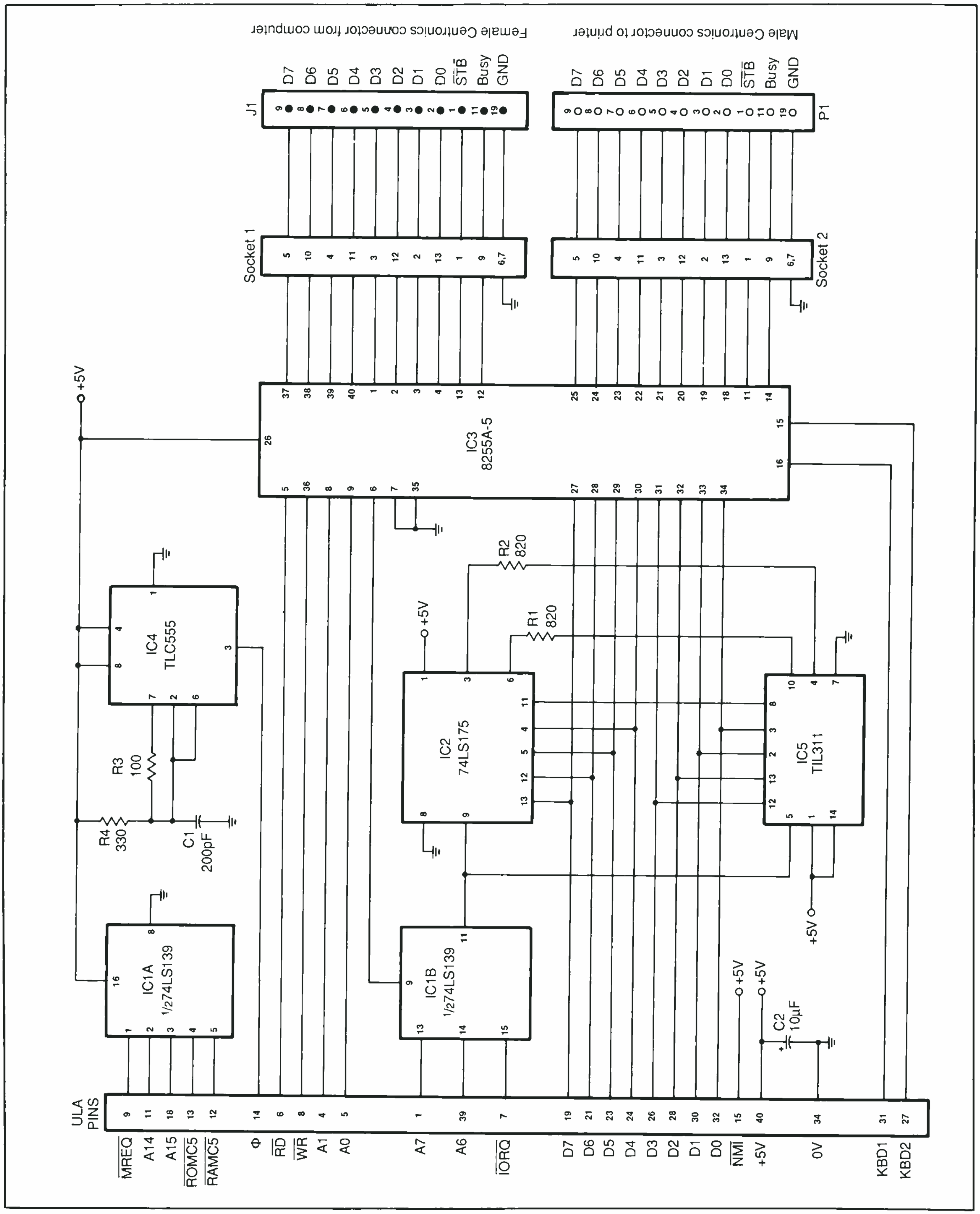
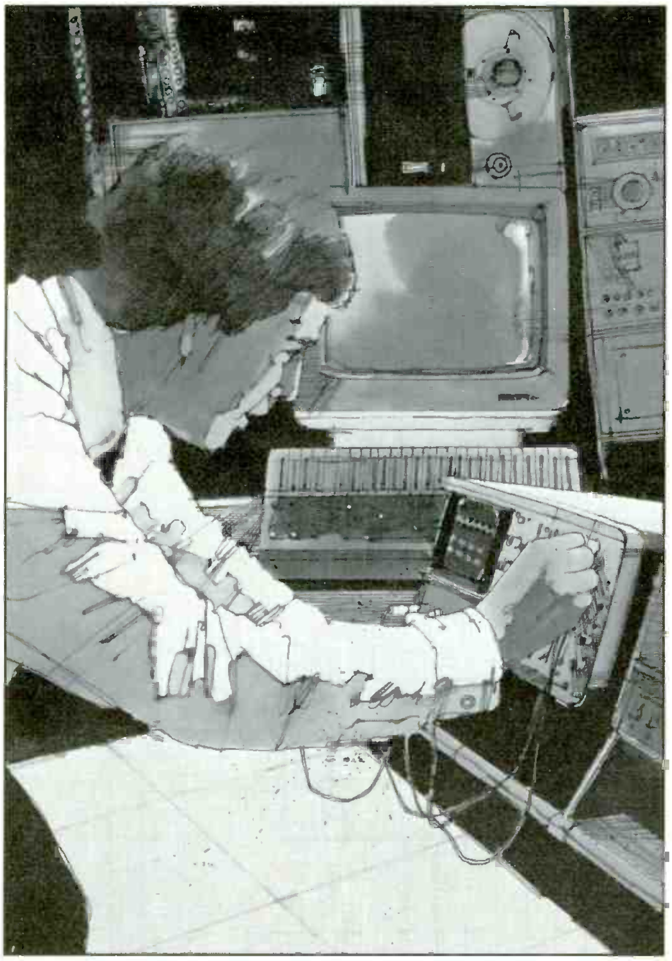
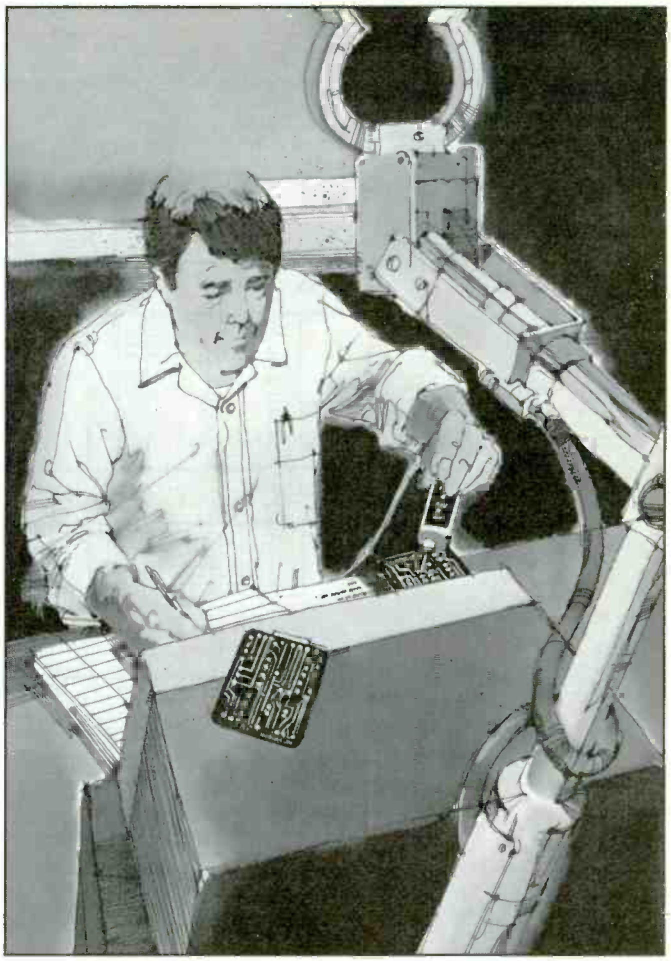
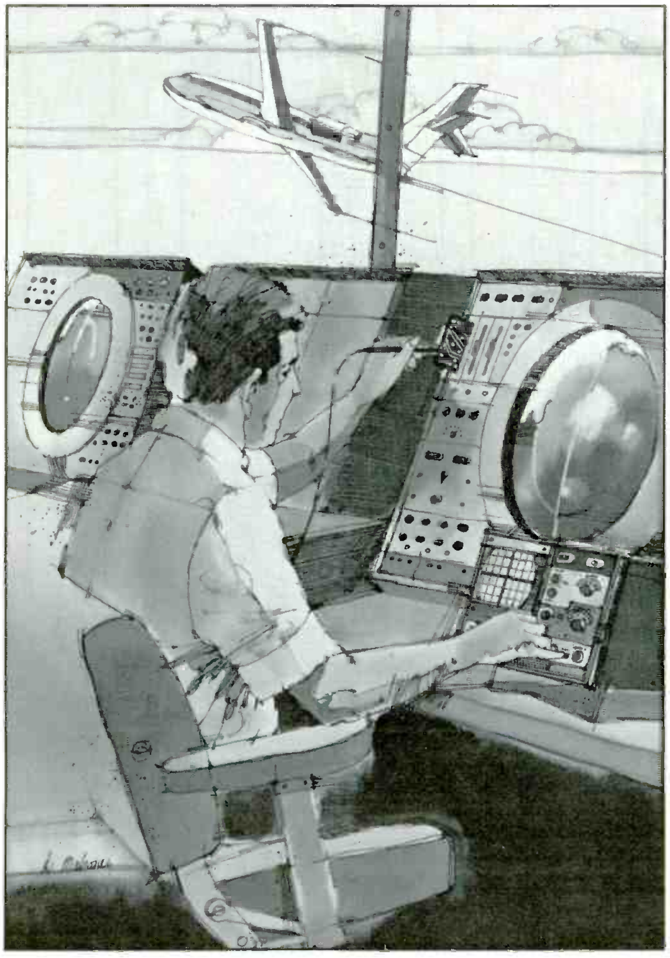
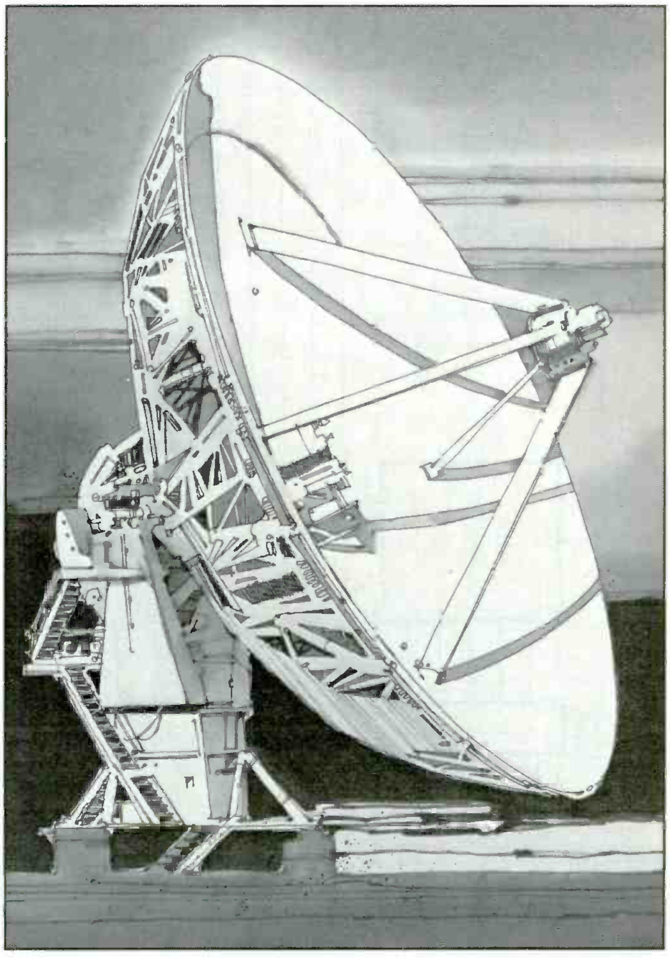


Fig. 1. Complete schematic diagram of modification module

PARTS LIST

Semiconductors
IC1—74LS139 dual 1-of-4 decoder
IC2—74LS175 Quad D flip-flop
IC3—8255A-5 programmable peripheral interface
IC4—TLC555 CMOS timer
IC5—TIL311 hexidecimal decoder/driver/display

Capacitors
C1—200-pF disc
C2—10-µF, 16-volt tantalum

Resistors (¼-watt, 5% tolerance)
R1,R2—820 ohms
R3—100 ohms
R4—330 ohms

Miscellaneous
Programmed MM2716-45 2K × 8 450-ns EPROM (see text); perforated board with 0.1" hole centers (Radio Shack Cat. No. 276-158 or similar); low-profile sockets for all ICs and plug-ins for Centronics cables; adapter pins for plugging into sockets (see text); male and female Centronics-compatible printer cables with 14-pin DIP connectors at other end; hookup wire; solder; etc.

Note: The source-code listing for the Printer Buffer Program is available in printed form from NAND Engineering, 1458 Meadowbrook Rd., Gloucester, Ontario, Canada K1B 5G7 for $18.00 ppd.

(uncommitted logic array) and ROM chips must be removed. A 2716 EPROM programmed with the Printer Buffer Program (see listing) goes into the original ROM socket and then a small interface board with ICs and cables that go to the printer and your present computer plugs into the original ULA chip socket. A 1-digit hexidecimal display, also on the interface board, shows the status of the Printer Buffer. Once the modification has been performed, functions such as pause, multiple copies and clear-buffer are provided through the ZX81's or TS1000's keyboard.

Shown in Fig. 1 is the schematic diagram of the interface-board's circuitry that converts the ZX81 and TS1000 into the Printer Buffer. The two halves of the 74LS139 dual 1-of-4 decoder used for *IC1* decodes both the memory and I/O (input/output) space. Quad D flip-flop *IC2* latches hexidecimal decoder/driver/display *IC5*. The TIL311 used for *IC5* contains all decoding and driving circuitry as well as the LED hex display itself in a single IC package. The left and right decimal points (see Fig. 2), for example, are used as extensions of the contents of 4-bit hex display *IC5*, representing the fifth and sixth bits, respectively. As a result, the possible range of the display is from 0 to 63, displayed as "0" through ".F.".

Programmable peripheral interface *IC3* handles all electrical interfacing required between computer and printer and monitors the Buffer's keyboard for operator commands. The system clock is derived from the TLC555 timer chip, shown as *IC4* in Fig. 1. The TLC555 timer was chosen for this application because it has a free-running clock frequency of up to 2 MHz. The stan-

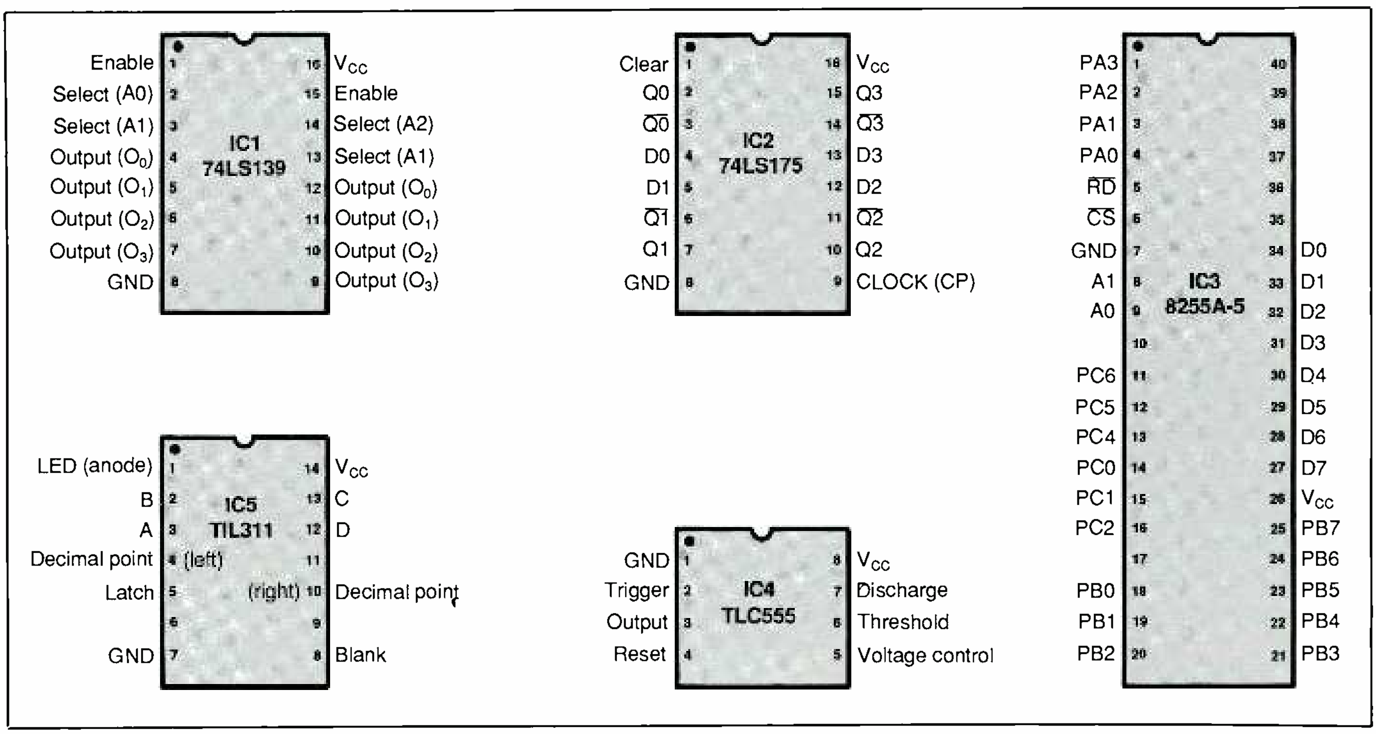


Fig. 2. Case outlines and pertinent pinouts of ICs used in this project.

dard 555 timer's clock frequency is much more restrictive and, thus, is not adequate for this application.

Of the 64K bytes of possible memory space available in the ZX81 and TS1000, the first 16K is allocated for ROM, while the second 16K is allocated for the standard 16K RAM pack. Though the third and fourth 16K spaces are not used by Sinclair, other manufacturers have built RAM packs that make use of these spaces. The Buffer's hardware and software have been set up to accommodate this maximum of 48K of user RAM, but be advised that the project has *not* been tested with such RAM packs.

```
:20000000F33EB1D3C33E0DD3C33E40D3403127402128401 1FFFF36AA7ABC20047BBD280326
:200020002318F3212B40220A40220C400100007EFEAA2025220C4003AFE5D5606911000408
:20004000A7ED5238033C18F9CBF7D340D1E17ABC20047BBD28032318D6210020CDA5022107
:20006000000020CDA5021806DBC2CB4F203611000001000D92A0A40220040220240AF3204B7
:20008000403206403207403208403213403224A403E013205403E403210402101002211404 9
:2000A0002228402A28401 10100A7ED5228062228 40C36B0121CB002228403A0740A720127B
:2000C0003A05403213403A2A40A7204D211340351847 3A0840A720021 80E3A2A40A720087B
:2000E0003A0640321340183108D9ED530E4060697CA720067DA720021 80A3ABA02A7280400
:200100001 1FF0319AF110004A7ED5238033C18F9ED5B0E4032134008D93A1040CB47200DBC
:20012000CBF7321040210100221140182D2A1140110100A7ED5222114020 1F3A1040CB77B0
:20014000280DCBB7321040210400221140180BCBF7321040210600221140 3A1040CB7728D9
:20016000073A1340CBF71801AFD340DBC2CB572060219600CDA502DBC2CB572054DBC2CB49
:20018000572BFA219600CDA502DBC2CB5728EE3A0740A720112105407EFEFFCA9F01343ED0
:2001A00001322A40182B3A05403D280E3E013208403205 40AF322A4018173A0440EE013224
:2001C0000440A73A10402004CB871802CBC73210403A0840A7205EED5B00402A0C40A7EDCD
:2001E00052280713AF3209401809ED5B0A403E013209402A0240A7ED52200EAF322A4032D7
:200200006403E01320540182CDBC2CB6F2826DBC012ED530040D90313D93A0940A728042E
:20022000AF3206403A0740A7200B3A05403206403E013207403A2A40A7C26700DBC2CB4772
:20024000C267003A0440A7C26700ED5B02402A0040A7ED5220273A0640A728063D320640FC
:20026000200E320840D911000001000D9C367003E01320840ED5B0A40D9424BD92A0C40E8
:20028000A7ED522803131804ED5B0A40ED5302401AD90BD9D3C13E0DD3C3CB87D3C3CBC744
:1C02A000D3C3C3670011 0100A7ED52280C380AED5AED52ED5AED5218ECC900013A
                                                             / \
:00000001FF
```

Exchange these two bytes to enable the rounding-up feature, as discussed in the article.

Listing 1. HEX listing of the Printer Buffer Program.

Construction

Two main procedures must be performed to convert the ZX81 and TS1000 from a computer into a Printer Buffer. First you must modify the computer's motherboard to accommodate the preprogrammed 2716 EPROM and the interface board. Then you build the interface board and install it in the computer.

When you disassemble the ZX81 or TS1000, make certain to remove the three screws hidden under the rubber feet. If you work carefully, there should be no need to remove the two keyboard ribbon cables from their connectors. If you do remove them, however, be *very* careful when putting them back.

Once you have the computer open, remove the 8K ROM and ULA chips from their sockets. Then remove the r-f modulator and tie all anode leads of *D1* through *D8* to ground.

Now is an excellent time to program the EPROM you'll be using in this project. The hexidecimal code for the Printer Buffer program is given in the Program Listing. When the Printer Buffer is operating, the amount of information accumulated at any instant is shown on the hex display as a whole number of kilobytes. (Actually, 1 KB = 1,024 bytes). Therefore, 1,500 bytes will be displayed as a "1". If you prefer to round the number up to the next kilobyte so that it is displayed as a "2" (kilobytes implied), make the changes indicated in the Program Listing when you program the data into the EPROM. (If you don't have and EPROM programmer, an excellent stand-alone model that handles up to 128K EPROMs can be built from plans featured in the February and March 1987 issues of *Modern Electronics—Editor*)

To make the 2716 EPROM work in the original ROM socket, pin 18 (–CE) must be tied to ground and pin 21 (V_{pp}) must be tied to +5 volts. Alternatively, you can bend pins 18 and 21 on the 2716 itself away from the IC case, install the EPROM in the ROM socket, and solder the pins to ground and +5 volts via lengths of hookup wire.

If you decide to cut traces, keep in mind that you may also be cutting off signals that are needed elsewhere on the motherboard. In such a case, jumper wires will have to be used to reconnect the isolated sections back into the circuit.

Cut a piece of perforated board with holes on 0.1" centers to the size and shape shown in Fig. 3. The board and component layout shown will fit both the ZX81 and TS1000 cases and motherboards. Any construction technique that will yield a low-profile wired modular assembly will do. The prototype shown in the photos was built using 3M's Scotchflex Breadboarding System. Other choices include Vector Electronics' wiring pencil, printed-circuit board

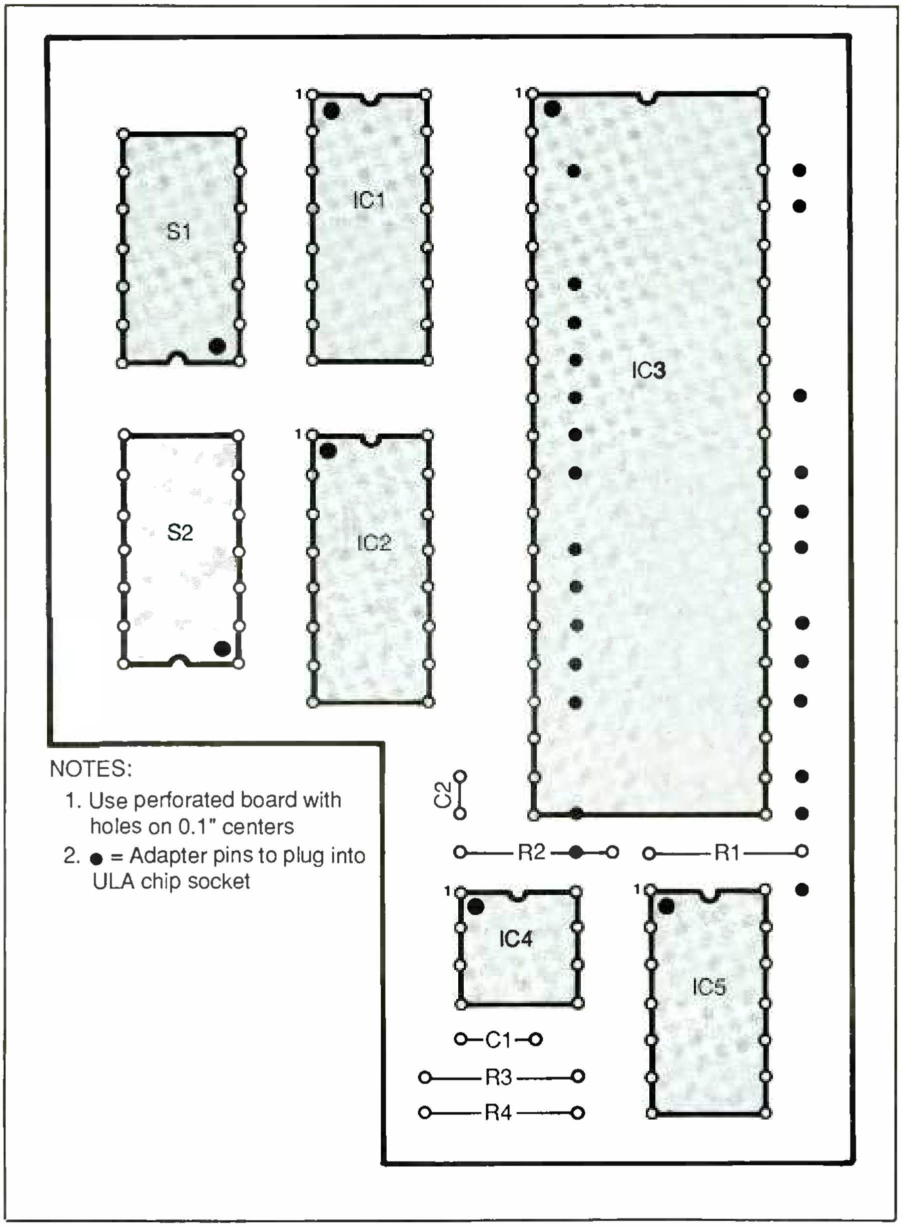


Fig. 3. Plug-in circuit-board module size, shape and component layout guide. Use board with holes on 0.1" centers and low-profile sockets with all ICs and for Centronics cable plug-ins. Refer to Fig. 1 for wiring details.

layout, etc. In all cases, use low-profile sockets for all ICs.

Using sockets for all ICs and for plugging in the DIP connectors at the ends of the Centronics cables, wire the circuit exactly according to Fig. 1. All signals from top to bottom on the left side of the schematic diagram are from the original ULA chip socket, at the pin numbers indicated. You need adapter pins that can be soldered to the interface board and be plugged into the ULA chip socket in the computer. Square header pins are too large for this purpose and are *not* recommended. If you can't find appropriate pins, try using pins removed from ribbon cable DIP connectors.

Plug the wired circuit board module into the ULA socket on the ZX81's or TS1000's motherboard. Make sure you plug it in so that the added pins line up exactly with the slots in the ULA socket and pins 1 through pin 40 are properly indexed. Then connect the cables from the interface board to your printer and the computer that will serve as the host. If your computer printer port doesn't use the eighth data bit, be sure to ground the appropriate pin going into the Printer Buffer. Also, signal lines such as Paper Out, Error, etc., should be tied to the appropriate logic level if your printer controller interrogates these lines.

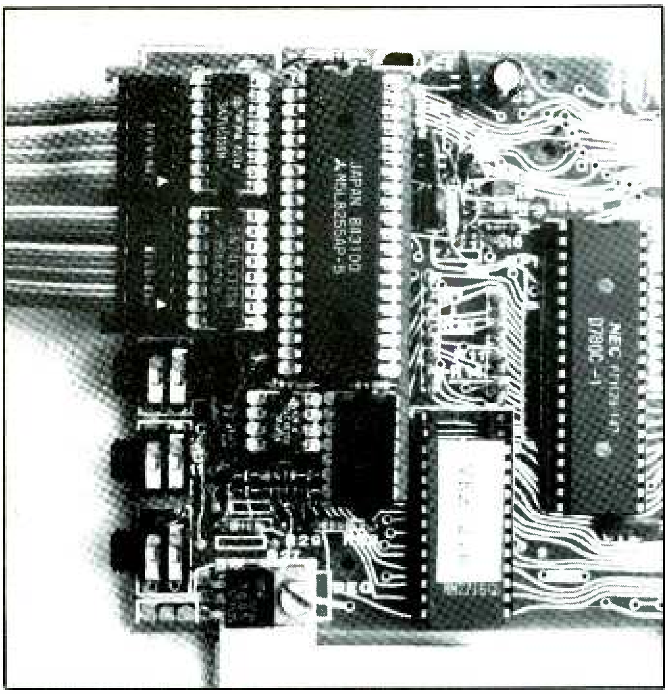
Without any RAM packs installed in the Buffer, power up the Buffer, printer and computer. Internal memory (1K in the ZX81 and 2K in the TS1000) is sufficient for testing the Printer Buffer. Go through all functions (see Operation below). Once the Buffer has tested okay, power down the system, plug in the RAM pack, power up the system again and repeat all function tests.

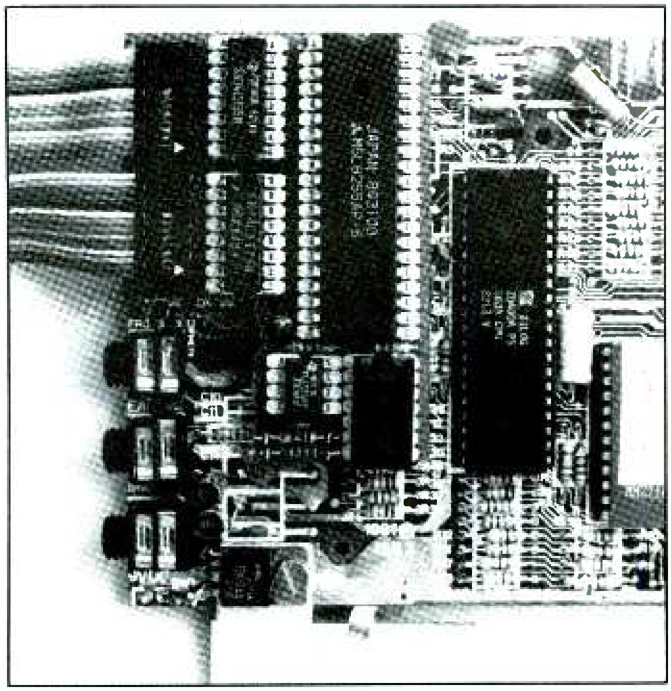
Before reassembling the modified ZX81 or TS1000, cut two holes in the case. Cut one hole in the top of the case to provide a window to view the hex display. Cut the other hole in the side for the printer cables. Make provisions for and install a strain relief for the printer cables as well.

Using the Buffer

Keyboard control for full operation of the Printer Buffer is provided by the "C" and "S" keys on the ZX81 and TS1000. These keys control the Clear and Start/Stop/Set Copy functions, respectively. Pressing the "C" key at any time resets the Buffer, which cancels in its entirety all settings and any print job in progress.

On power-up, the Buffer runs through a simple memory test and determines the amount of memory available. The display indicates the current kilobyte of memory being tested. With the 16K RAM pack, the display will cycle up from 0 to F and then pause briefly prior to becoming





Modification board installed in Sinclair ZX81 (left) and Timex/Sinclair TS1000 (right) computers. Keyboard is at right, and left side of computer is at bottom in both photos. Computer and printer cables plug into board as shown and should be secured with a strain relief. Note that boards do not interfere with other components inside computers.

ready for use. The Buffer is now in the Buffer Mode.

• *Buffer Mode.* In this mode, the Buffer simply accepts data from the host computer and sends it to the printer. This is the default mode. The Buffer will always be in this mode unless the Multi-Copy Mode is selected. Hence, immediately after power-up, pressing "C" to clear the Buffer, or termination of a multi–copy job, this is the active mode.

Since the output speed of the host computer is considerably faster than the printing speed of the printer, data will accumulate in the Printer Buffer. The amount of accumulation at any moment in time is shown on the hex display in kilobytes.

In the Buffer Mode, pressing the "S" key temporarily suspends the printing operation. During suspension, the display flashes on and off, but data from the host computer will be accepted if the Buffer is not full. Pressing the "S" key once more resumes the printing operation.

• *Multi-Copy Mode.* This mode allows a block of data to be printed up to a maximum of 255 times without intervention from the host computer. This mode can be selected only after a power-on or pressing of the "C" key to clear the Buffer and while the Buffer is waiting for the first character from the host computer. The number of copies to be printed is then set.

Should any characters be received from the host before the number of copies is set, the multi-copy option expires and the Buffer reverts to its default Buffer Mode. If this occurs, you must turn the Buffer off and then on or press the "C" key to clear the buffer and then reenter the Multi-Copy mode.

You select the number of copies to be printed by pressing the "S" key once for each additional copy desired. Each time the "S" key is pressed, the display increments to indicate the number of copies set. The largest number that can be displayed unambiguously by the display is 63, which is shown as ".F.". Consequently, if the number of copies to be printed exceeds 63, the display restarts from 0. However, the number of copies is not returned to 0, and the internal counter continues to register the correct number of copies, up to 255 maximum.

After selecting the number of copies, you instruct the host computer to download whatever is to be printed to the Buffer. Once data transfer has begun, the display will show the number of kilobytes transferred. When downloading is complete, press the "S" key to commence multi-copy printing. At this time, the display will go back to showing the number of copies to be printed, including the current copy being printed.

Should the Pause/Copy key be pressed prior to completion of downloading, multi-copy printing will

(Continued on page 96)

An In-Circuit Component Tester

Simple oscilloscope accessory speeds up in-circuit testing of resistors, capacitors, inductors, and transistor and diode junctions

By William R. Hoffman

Designing and building electronic circuits is both challenging and fun to do. However, when a circuit or piece of equipment attached to it suddenly fails to function, troubleshooting it can be anything but fun. This is especially so if the circuit is complex and nothing has obviously happened to give a hint of the problem's cause. In some cases, the troubleshooting procedure may require that the components in the circuit be individually tested. This is a very lengthy and frustrating job, and the components can be damaged if they must be removed from the circuit for testing.

An obvious solution to the dilemma is to use some kind of tester that allows the components to be individually tested *without* removing them from the circuit. Fortunately, such test equipment does, indeed, exist. Presented here, for example, is a simple accessory device you use with any oscilloscope that has X-Y capability. With the In-Circuit Component Tester to be described, you will be able to generate a recognizable trace pattern on the scope's CRT for each common type of component. The displayed pattern can show when a component is open or shorted, as well as when it is functioning properly. Though this is called an "in-circuit" tester, it can be used to test individual components out-of-circuit as well.

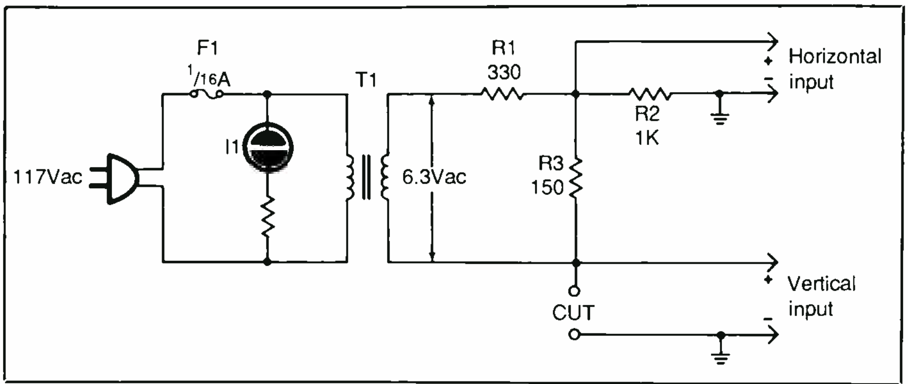


Fig. 1. Overall schematic diagram of In-Circuit Component Tester.

About the Circuit

The schematic diagram of the In-Circuit Component Tester accessory is shown in Fig. 1. This is simply a bridge-type circuit that supplies a test signal of about 2.5 volts ac rms at 60 Hz to the component under test (CUT). This signal allows you to make a comparison between the component being tested and a reference known good component.

Shown in Fig. 2 are some of the typical trace patterns that can be displayed on the scope CRT being used with the In-Circuit Component Tester. Note here that with good components, both a capacitor and an inductor will produce a loop in the trace, which is a consequence of the internal voltage-current phase shifts of these components. Also, any normal semiconductor (diode or transistor) junction will generate a trace that is

PARTS LIST

- F1—1/16-ampere, 250 volt fuse
- I1—Panel-mount 117-volt ac neon-lamp assembly with built-in limiting resistor
- R1—330-ohm, ¼-watt, 5% tolerance resistor
- R2—1,000-ohm, ¼-watt, 5% tolerance resistor (see text)
- R3—150-ohm, ¼-watt, 5% tolerance resistor
- T1—6.3-volt power transformer
- Misc.—Small metal box; terminal strips (2); fuse holder; ac line cord with plug; output cables with connectors to match scope inputs; test leads; machine hardware; hookup wire; solder; etc.

flat horizontally and rises to the right or left, depending on the polarity of the test leads. Because it has no reactance, a resistor will produce only a straight diagonal line. The angle of the line (and the loop if any) generated depends on the value of the inductor, capacitor or resistor being tested.

Feel free to experiment with the value of *R2* in this Tester, or have resistors with different values between which you can switch as desired. As a general rule, increasing the value of *R2* will make measuring of small values of inductance and capacitance much easier to perform. Conversely, decreasing the value of *R2* permits more accurate testing of large-value electrolytic capacitors and large-value inductors.

With the value of *R2* set to 1,000 ohms, the capabilities of the Tester are substantial. Some of the component types and values you can test include:

• *Capacitors* over a range of values from about 0.05 to 200 microfarads. By raising *R2*'s value to 10,000 ohms, the range of values that can be checked changes to about 5,000 picofarads to 20 microfarads. This is enough of a range to check most capacitors in modern solid-state circuits. The CRT display for a good capacitor is shown in Fig. 2(A).

• *Inductors* (and transformer windings) can be tested over a range of about 200 microhenries to 2 henries, which covers just about any inductance you are likely to encounter in today's circuits, including the values of power filters. The CRT display for a good inductor is shown in Fig. 2(B).

• *Resistors* display a straight diagonal line whose angle is a function of resistance, as shown in Fig. 2(C). This line's angle will vary from horizontal at 10 ohms or less to vertical at about 100,000 ohms. Potentiometers can be tested by connecting the Tester's probes to either outer and the center lug and varying the control shaft from stop to stop. As you do this, the diagonal-line trace should vary very smoothly over a range of angles to horizontal at minimum resistance. If the trace jumps around as the control shaft is rotated, the pot's wiper contact or resistive element is dirty or bad.

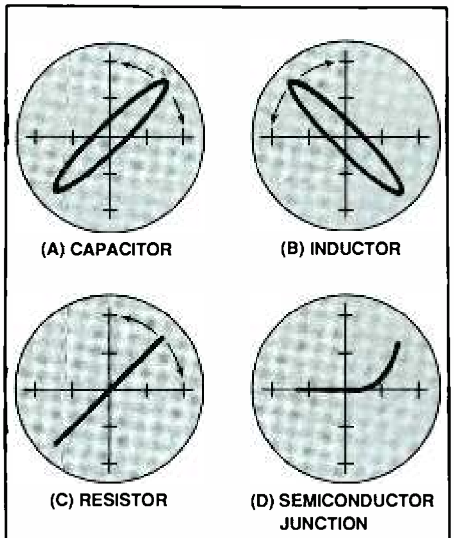


Fig. 2. Typical scope displays obtained for the most common circuit components. Traces shown are for good components. Departures from these indicate that the component being tested is defective.

• *Semiconductor Junctions* of any good diode, transistor or JFET will cause the distinctive trace shown in Fig. 2(D) to be displayed. If a junction is shorted or open, only a horizontal or vertical line will result.

If any component being tested is short-circuited, the scope trace will simply be a flat horizontal line. Should a component become open-circuited, a straight vertical line will be displayed. Bear in mind, too, that since most circuits have components that are in parallel with other components, you can obtain a scope display that is a combination of the traces shown in Fig. 2 during testing. By following your troubleshooting on the circuit's schematic diagram as you perform the individual tests, you will see that the component being checked is properly connected with the other circuit elements.

Construction

Because of the Tester's simple circuitry, printed-circuit or other types of board wiring is unnecessary. The prototype for this project was built in a small metal box. All components were mounted on two terminal strips. If you prefer, you can build the circuit into a spare corner of your oscilloscope, assuming there is enough room for it, for the ultimate in compactness and neatness.

If you mount the Tester circuit inside a separate metal box, be sure to line the entry hole for the ac line cord with a rubber grommet. Otherwise, the sharp edges of the hole can cut through the cord's insulation and create a hazardous condition.

Using the Tester

Plug the In-Circuit Component Tester's line cord into an ac receptacle and connect the test cables to the scope's vertical and horizontal inputs. With a 1,000-ohm resistor connected across the CUT terminals, adjust scope sensitivity and trace positioning so that the CRT displays a flat diagonal line centered on the zero axes of the X and Y graticule lines. This trace should slope upward from lower-left to upper-right, as in Fig. 2(C). You can now proceed with using the Tester. No other calibration or adjustment is needed.

Once you become familiar with the Tester, it will become obvious why so many professionals and hobbyists have come to rely so heavily on it for speedy troubleshooting. In complex circuits, some users have reported as much as a 90% reduction in troubleshooting time! Now you, too, can take advantage of this powerful, simple troubleshooting tool.

A Jumbo LED Digital Clock

Read it from 100 feet away, set it for a 12- or 24-hour format and 4 or 6 digits, use it on 50- or 60-Hz ac lines with battery backup if ac power fails

By C. Barry Ward

Most digital electronic clocks with so-called "jumbo" displays offer numerals that are no more than 1" high. If you are looking for a digital timepiece with a billboard-like display that can be easily read from 100 feet or more away, you can build the Jumbo LED Digital Clock to be described for little more than you would expect to pay for a good-quality commercial clock with only 1" display digits.

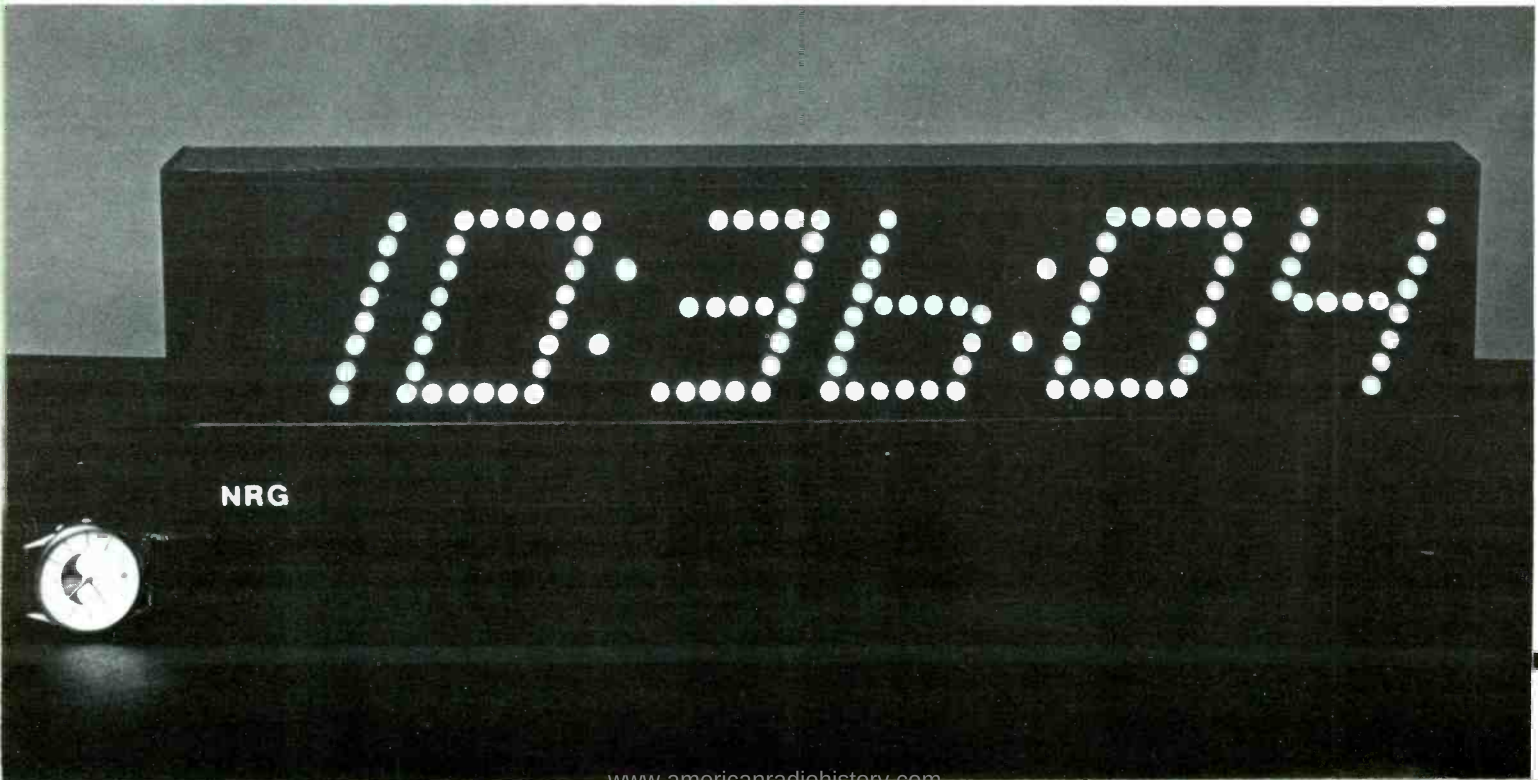
Our clock is versatile, too, For example, it can be used on either 50- or 60-Hz ac power lines. Furthermore, you can choose between a 6-digit hours/minutes/seconds or a less distracting 4-digit hours/minutes-only display format. And whether you wish to keep time in the usual 12-hour or the 24-hour format preferred by amateur radio operators and others, our clock offers a choice between the two.

Versatility is carried an important step further with the clock's battery-powered, crystal-controlled timebase oscillator. Any time ac power to the clock is interrupted, the dc-powered timebase automatically kicks in so that the clock keeps counting off the seconds until ac power is restored. There is no need to reset the clock every time there is a power failure or someone accidentally pulls the plug.

About the Circuit

Three special-purpose integrated-circuit "chips" are used in this clock. The main one is the popular MM5314 clock chip, which is designed to provide a display capability of either four or six digits. It contains all the circuitry needed for timekeeping and 7-segment digit generation. The second special-purpose chip is an MM5369 oscillator/divider that is used with a quartz crystal to provide the temporary 60-Hz timebase in the battery-backup circuit. The final special-purpose IC used in the clock is the PU4110 Darlington transistor array, two of which are used to provide segement drive for the display.

Two of these chips, the National Semiconductor 5314 and MM5369 (plus a common CD4066 CMOS quad transmission gate) are in standard dual-inline packages, or DIPs. The two PU4110 Darlington transis-



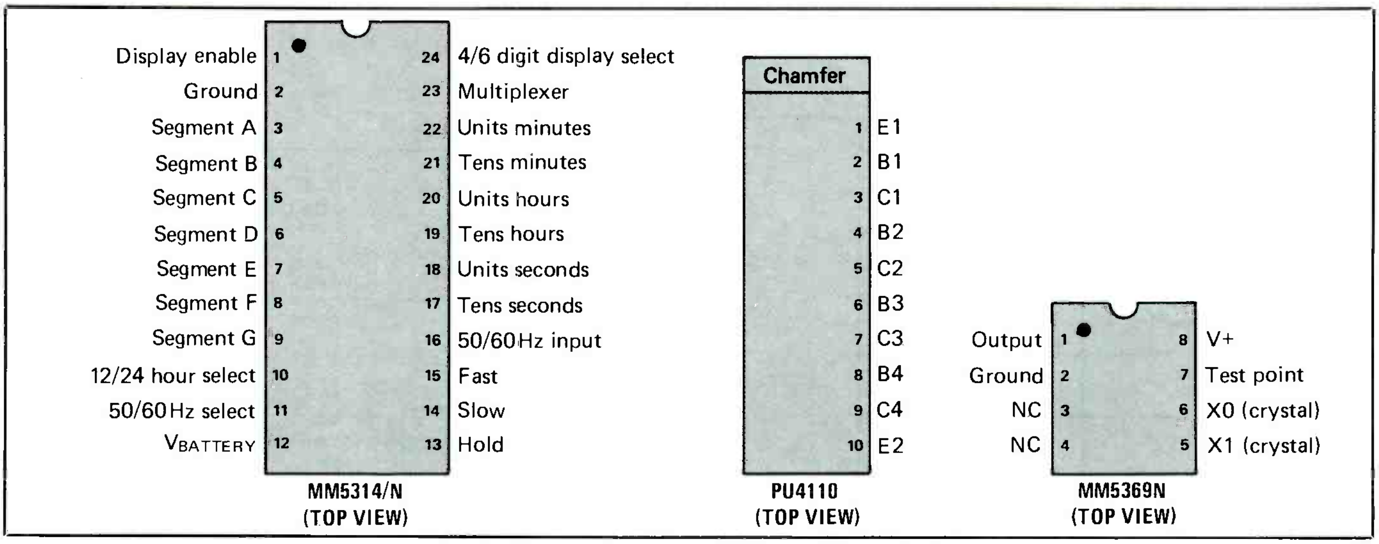
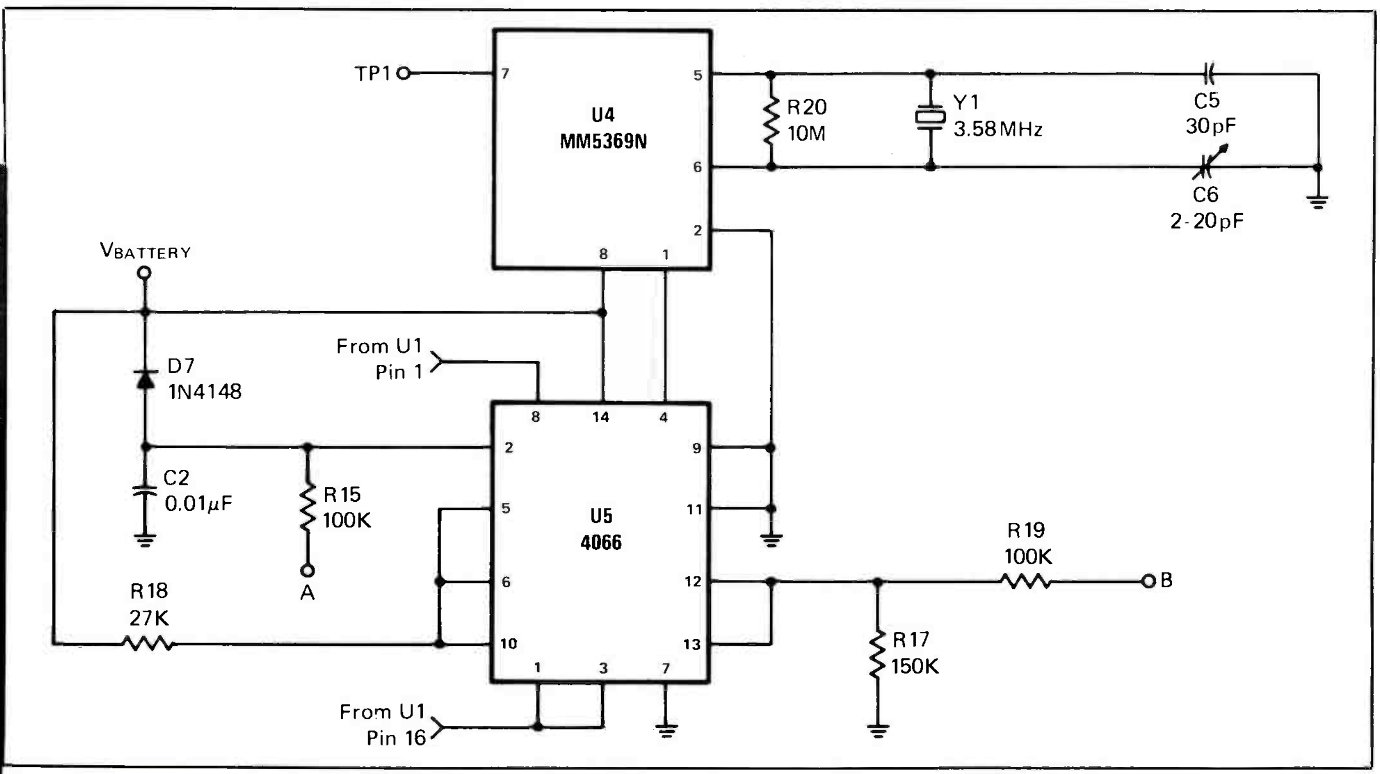


Fig. 1. Pinouts for special ICs used in project.

tor arrays are in single-inline packages, or SIPs. Pinouts for the special-purpose ICs are shown in Fig. 1.

Four basic circuits make up the clock. The basic timekeeping and segment- and digit-drive circuit is shown in Fig. 2. The heart of this circuit is MM5314 clock chip *U1*. Note here that time setting is accomplished with HOLD, SLOW and FAST switches *SW1*, *SW2* and *SW3*, respectively and that jumper wires are installed to obtain a 12-hour display format, operation with a 60-Hz ac line and six digits in the display by grounding pins 10, 11 and 24, respectively, of *U1*. Omitting the jumper wires configures the clock for a 24-hour display format, 50-Hz ac-line operation and a four-digit display. If you wish to be able to reconfigure your clock at any time without having to solder and/or desolder connections, you can wire spst

Fig. 2. Oscillator/divider circuit drives basic clock circuit.



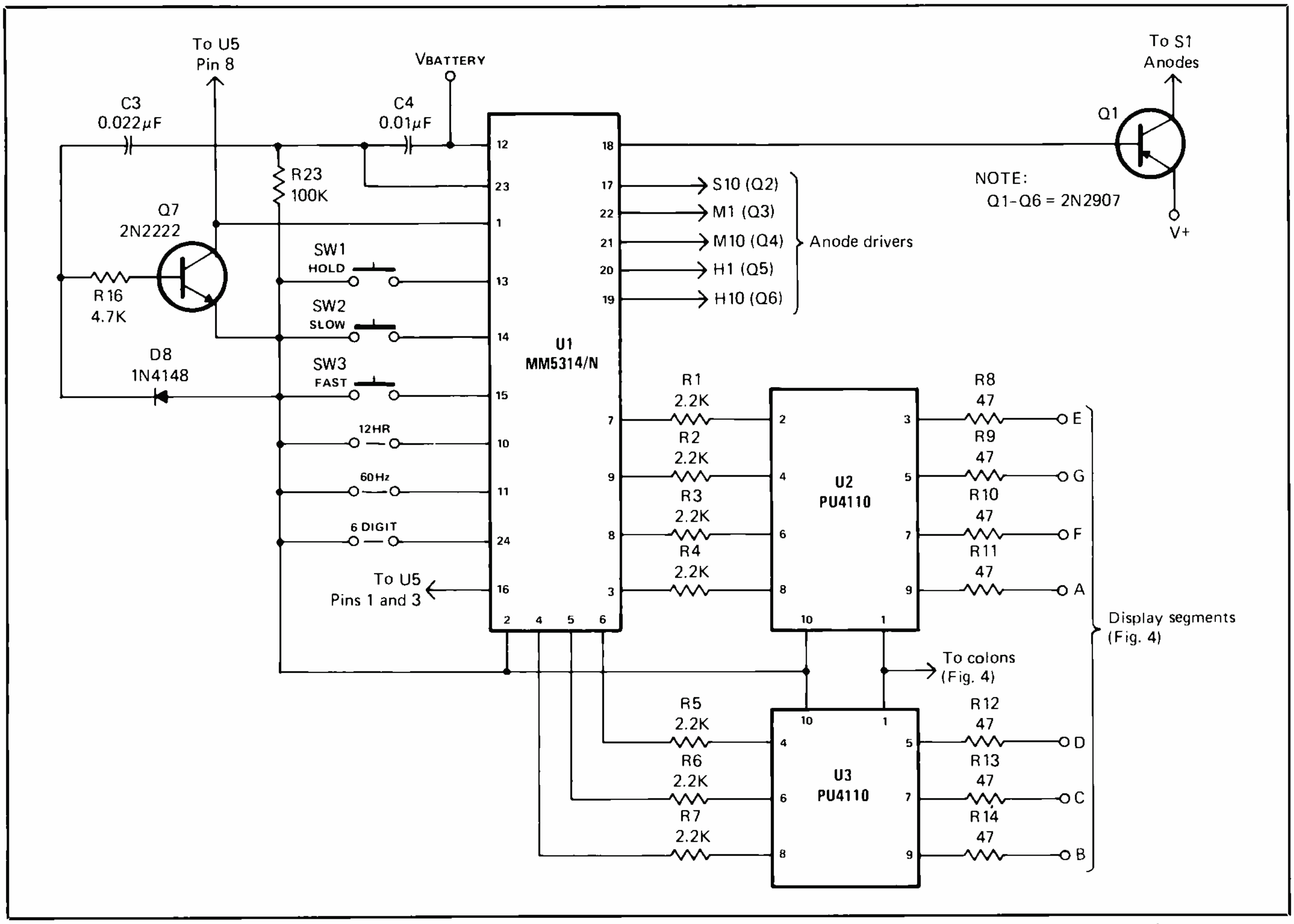


Fig. 3. Basic clock circuit's MM5314 clock chip offers 50/60-Hz, 4/6-digit and 12/24-hour options.

switches between pins 10, 11 and 24 of *U1* and ground.

Digit drive for the display decades is provided by pnp transistors *Q1* through *Q6* via multiplexed lines from pins 17 through 22 of *U1*. Only one digit-drive stage is shown. The *Q2* through *Q6* stages are identical to the *Q1* units-seconds (S1) drive stage. Transistors *Q2*, *Q3*, *Q4*, *Q5*, and *Q6* are the drivers for the tens-seconds (S10), units-minutes (M1), tens-minutes tens-minutes (M10), units-hours (H1) and tens-hours (H10) decades from pins 17, 22, 21, 20 and 19, respectively.

Drive outputs for Darlington transistor arrays *U2* and *U3* are obtained at pins 3 through 9 for display segments A through G, respectively.

Transistor *Q7* and its associated components are used to turn off the display when *U1* is changing the outputs from one digit to the next during multiplexing. This prevents unwanted "ghosting" of a digit number in an adjacent blank segment.

Figure 3 shows the schematic details of the colons that separate the hours and minutes and seconds in the display and the individual decades in the LED display. All decades are identical, except the tens-hours decade, which has no segment F, because it counts up to only 1 in the 12-hour format and 2 in the 24-hour format. Note that each segment is made up of four discrete light-emitting diodes (LEDs). There are 168 LEDs in the display, 164 in the six numeric decades and four in the colon circuits. If you decide upon a permanent four-digit display format, your circuit would not need the two seconds decades and the colon that precedes them.

Shown in Fig. 4 is the 60-Hz timebase oscillator that maintains timekeeping on battery-backup when an interruption of ac power occurs. The timebase oscillator's frequency is determined basically by *Y1*, a standard color-TV color-burst crystal. The frequency can be precisely trimmed to be "on the money" by adjusting trimmer capacitor *C6* while observing the display of a frequency counter connected between test point *TP1* and circuit ground.

A 60-Hz pulse train from the Fig. 4 circuit's output at pins 1 and 3 of *U5* is delivered to the clock input at pin 16 of *U5*.

PARTS LIST

Semiconductors
D1 thru D5,D9,D10—1N4004 or similar 100-volt, 1-ampere diode
D6,D7,D8—1N4148 or similar diode
LED1 thru LED168—Red T-1¾ light-emitting diode
Q1 thru Q6—2N2907 pnp transistor
Q7—2N2222 npn transistor
U1—MM5314 clock chip
U2,U3—PU4110 Darlington transistor array
U4—MM5369A CMOS oscillator/divider
U5—CD4066 CMOS quad transmission gate

Capacitors
C1—1,000-μF, 16-volt axial-lead electrolytic
C2,C4—0.01-μF disc
C3—0.022-μF Mylar
C5—30-pF disc
C6—2-to-20-pF trimmer

Resistors (¼-watt, 5% tolerance)
R1 thru R7—2,200 ohms
R8 thru R14—47 ohms
R15,R19,R23—100,000 ohms
R16—4,700 ohms
R17—150,000 ohms
R18—27,000 ohms
R20—10 megohm
R21,R22—100 ohms

Miscellaneous
B1—9-volt battery
SW1,SW2,SW3—Normally-open, momentary-action spst pushbutton switch
T1—12-volt, 1-ampere ac plug-in wall transformer
Y1—3.59545-MHz crystal
Printed-circuit board; suitable enclosure (see text); 9-volt battery snap connector; IC sockets (optional—see text); flat black paint; rubber feet; hookup wire; solder; etc.

Note: The following items are available from NRG Electronics, P.O. Box 24138, Ft. Lauderdale, FL 33307: actual-size etching-and-drilling guide for pc board—send SASE; complete kit of parts (including Plexiglass enclosure) for $59.95 plus $4.50 for P & H; etched and drilled pc board for $25.00; MM5314 clock IC for $3.95; PU4110 for $4.95 each; MM5369 oscillator/divider IC for $2.95; 168 matched red T-1¾ jumbo LEDs for $16.80; Plexiglass enclosure for $25.00. Florida residents, please add state sales tax.

The final circuit that makes up the clock is the ac power supply shown schematically in Fig. 5. Ac power is stepped down to 12 volts by plug-in wall transformer *T1*. The 12 volts ac thus obtained is rectified by the bridge circuit made up of *D1* through *D4* and is filtered to clean dc by *C1*. Power going to the clock must be well-filtered to prevent flickering that could be caused by a "beat frequency" between the multiplex and ac-line frequencies.

Diodes *D5* and *D6* isolate the backup-battery supply (V_{BATT}) from the V+ main power line for the LED display. This assures that the timekeeping circuits will remain operational via the oscillator/divider circuit during periods when ac power to the clock is interrupted.

In operation, the clock can be driven from either of two different time references. When operated from the ac line, the main reference is the 60-Hz signal picked up from the secondary side of *T1* in the power supply. This reference is extremely accurate. Though it may not be precisely 60.0000 Hz at any given moment in time, corrections are being constantly made by the utility companies to maintain an extremely precise long-term accuracy over any 24-hour period. Hence, this reference is considerably more accurate over the long haul than is the battery-powered oscillator/divider circuit that provides the timebase reference when ac power is interrupted.

Stabilization of the alternate-reference crystal-controlled oscillator over a long period of time is difficult to obtain. Any of a number of physical factors (temperature, humidity, etc.) can cause the crystal oscillator's frequency to drift. Therefore, the crystal-controlled trimebase reference is used only as a backup to the main ac power line reference. It can, of course, be used as the primary reference when the clock is continuously powered from a dc power source, such as in an automotive or marine environment.

CMOS transmission gate *U5* in Fig. 3 directs either the power-line or the oscillator/divider reference frequency to the clock chip. During periods when the normal ac-line reference is being used, one transmission gate in *U5* (call it *U5A*) is turned on by power from the diode bridge in the power supply, pulling pin 10 of this IC low. This turns off two of the gates in *U5* (call them *U5B* and *U5C*). The *U5C* gate's output at pin 8 controls display blanking. It turns off both the digit and segment drives to conserve power when the clock is operating from the battery-backup system and routes the oscillator reference to the clock during battery operation.

A small part of the 60-Hz power-line signal is filtered by *C2* and *R15* and is clamped by *D7* in Fig. 3. This signal is the power-line reference frequency. The *U5A* gate routes this signal to the clock chip during normal ac operation of the clock.

Construction

Because there are several hundred connections that must be made in wiring together this large clock project and the need for a reliable means of physically lining up all the display LEDs, printed-circuit wiring is almost mandatory. If you wish, you can etch and drill your own pc board. Though we usually print our pc etching-and-drilling guides actual-size so that readers who wish to fabricate their own boards can use them di-

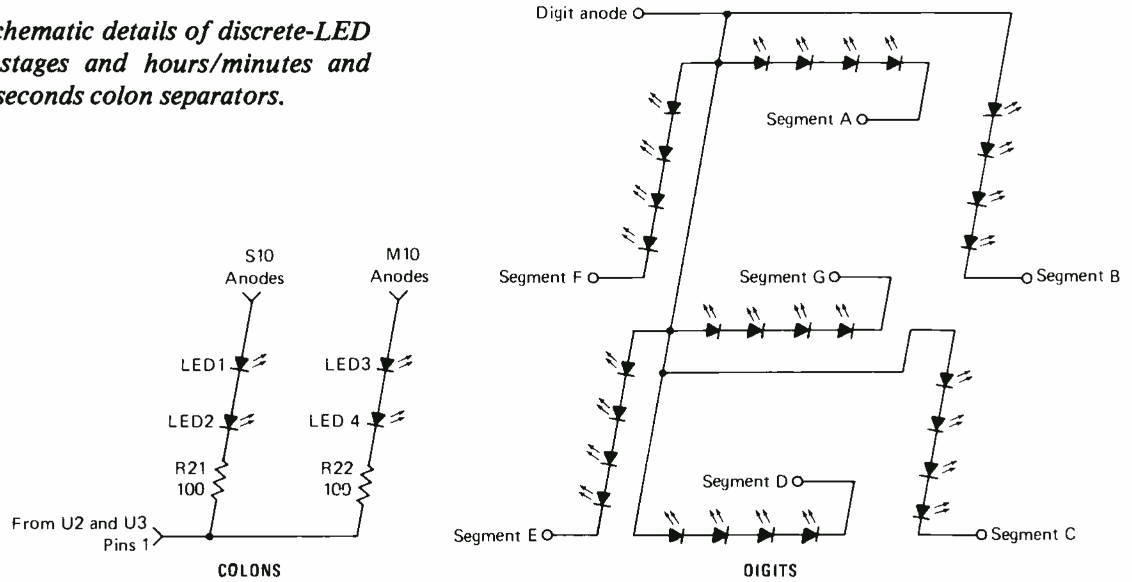


Fig. 4. Schematic details of discrete-LED numeric stages and hours/minutes and minutes/seconds colon separators.

rectly, the very large size of the board required for this jumbo clock precluded actual-size reproduction of its etching-and-drilling guide here. However, we have reproduced it half-size in Fig. 7.

Those readers who wish to fabricate their own pc boards can have the Fig. 7 guide photographically blown up to twice the size shown or can send a self-addressed, stamped envelope to the kit supplier given in the Note at the end of the Parts List to obtain a full-size guide. Alternatively, you can purchase a ready-to-wire board from the same source.

Before mounting any components on the top of the pc board, give it a coat or two of flat black spray paint to prevent the background against which the display LEDs are mounted from showing through the display window. When the paint has fully dried, use a pin or needle to clear the paint from every hole on the board. If you fabricate your own board, you can paint the component side before drilling any holes, which obviates the need to clear paint away later on.

Begin wiring the pc board by installing the 14 wire jumpers in the locations indicated. You can use solid bare hookup wire for the jumpers. If you plan to use your clock on a 50-Hz power line, you prefer a 4-digit display (hours and minutes only) or you want a 24-hour display format, leave out the associated wire jumpers. Installing all jumpers sets the clock up for 60-Hz, 6-digit and 12-hour display format operation. Optionally, you can install spst slide or toggle switches in place of the options jumpers to allow you to reconfigure the clock whenever you wish or as needed.

Install all resistors and capacitors (make sure you properly polarize *C1*). Note that *R17* and *R23* mount on the bottom of the board. Take careful note of how they are to be installed by referring to Fig. 7. Then flip over the board and mark with a pencil the traces to which the resistor leads are to be soldered. Trim the leads of both resistors as needed and carefully tack-solder them into place. Make sure that the resistor leads contact only the traces to which they are supposed to connect. Install

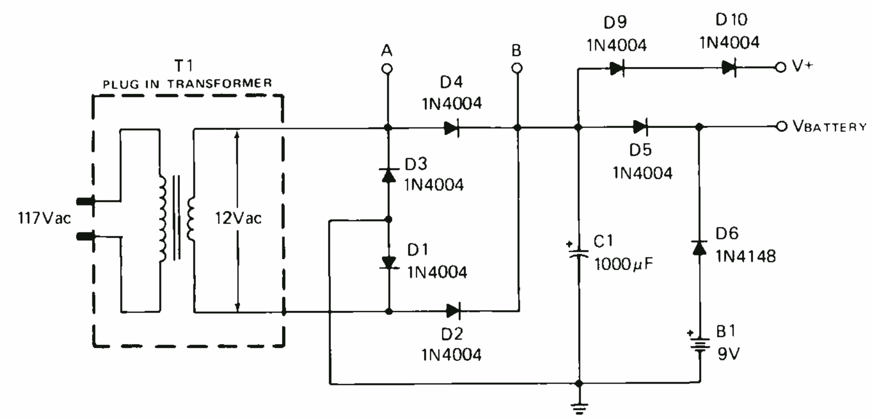


Fig. 5. Ac power supply circuit has battery backup to maintain time, not display, during brief power interruptions.

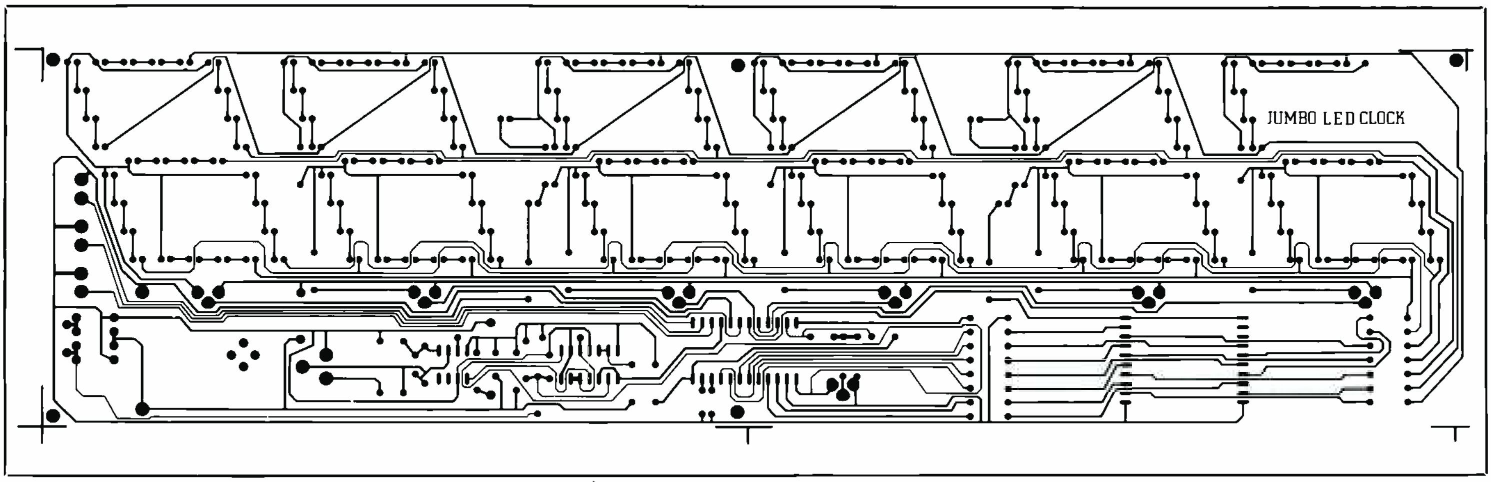


Fig. 6. Etching-and-drilling guide for clock's pc board is shown half-size to fit on a page. To use this to make a board, photographically enlarge it by 200%.

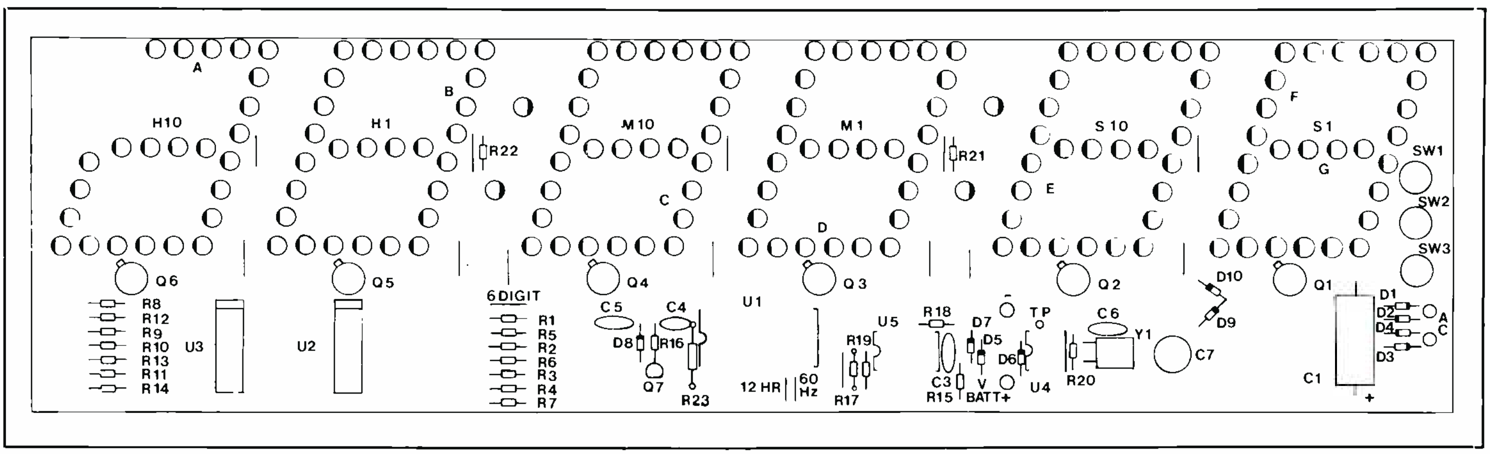


Fig. 7. Wiring guide for pc board. Exercise care when installing LEDs, transistors and ICs.

the diodes in their respective locations, again making sure that they are properly oriented before soldering their leads to the copper pads. Then install and solder into place the trimmer capacitor.

Use of sockets for the ICs is optional but recommended. Use standard DIP sockets for *U1*, *U4* and *U5*. For *U2* and *U3*, which have only one row of pins, you can use either Molex Soldercons or a 20-pin DIP socket carefully separated down the middle to yield two 10-pin SIP sockets that will work fine. Whether or not you use sockets for the ICs, do not install the ICs themselves at this time. The CMOS devices are easily damaged by static electricity and should be left for last. Once you have installed the IC sockets, install the seven transistors in their respective locations. Make sure you do not mix up the two types and that the transistor leads go into the appropriate holes in the board.

The most tedious part of construction is installation of the 168 LEDs that make up the numeric/colon display. To get the proper effect from the display, all LEDs must be closely matched in intensity. Even a slight difference in intensity between LEDs can be quite noticeable when the clock is operating. A good way to assure that the LEDs are properly matched is to purchase all of them at the same time from the same manufacturer's lot. If you wish, you can purchase matched LEDs from the kit supplier given in the Note at the end of the Parts List.

Mounting the LEDs on the board can become tedious, due to the quantity that must be installed. Work carefully, making sure that each Led is properly polarized before soldering its leads to the copper pads on the bottom of the board. All cathodes in Fig. 7 are identified by the heavy black "flats" in the case outlines. Note that the orientations of the LEDs in the colons (*LED1* through *LED4*) are opposite those for the numerals. Make sure you match the flats on the cases of the LEDs with the flats on the wiring guide.

Mount the LEDs with the bottoms

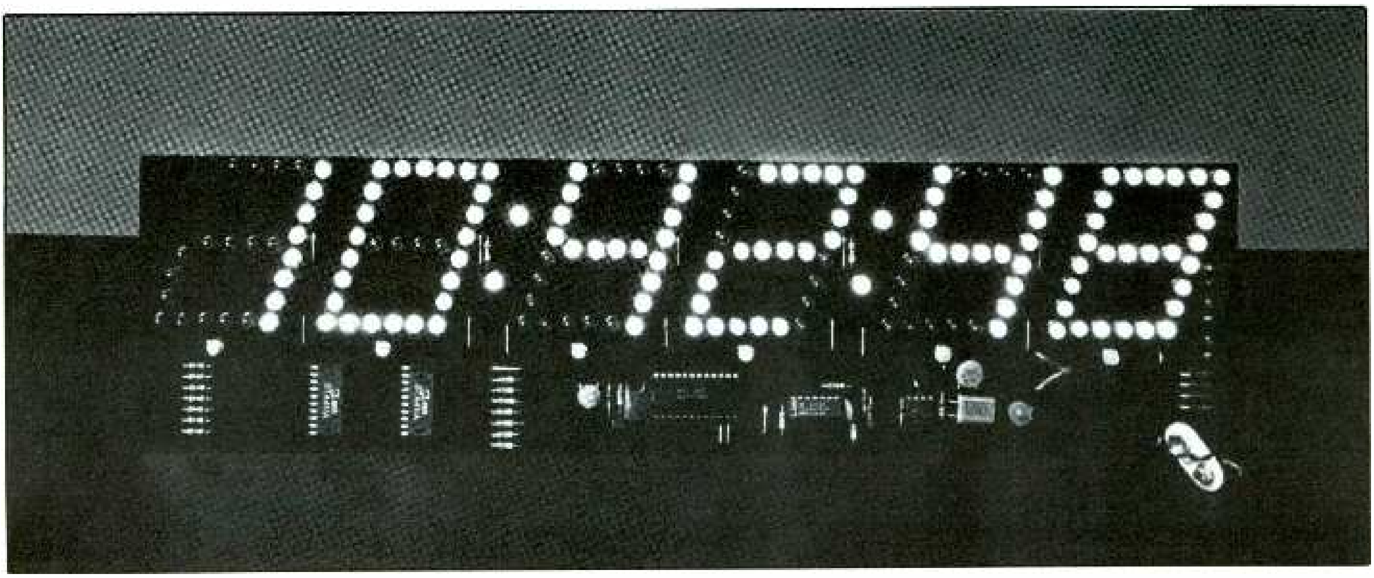


Fig. 8. Wired board ready to install in enclosure.

of their molded cases flush with the top of the board. If necessary, use a sharp hobby knife to trim away any excess plastic that prevents any LED from seating flat. Mount and solder into place no more than eight LEDs at a time. Avoid excessive heating that can damage the LEDs during soldering. One way to avoid excessive heat is to solder only one lead of each LED in an installed string and then return to the first LED and solder each LED's other lead.

Finish wiring the board by connecting and soldering into place the leads from plug-in wall transformer *T1* and mount the three time-setting switches (*SW1*, *SW2* and *SW3*) on the *foil* side of the board. Finally, wire the battery snap connector into the circuit from the foil side of the board, taking care to properly polarize its leads.

Now install the ICs in their respective locations. If you are using sockets, just plug them in. Make sure as you plug in the DIP devices that no pins fold under or overhang the sockets as you install the ICs in their sockets. All pins must go squarely into the sockets. The SIP devices plug into their half sockets and are held in place with double-sided foam tape between their cases and the surface of the board. If you have decided to install the ICs without sockets, do this now. Whichever method you use, handle the ICs with the care required for any CMOS device and make sure you properly orient them. This done, plug a fresh 9-volt battery into the snap connector and secure the battery to the bottom of the board with a strip of double-sided foam tape.

Now that all soldering is complete, check your wiring. Carefully examine all solder connections for good soldering. If any connection appears to be questionable, reflow the solder on it. Be on the lookout for solder bridges between traces on the bottom of the board, particularly between the closely spaced pads into which the IC socket pins are installed. Flip over the board and double check all component orientations.

Your Jumbo LED Clock can be housed in any type of enclosure that suits your taste. For example, you can make a large shallow box out of thin lumber or tinted Plexiglass. Whatever material you use for the enclosure's walls, however, you should use a red filter in front of the display area to increase contrast and legibility of the numerals. If you decided to add the optional switches to the 50/60-Hz, 4/6-digit and 12/24-hour select lines, mount them in a location where they will not interfere with the rest of the circuit and label each accordingly.

If you plan to use your clock on 50-Hz ac power, install a jumper wire between pin 11 of *U1* and pin 13 of *U5*. This arrangement automatically switches the MM5314's clock frequency select input between 50 Hz for ac-line operation to 60 Hz for battery backup.

To use the clock in a dc-only application, connect a jumper wire from pin 12 of *U5* to ground. This puts the Crystal-controlled timebase into continuous operation and assures proper clock operation.

Checkout and Use

When you are sure that your wiring is correct and that your soldering is okay, plug the wall transformer into an ac outlet to power up the clock. If everything is indeed okay, the LED display should light up with a random time readout. If one segment in a given decade does not light, carefully inspect that segment to determine if you installed one or more LEDs backward. If this is not the

case, one or more of the LEDs is bad.

There is a simple way to isolate the problem to a bad LED. Using a short length of insulated solid hookup wire with about ⅛" of insulation trimmed form each end, temporarily short out one LED at a time by jumpering its pads on the bottom of the board with the wire. Do this while the clock is powered, but make sure you short out only the one LED's pads—not one pad to a different part of the circuit. Short out only one LED at any given time. If you should short out more than one, the remaining LEDs in the string or the segment driver circuit can be permanently damaged.

As you short out each successive LED, somewhere along the line, the remaining LEDs in the segment should flash on. If this occurs, you have isolated the problem to the LED that is currently being jumpered. All you have to do then is remove the jumper wire, power down the clock and replace the bad LED with a good one. With the repair made, you can return the clock to service.

When all clock segments in all decades are checked out and the seconds decades are repeatedly counting up from 00 to 59, the clock is working. At this point, press and hold FAST pushbutton switch *SW3* and note that the seconds decades count up so rapidly that they appear to be blurred, while the minutes decades count up fast but not so fast that you cannot follow the count, and the hours decades advance at a rate of about one per second. Release the FAST button and press and hold SLOW pushbutton switch *SW2*. This time, note that the seconds and minutes decades count up at what appears to be the same rates the minutes and hours decades did when the FAST button was pressed and held. Releasing the SLOW button and pressing and holding HOLD pushbutton switch *SW1* should "freeze" the displayed count for as long as the button is held.

Now check out the battery-backup crystal timebase. To do this, first check the voltage between pin 10 of *U5* and circuit ground with the clock running on ac power. The meter should indicate a potential of less than 1 volt. This is the power-failure signal. The clock will not function properly unless the potential on pin 10 of *U5* is about 1 volt or less during normal operation.

With a fresh 9-volt battery connected into the circuit, unplug the wall transformer from the ac line. Within a few seconds, the measured potential on pin 10 of *U5* should jump to greater than 7 volts, which indicates that the automatic changeover circuit is functioning properly.

If you own or have access to an accurate frequency counter, you can trim the timebase oscillator's frequency to precisely 60 Hz. To set the timebase, connect the frequency counter between pin 7 of *U4* and ground. While observing the counter's display, adjust trimmer capacitor *C6* for a frequency of exactly 3.579540 MHz. This adjustment is not supercritical if your clock will normally be powered from the ac line because the timebase oscillator will be used only when there is a power failure. Of course, if you plan on using the clock in a mobile environment where the only power is 12 volts dc, the more accurate you make the trimmer adjustment, the more precise the timekeeping.

Once you know that your clock is operating properly and you have checked out and adjusted the crystal-controlled timebase circuit, you can set the time. This is very easily accomplished. Just use the FAST button to get the hours and tens of minutes decades to within about 10 minutes of the proper time. Then use the SLOW button to zero in on the next highest minute to the actual time. Finally, press the HOLD button to freeze the display until the clock or watch you are using as the reference comes up to the exact time to which the display is frozen and release. **ME**

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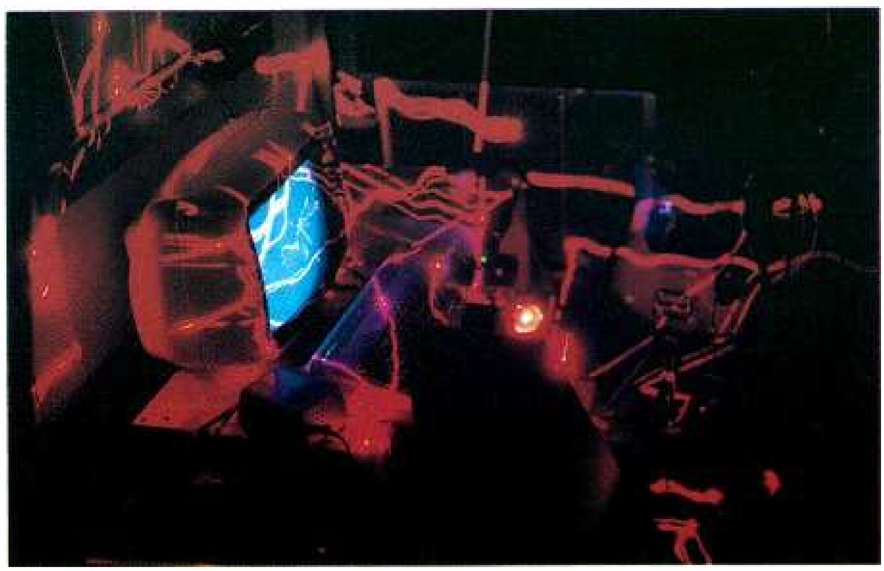
Computer-Controlled Laser Light Show

A low-power He-Ne laser, two miniature servos, some build-it-yourself circuitry and a home computer let you create dramatic lighting effects to accompany your music

By Ronald A. Peterson



If you've ever attended a rock concert, you've probably been impressed by the dramatic effect of the special lighting that added new excitement to the music being heard. You can create a similar effect at home with a computer, a low-power helium-neon laser and model-aircraft servos. While the effect of our Laser Light Show may not be quite as dramatic as that in a concert hall, it can give your listening a new dimension with a complex interplay of light and sound.

A simple BASIC program and a Commodore 64 home computer, plus some inexpensive build-it-yourself circuitry are all you need to create this exciting visual effect at a tiny fraction of the cost of the professional systems that cost thousands of dollars. The Laser Light Show works in conjunction with a joystick controller you plug into the C-64 and position as you wish to swing the laser beam to create a hemispheric lighting effect "dome" in your listening room or a small hall. By pressing the "fire" button on the joystick, you can feed into the C-64's memory a series of coordinates to which you wish the beam to go, making the pattern to be described as simple or as complex as you wish. The fire button lets you play back the pattern in the sequence in which it was fed into memory. It doesn't take complex geometry or special programming knowledge to do, either.

There are practical benefits to building the Laser Light Show as well. For example, you can omit the laser and mirror needed for the Light Show function and attach a lightweight gripper on a slideable shaft to the servos instead to use the servo system as a simple robot arm. And with a heftier set of servos, it can be converted into a remote-controlled pan/tilt head for a video or movie camera.

System Operation

Model aircraft servos are an ideal choice for building a computer-controlled precision positioner for the laser beam used in the Laser Light Show. These servos are relatively inexpensive, accurate and, just as importantly, easy to interface to the parallel ports of most home computers. A typical example of such a servo is the Royal Titan No. RP-1F that develops an output torque of 39.4 ounces and has a stop-to-stop transit time of 0.6 second. Just about any other brand of servo will serve as well in this project.

There are usually three wires on a servo to provide the ground, positive dc voltage and control lines. Color coding of the wire insulation follows a certain convention: black or green

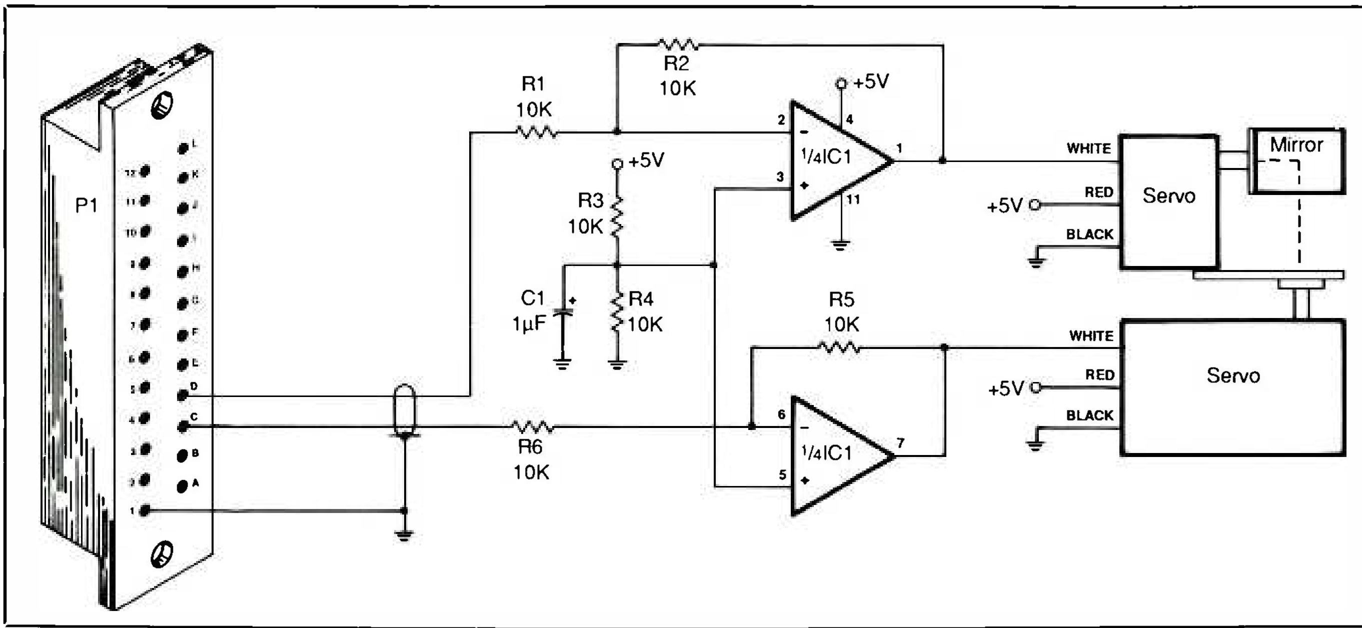


Fig. 1. Schematic of buffer interface.

for ground, red for positive dc and the remaining line, usually white, for the control input.

Figure 1 shows the schematic diagram of the circuit needed to drive the servos. To keep costs down, the circuit hardware was made as simple as possible, with the control logic implemented in software. The Fig. 1 interface circuit is built around *IC1A* and *IC1B* that perform as buffers between the computer and servos. Operational amplifiers were selected for the buffer function simply because a quad op-amp IC was available, but a 7404 TTL inverter would probably work just as well.

The buffers are connected to the C-64 computer's User Port through a 24-pin connector. The pinout for the User Port, along with pertinent signal information for each of the Port's contacts, are shown in Fig. 2.

Shown in Fig. 3 is the basic ac-line-operated, low-voltage dc power supply for both buffer interface and servos. This is a standard full-wave bridge rectifying circuit with filtering supplied by *C2* and voltage regulation supplied by *IC2*. Ac receptacle *SO1* provides the means by which the laser gets power from the ac line. This arrangement allows the entire system to be turned on and powered down via *S1*.

Pin	Type	Note	Pin	Type	Note
1	GND		A	GND	
2	+5V	MAX. 100 mA	B	FLAG2	
3	RESET		C	PB0	
4	CNT1		D	PB1	
5	SP1		E	PB2	
6	CNT2		F	PB3	
7	SP2		H	PB4	
8	PC2		J	PB5	
9	SER. ATN IN		K	PB6	
10	9 VAC	MAX. 100 mA	L	PB7	
11	9 VAC	MAX. 100 mA	M	PA2	
12	GND		N	GND	

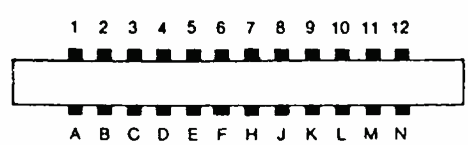
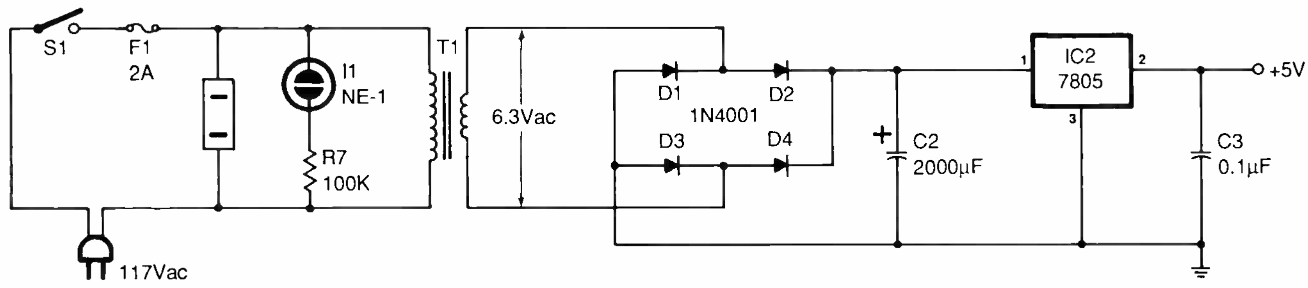


Fig. 2. Pinouts and signal information for C-64's User Port connector.

Position information supplied to the servos must be variable-width pulses of between 1 and 2 milliseconds in duration. The pulses are repeated at a fairly slow rate of between 30 and 120 pulses per second. The Machine-Code Interrrupt Handler Routine shown in Listing 1 provides this signal by toggling two of the User Port's lines. The C-64's 60-Hz internal interrupt clock, used for keyboard scanning and other simple I/O (input/output) functions, is set to trigger execution of this routine every 16.67 milliseconds (1/60 of a second) to provide a stable pulse train to each of the servos.

Every 16.67 ms, the routine alternates between two independent timing loops that provide the variable



PARTS LIST

Semiconductors
D1 thru D4—1N4001 rectifier diode
IC1—LM324 quad operational amplifier (see text)
IC2—7805 + 5-volt regulator

Capacitors (15-volt or more)
C1—1-μF electrolytic
C2—2,000-μF electrolytic
C3—0.1-μF disc

Resistors (¼-watt, 5% tolerance)
R1 thru R6—10,000 ohms
R7—100,000 ohms

Miscellaneous
F1—2-ampere fuse and fuse holder
I1—Panel-mount neon-lamp assembly
P1—24-pin card-edge connector (Digi-Key Part No. C1-12; $2.90)
S1—Spst slide or toggle switch
SO1—Chassis-mount ac receptable
T1—6.3-volt ac, 1.2-ampere power transformer
Low-power He-Ne laser (see text and Note below); 2 model-airplane servos (Titan RP-1F or similar; available from local hobby shop); 32 × 40-mm front-surface mirror (Edmund Scientific Cat. No. F30,429; $5.35—see text and Note below); perforated board and soldering or Wire Wrap hardware or printed-circuit boards (see text); suitable metal enclosures for buffer interface, low-voltage and high-voltage laser power supplies (see text); ac line cord; materials for enclosure; machine hardware; hookup wire; solder; etc.

Note: A ready source of supply for front-surface mirrors and low-power lasers is: Edmund Scientific Co., 101 E. Gloucester Pike, Barrington, NJ 08007.

Fig. 3. Schematic of low-voltage power supply.

pulse widths required to position the servos. The advantage of using an interrupt handler to drive the servos is that a simple BASIC program can then be run simultaneously to provide the "smarts" for overall direction of the laser beam without having to deal with timing problems. The machine code in Listing 1 is given only for reference purposes, since it is contained in the DATA statements of the BASIC program and is automatically loaded when this program is loaded and run.

Shown in Listing 2 is the BASIC program that reads the information inputted at the joystic port of the computer and communicates position requirements to the interrupt handler as two numbers between 0 and 255. Communication takes place through memory locations 33792 and 33793 ($8400 and $8401, respectively, in hex).

If the joystick's "fire" button is pressed, the position coordinate numbers read from the joystick port are also stored in arrays PX and PY. If the joystick is moved again after the values are stored, the program reverts to manual-positioning mode to allow another position to be inputted. If instead of inputting another set of positioning coordinates, the fire button is pressed once again, the stored values are recalled and are cycled through, causing the servos to track the laid-out pattern point by point. Pressing the fire button one more time resets the program and jumps the system into the manual-positioning mode again.

Because the chip that handles screen updates in the C-64 steals some time from the 6510 processor chip, the screen must be blanked during the period the servo timing loops are running to keep the timing accurate. Because of this, a simple beeper has been included to provide audible indication when a point has been successfully stored in memory.

Since the C-64 operates with a 1-MHz clock, there is a limit to how fast the machine-code timing loops can operate. This limit determines how fine a change can be made in the width of the servo-control pulses, thus setting a minimum step between servo positions. The machine-code routines in the program have been optimized to give as fine a step range as possible within the hardware limitations.

As written, the code divides the approximately 180-degree swing of the servos into about 250 steps. This yields a roughly 0.7-degree accuracy in servo positioning. It also means that there is a little bit of discernible "wiggle," due to moving in discrete steps, that shows up in the reflected laser beam when the mirror is moved manually. This wiggle is less apparent when the servos are swung directly from one position to another under automatic playback via the BASIC program.

Employing D/A (digital-to-analog) converters to drive a variable-pulse-width oscillator might have provided greater accuracy in positioning and smoother beam travel, but the cost of building the project would have been much greater. Going this route would also have made the software considerably more complex.

Construction

Circuit layout and wiring are not critical in the electronic portions of the project. You can use perforated board with holes on 0.1″ centers and suitable soldering or Wire Wrap hardware and wire the circuits point-to-point. Alternatively, you can design and fabricate separate printed-circuit boards for the buffer interface and low-voltage power-supply circuits. Whichever method of wiring you choose, be sure to use a socket for *IC1*.

Wire the circuits exactly according to Figs. 1 and 3. Make certain that you properly orient the IC and electrolytic capacitor in the buffer interface circuit and the rectifier diodes, filter capacitor and voltage regulator in the power-supply circuit.

House the buffer interface circuit-board assembly inside a metal box. Also, use shielded cable to the connector that goes to the computer (*P1* in Fig. 1) and the lines going to the servos, especially if they're long, to keep stray noise from getting into the circuit and disrupting smooth operation. The 5-volt dc power supply should be housed in a metal enclosure, too, but make sure there is adequate ventilation to allow heat to escape.

Packaging for the servo controller will be determined by the application you've chosen for the project. A suggested arrangement for the Laser Light Show is detailed in the Fig.4 drawing and is shown in the photos of the prototype in Figs. 5 and 6. Here, the laser tube, 5-volt dc power supply, high-voltage supply for the laser and the servos are shown mounted on a triangular-shaped wooden enclosure with *S1* and *I1* in Fig. 3 mounted on the "front" panel. This arrangement assumes that the laser tube and high-voltage laser power supply are separate items (as they were for the kit laser used in the prototype). If you use such a kit laser, mount its power supply inside a metal enclosure for safety, and provide good ventilation for it.

Since they are to move the laser beam along predefined paths to create the Laser Light Show, mount the servos at a 45-degree angle to the beam as shown. Additionally, the servos must be mounted at right angles to each other to assure that the sweep of the laser beam will be hemispherical. With the servos mounted in this manner on the laser's platform set at the 45-degree angle illustrated, the beam will, indeed, be able to describe a hemisherical pattern.

The kit laser used for the prototype made it easy to mount the laser tube and servo/mirror assembly in the proper locations and orientations. The tube was held in place in a pair of wooden V blocks with strong rubber bands, and the power supply was mounted inside the project's wooden enclosure. However, you can use an assembled laser with the tube and power supply housed inside a single enclosure without experiencing any mounting difficulty in getting the system to work properly. You simply have to use heavier-duty V blocks and a more substan-

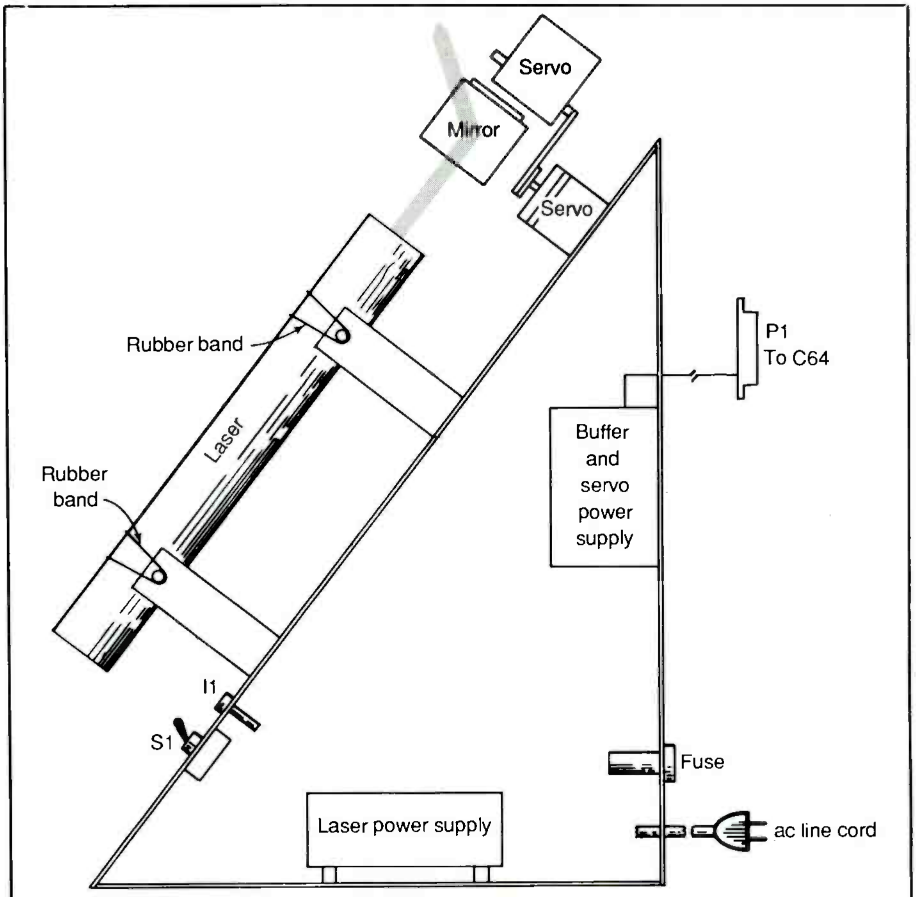


Fig. 4. A suggested enclosure and layout for project's laser, servo/mirror assembly, buffer interface, power supplies and power indicator and switch.

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COMB COMB COMB COMB COMB COMB COMB

tial method of securing the laser to the V blocks.

Whether you use a kit laser with separate tube and power supply or an assembled integrated laser, it's important that you mount it so that its beam is parallel to the mounting surface. Otherwise, the beam is likely to strike the reflecting surface of the mirror at the wrong angle for proper system operation.

Use only a front-surface mirror. With this type of mirror, the reflecting material is on the viewing surface—not buried behind the thickness of glass. If you don't use a front-surface mirror, the surface of the glass and the reflecting material behind it will both give reflections that can spoil the effect of the Laser Light Show. One good source of front-surface mirrors is Edmund Scientific Co. (see Parts List for address). Other sources are optics suppliers.

You can check whether or not your mirror is indeed a front-surface type with the aid of a sharpened pencil. Simply place the mirror, reflective side up and *gently* touch the point of the pencil to it an an angle. If the mirror is a front-surface type,

Words of Caution

If you use a laser, you should exercise care to protect your eyesight and that of anyone else who may be in the vicinity of an operating laser. Tests with anesthetized monkeys have shown that as little as 7 milliwatts of laser light focused directly onto the retina causes observable damage. Though it doesn't affect vision, this damage is, nevertheless, detectable with instruments. Other tests show that a minimum of 20 milliwatts is required to produce a similar effect on human eyes (perhaps because the test subjects were not sedated, which caused their eyes to wander about). The information regarding retinal damage cited here was taken from a page in a Metrologic Laser catalog, which summarized research papers on this topic.

Workers who have been "zapped" accidentally with as much as 60 milliwatts of laser light have reported a temporary loss of sight in only a small area of their vision for a few weeks. So with a low-power laser of 2-milliwatt output or less, there *appears* to be little danger, particularly if the beam is constantly moving. But keep in mind that even a low-power laser's beam is very bright.

It's always best to exercise caution, regardless of the output power of the laser beam. Therefore, you and anyone else in the vicinity should avoid staring into the beam from a laser for long periods of time. If you don't take this advice, you'll suffer from spotted vision, at the very least, just as you would after staring at a 150-watt incandescent light bulb or taking a brief glimpse of the sun. Though the evidence so far doesn't support it, it's even possible for permanent retinal damage to occur.

Listing 1. Machine-Code Interrupt Handler Routine

```
LINE# LOC   CODE       LINE

      0000             ;
      0000             ; CONSTANTS DEFINITION
      0000             ;
      0000             BDIREC=$DD03
      0000             PORTB=$DD01
      0000             ;
      0000             ; ZERO PAGE VARIABLES
      0000             ;
      0000             CNT1=$FB                ;LO BYTE OF COUNTER
      0000             CNT2=$FC                ;HI BYTE
      0000             PORT=$FD                ;MIRRORS PORTB STATUS
      0000             ANG1=$8400              ;COUNTER VALUES
      0000             ANG2=$8401              ;PASSED FROM BASIC
      0000             FLAG=$FE                ;ALTERNATE SERVOS
      0000             ;
      0000             ; PUT IN HI RAM SO CAN RUN BASIC
      0000             ; PROGRAM CONCURRENTLY $8000=32768
      0000             ;
      0000             *=$8000
      8000             ;
      8000             ;   S E R V O . M A C
      8000             ;
      8000             ;
      8000             ; SET UP DATA DIRECTION REGISTER
      8000             ;
      8000  A9 FF            LDA #%11111111    ;1=OUT,0=IN
      8002  8D 03 DD         STA BDIREC        ;FROM C64.
      8005             ;
      8005             ; ZERO COUNTERS
      8005             ;
      8005  A9 00      ZERO  LDA #$00
      8007  85 FB            STA CNT1
      8009  85 FC            STA CNT2
      800B  85 FE            STA FLAG
      800D             ;
      800D  A9 08            LDA #%00001000
      800F  8D 11 D0         STA $D011         ;BLANK SCREEN
      8012             ;
      8012             ;
      8012             ; SET OUTPUTS HIGH
      8012             ;
      8012  A9 03            LDA #%00000011
      8014  8D 01 DD         STA PORTB
      8017  85 FD            STA PORT          ;INIT MIRROR OF PORT
      8019             ;
      8019             ; INIT IRQ VECTOR
      8019             ;
      8019  78               SEI               ;DISABLE INTERRUPT
      801A  A9 00            LDA #$00          ;POINT IRQ VECTOR
      801C  8D 14 03         STA $314          ;TO THIS HANDLER
      801F  A9 81            LDA #$81
      8021  8D 15 03         STA $315
      8024  58               CLI               ;ENABLE INTERRUPT
```

```
LOC    CODE        LINE

8025   60                RTS               ;RETURN TO BASIC
8026               ;
8026               ; START OF TIMING ROUTINE
8026               ; THIS IS IRQ ENTRY POINT
8026               ;
8026               *=$8100                 ;START HANDLER AT
8100               ;        KNOWN LOCATION
8100   78                SEI               ;DISABLE IRQ
8101   AD 00 84          LDA ANG1          ;GET ANGLES
8104   85 FB             STA CNT1          ;PASSED FROM BASIC
8106   AD 01 84          LDA ANG2
8109   85 FC             STA CNT2
810B               ;
810B               ; CHECK FLAG TO ALTERNATE SERVOS
810B               ;
810B   A5 FE             LDA FLAG
810D   D0 1A             BNE SERVO2
810F               ;
810F   A9 01       SERVO1 LDA #01
8111   85 FE             STA FLAG
8113               ;
8113   A9 01             LDA #%00000001    ;OUTPUT LOW
8115   8D 01 DD          STA PORTB
8118               ;
8118   A0 7A             LDY #122          ;SETS MIN PULSE
811A   88          DLAY1 DEY               ;WIDTH.
811B   D0 FD             BNE DLAY1
811D               ;
811D   C6 FB       LOOP1 DEC CNT1          ;TIME PULSE WIDTH
811F   D0 FC             BNE LOOP1
8121               ;
8121   A9 03             LDA #%00000011    ;OUTPUT HI
8123   8D 01 DD          STA PORTB
8126   4C 31 EA          JMP $EA31
8129               ;
8129   A9 00       SERVO2 LDA #00
812B   85 FE             STA FLAG
812D               ;
812D   A9 02             LDA #%00000010    ;OUTPUT LOW
812F   8D 01 DD          STA PORTB
8132               ;
8132   A0 7A             LDY #122          ;SETS MIN PULSE
8134   88          DLAY2 DEY               ;WIDTH.
8135   D0 FD             BNE DLAY2
8137               ;
8137   C6 FC       LOOP2 DEC CNT2          ;TIME THE PULSE
8139   D0 FC             BNE LOOP2         ;WIDTH
813B               ;
813B   A9 03             LDA #%00000011    ;OUTPUT HI
813D   8D 01 DD          STA PORTB
8140   4C 31 EA          JMP $EA31
8143               ;
8143               .END
```

there will be no gap between the point of the pencil and its image in the mirror. If it's not, there will be a definite gap equal to the thickness of the glass on which the reflective material is deposited. Note, though, that with some mirrors, both surfaces appear to be equally reflective. If this is the case, use the front surface to reflect the laser beam.

To make the servo/mirror assembly, you must first mount the servos at a right angle to each other so that one servo pivots the other and the second servo pivots the mirror (see Fig. 4). When securing one servo to the other, align both servos so that the center of the mirror is on-axis with both servos, as illustrated in Fig. 1. Otherwise, as the mirror is pivoted, it might be taken completely out of the path of the laser beam, which will limit the angle of travel.

A quick-setting epoxy cement is ideal for mounting the mirror to the small plastic actuator that comes with the servos. One servo can be attached to the actuator of the other with a small metal angle bracket machined to match the mounting holes on the servo.

To obtain the best effect from the project, alignment of the servo/mirror assembly with the axis of the laser beam is relatively critical. The beam should always be centered on the mirror, no matter what angle to which it is set. This will assure that the mirror will never swing out of the beam's path. Hence, take care in locating the assembly with respect to the beam.

A simple alignment must be performed to get the mirror to point in the proper direction. Use the BASIC program (see Using the Software below) to send the servos all the way to one end of their travel. Then attach the actuators so that the mirror is parallel to the laser beam with the front surface facing directly into the beam. You should now be able to use the joystick to swing the mirror through a −90-degree to +90-degree arc both left/right and up/down as the beam remains centered on the front surface of the mirror. If necessary, adjust servo/mirror positioning to obtain the proper results.

Using the Software

Before installing the project, fire up your computer and type in the BASIC program in Listing 2. Save it on tape or disk and then power down the computer. Attach 24-pin connector *P1* to your computer via its User's Port. Then power up the computer and servos and connect a joystick to Port 2 on the computer. Now recall the BASIC program and run it. If everything is okay, the computer's screen should go blank and the servos should turn as you operate the joystick. If the servos do not turn,

Listing 2. BASIC Program for Operating Laser Light Show

```
10 REM--LOAD INTERRUPT HANDLER
20 FOR I=32768 TO 32805
30 READ A:POKEI,A
40 NEXT I
50 FOR I=33024 TO 33090
60 READ A:POKEI,A
70 NEXT I
75 REM--SET UP SOUND CHIP
80 GOSUB 800
90 REM--MAIN ROUTINE
100 DIM PX(50),PY(50)
110 NP=0
120 I1=120:I2=120:SYS 32768
130 JV=PEEK(56320):FR=JVAND16
135 JV=15-(JVAND15)
140 IFFR=0THENGOSUB290
150 IFJV=1THENI1=I1+1
160 IFJV=2THENI1=I1-1
170 IFJV=4THENI2=I2-1
180 IFJV=5THENI2=I2-1:I1=I1+1
190 IFJV=6THENI2=I2-1:I1=I1-1
200 IFJV=8THENI2=I2+1
210 IFJV=9THENI2=I2+1:I1=I1+1
220 IFJV=10THENI2=I2+1:I1=I1-1
230 IF I1>255 THEN I1=255
240 IF I1<3 THEN I1=3
250 IF I2>255 THEN I2=255
260 IF I2<3 THEN I2=3
460 GOTO110
470 DATA 169,255,141,3,221
480 DATA 169,0,133,251,133
490 DATA 252,133,254,169,8
500 DATA 141,17,208,169,3
270 POKE 33792,I1:POKE 33793,I2
280 GOTO 130
285 REM--STORE POINT SUBROUTINE
290 POKE54283,33:POKE54283,32
295 NP=NP+1:PX(NP)=I1:PY(NP)=I2
300 JV=PEEK(56320):FR=JVAND16
310 IFFR=0THENGOTO300
320 JV=PEEK(56320):FR=JVAND16
325 JV=15-(JVAND15)
330 IFJV=0ANDFR=16THENGOTO320
340 IFJV<>0THENRETURN
350 JV=PEEK(56320):FR=JVAND16
360 IFFR=0THENGOTO350
370 FORID=1TONP
380 FORI=1TO300:NEXT
390 POKE 33792,PX(ID)
395 POKE 33793,PY(ID)
400 JV=PEEK(56320):FR=JVAND16
410 IFFR=0THENGOTO440
420 NEXT
430 GOTO370
440 JV=PEEK(56320):FR=JVAND16
450 IFFR=0THENGOTO440
510 DATA 141,1,221,133,253
520 DATA 120,169,0,141,20
530 DATA 3,169,129,141,21
540 DATA 3,88,96
550 DATA 120,173,0,132,133
560 DATA 251,173,1,132,133
570 DATA 252,165,254,208,26
580 DATA 169,1,133,254,169
590 DATA 1,141,1,221,160
600 DATA 122,136,208,253,198
610 DATA 251,208,252,169,3
620 DATA 141,1,221,76,49
630 DATA 234,169,0,133,254
640 DATA 169,2,141,1,221
650 DATA 160,122,136,208,253
660 DATA 198,252,208,252,169
670 DATA 3,141,1,221,76
680 DATA 49,234
800 REM--SOUND INITIALIZATION
810 S=54272:FQ=10
820 FORL=STOS+24:POKEL,0:NEXT
830 POKE 54283,33
840 POKE 54285,122
850 POKE 54296,15
860 POKE 54280,FQ
870 POKE 54283,32
880 RETURN
READY.
```

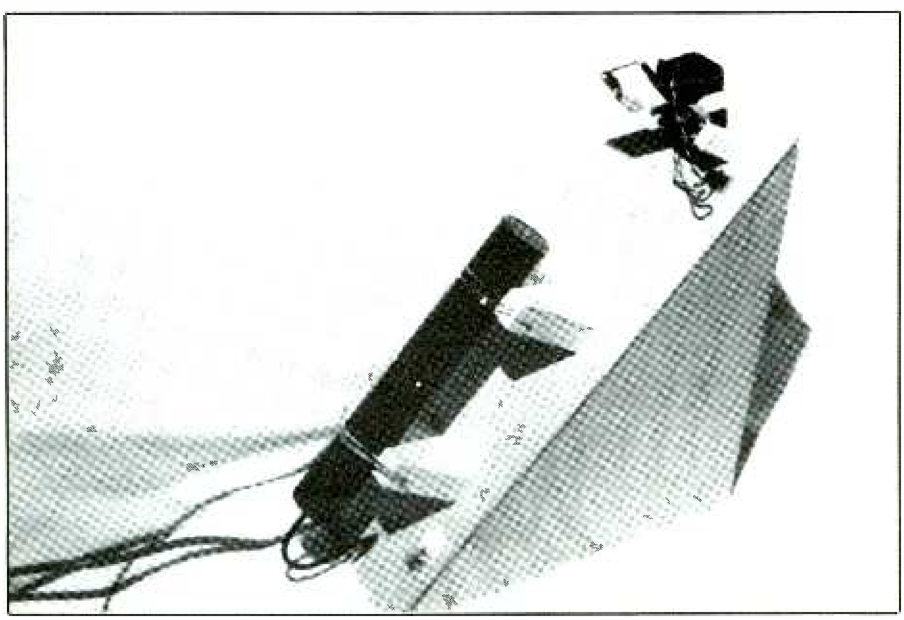


Fig. 5. In this photo of the assembled project, note how the laser tube is mounted in V blocks and is held in place with rubber bands. If an integrated laser/ power supply is used, blocks must be larger and heavy-duty straps must be used.

you have to check for one or more errors in your entered program or your wiring of the circuit or both. If you find no errors, you have a bad component in the buffer interface or power supply.

To determine if you made any program-entry errors, list the program and compare your entry with the listing keystroke by keystroke. If after making the comparison and correcting any errors in wiring, the project still doesn't run, you have to troubleshoot the circuitry with an oscilloscope or a signal tracer. If you don't have either of these instruments, you can use an amplifier/speaker arrangement to trace the positioning signals from computer output, through interface buffers to the servos. This 30-Hz square-wave pulse appears nicely on an oscilloscope screen or the indicators of a logic probe, and is easy to hear through a speaker or headphone.

Once everything is okay, use the joystick to move the laser beam to a given position. Hit the "fire" button on the joystick to store the coordinates for this location in the computer's memory. You should hear a "beep" as you do this. Moving the joystick should now cause the servos to reposition the beam for a second set of coordinates, which you can also store in memory with the fire button. You can repeat this proce-

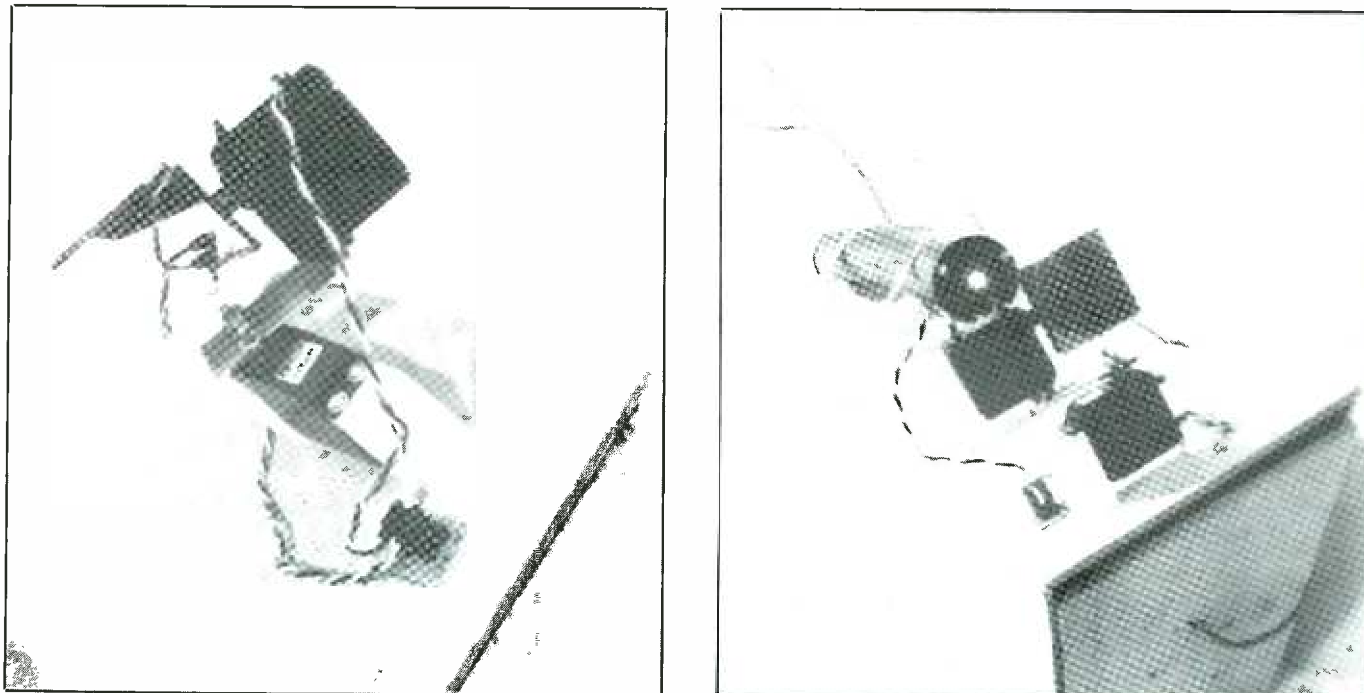


Fig. 6. These photos show proper servo and mirror mounting left (left) and location and orientation of servo/mirror assembly with respect to path of laser beam (right). Note that beam strikes center of mirror.

dure to store up to 50 sets of position coordinates. If you wish to store a greater number of coordinates, increase the size of arrays PX and PY.

To play back the positions stored in memory, simply hit the fire button a second time after storing the last set of coordinates *instead* of moving the joystick. The servos should now automatically swing to each pair of position coordinates in the same sequence in which you stored them. Hitting the fire button once again should reset the program so that you can define a new series of coordinates for playback. To halt the program at any time, hit the Run/Stop key and type in POKE 53265,24 to reactivate the screen.

You can easily modify or replace the BASIC program with one you write yourself, but don't change the DATA statements and the part that loads the machine code. But you can add your own code to calculate the positions in whatever fashion you prefer. Then POKE them into memory locations 33792 and 33793. The interrupt handler will automatically read them and position the servos as you command.

Because the interrupt handler is located at $8000 in memory, your BASIC programs can't use all of the memory space usually allocated for BASIC without writing over the machine code. This should not be a problem for most people. But if you do need more space for BASIC, you can move the machine code into a higher memory location. **ME**

Automatic Redialer for Busy Telephone Numbers

This telephone accessory takes the tedium out of repeatedly dialing a busy number until it is free to accept incoming calls and includes a hands-free phone-line monitor

By Anthony J. Caristi

It's tiresome to repeatedly dial a telephone number and hear a busy signal. Our "Busybody" automatic redialer can relieve you of this chore by repeatedly dialing a busy number until it gets through. As the device runs its automatic operating cycle, a built-in amplifier/loudspeaker lets you hear the signal when the connection is made. At this time, you simply pick up your telephone handset and disable Busybody to complete the call.

Also built in is a manual operating mode that lets you use Busybody as a telephone line monitor when you do not have to speak during a call, such as when listening to a recorded message. To use this feature, you dial the desired number using the project's keypad and set the VOLUME control for a convenient listening level.

Busybody is powered by the line coming from the telephone company, so it never needs batteries or ac line power. It has no effect on normal telephone operation and is compatible with both pulse (rotary) and Touch Tone™ lines.

About the Circuit

As shown in Fig. 1, the heart of Busybody is *IC3*, a low-power CMOS telephone pulse-dialing IC with on-chip last-number-dialed recall capability. Telephone number entry is via a 3 by 4-button matrix keypad (see Fig. 2). Since power requirements are very low, it is possible to operate the unit from the dc loop current provided by the telephone company network and delivered to your telephone wall jack.

When Busybody is activated by setting *S1* to ON, the dc potential across the telephone line is regulated to 3.9 volts by zener diode *D5*, which is then used to power the project's circuit. With *S2* set to MANUAL, the output at pin 3 of *IC2* is 0, which causes *IC3* to be set to the off-hook condition. When this occurs, *Q1* and *Q2* are sent into conduction, causing *LED1* to light. It also causes the central office equipment at the telephone company to place a dialtone on your line. This dialtone is amplified by *IC5* so that it can be heard through the loudspeaker connected via *C6* to pin 5 of the IC.

When the telephone number of the party you wish to call is keyed in via the keypad, *IC3* outpulses the digits and *LED1* flashes in step with the pulses going out to the telephone company's equipment. After all pulses have been delivered to the telephone line and the central office's equipment makes the connection to the line of the party being called, you will hear the sound of ringing if the line is free or a busy signal if it is not.

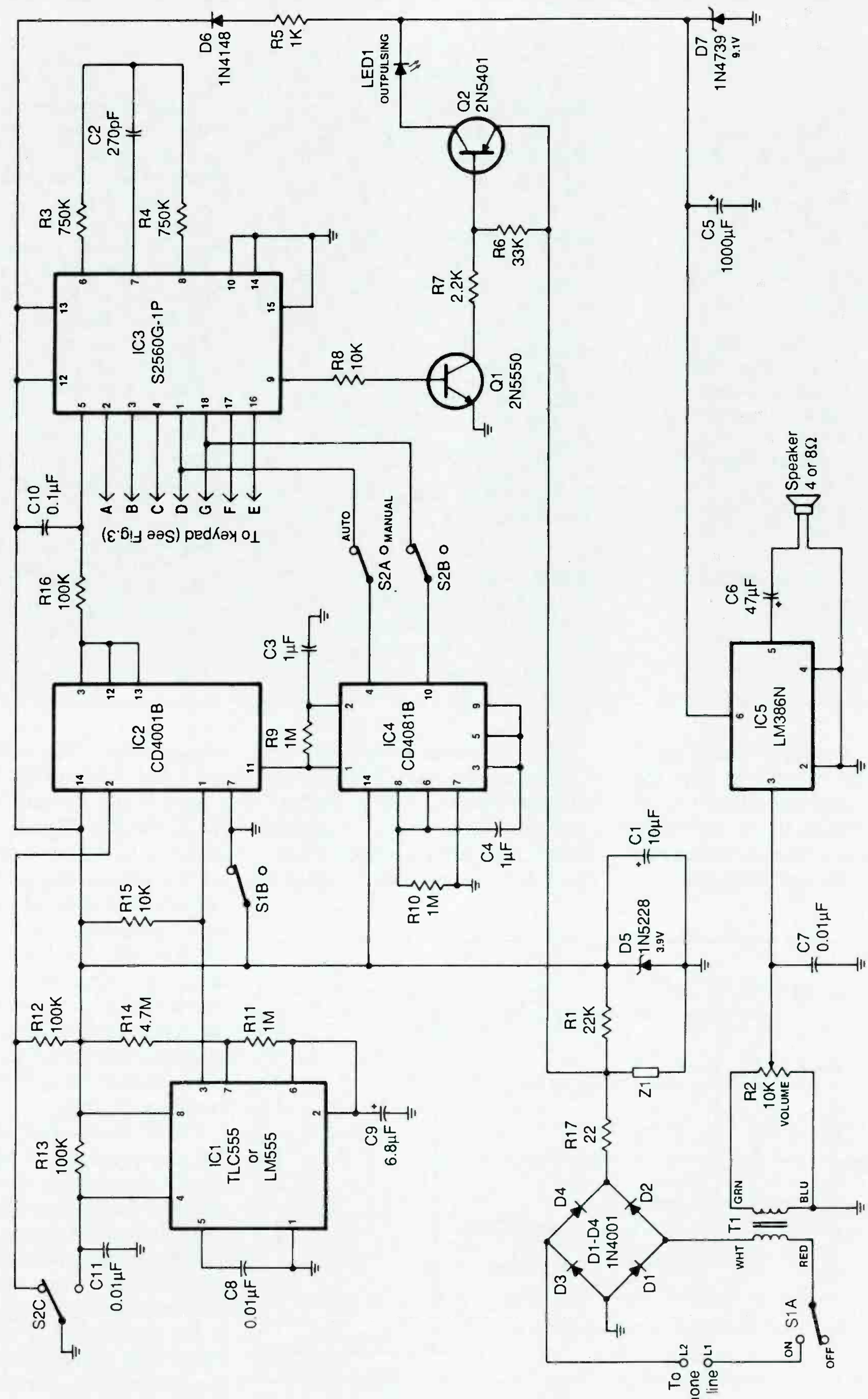


Fig. 1. Overall schematic diagram of project minus matrix keypad.

PARTS LIST

Semiconductors
D1 thru D4—1N4001 rectifier diode
D5—1N5228 or similar 3.9-volt zener diode
D6—1N4148 switching diode
D7—1N4739 or similar 9.1-volt zener diode
IC1—TLC555 or LM555 timer
IC2—CD4001B quad 2-input NOR gate
IC3—S2560G-1P (AMI) pulse dialer
IC4—CD4081B quad 2-input AND gate
IC5—LM386N audio amplifier
LED1—Red light-emitting diode (2 volts at 20 mA)
Q1—2N5550 or similar 140-volt npn silicon transistor
Q2—2N5401 or similar 140-volt pnp silicon transistor

Capacitors (all 25 V dc working volts)
C1—10-μF electrolytic
C2—270-pF disc
C3,C4—1-μF ceramic
C5—1,000-μF electrolytic
C6—47-μF electrolytic
C7,C8,C11—0.01-μF disc
C9—6.8-μF electrolytic
C10—0.1-μF disc

Resistors (¼-watt, 5% tolerance)
R1—22,000 ohms
R3,R4—750,000 ohms
R5—1,000 ohms
R6—33,000 ohms
R7—2,200 ohms
R8,R15—10,000 ohms
R9,R10,R11—1 megohm
R12,R13,R16—100,000 ohms
R14—4.7 megohms
R17—22 ohms
R2—10,000-ohm linear-taper potentiometer

Miscellaneous
S1—Dpdt slide or toggle switch
S2—3pdt slide or toggle switch
SPKR—Miniature 4- or 8-ohm speaker (2.5")
T1—1,000:8-ohm audio transformer (Radio Shack Cat. No. 273-1380 or equivalent)
Z1—Spike suppressor (Radio Shack Cat. No. 276-570)
Telephone-type 3 by 4-key matrix keypad (Refrac Electronics Corp. No. WRKB002BMW or equivalent); printed-circuit board or perforated board and soldering or Wire Wrap hardware; sockets for ICs; cabinet (Radio Shack Cat. No. 270-223 or similar); telephone cable with modular connector; control knob; rubber grommet; heat-shrinkable tubing; lettering kit; clear acrylic spray; hookup wire; solder; etc.

Note: The following are available from A. Caristi, 69 White Pond Rd., Waldwick, NJ 07463: Printed-circuit board for $8.75; S256OG-1P for $8.50; matrix keypad for $6.95; 2N5550 and 2N5401 transistors for $2.75 each. Add $1.00 P&H. New Jersey residents, please add sales tax.

In the latter event, you simple set *S2* on Busybody to AUTO to have the project take over the tedious task of repeatedly dialing the number until the party being called hangs up and frees his line for incoming calls.

In the automatic mode, pin 4 of *IC1* goes low to enable the *IC1* astable multivibrator circuit to oscillate at a rate of about one pulse every 40 seconds. The frequency and duty cycle of *IC1* is determined by the RC time constant of the network made up of *R14*, *R11* and *C9*. The output at pin 3 of *IC1* controls *IC3* through gate A in *IC2* (see Fig. 3), causing the circuit to be off-hook for about 35 seconds and on-hook for 5 seconds.

When *IC3* goes on-hook, Busybody "hangs up," disconnecting itself from the telephone line. However, the telephone number last keyed into memory remains ready for instant recall. When *IC3* returns to the off-hook condition 5 seconds later, the dialtone is restored by the telephone network.

The off-hook signal generated by *IC1* goes to gates A, B and C in *IC4* (see Fig. 3), which produce a delayed pair of pulses that become the redial signal and are fed to pins 1 and 18 of *IC3*. When the redial signal is generated, *IC3* outpulses the telephone number still stored in memory.

The sequence of events described above repeats every 35 seconds for as long as *S2* is set to AUTO and power is applied to the circuit. (Of course,

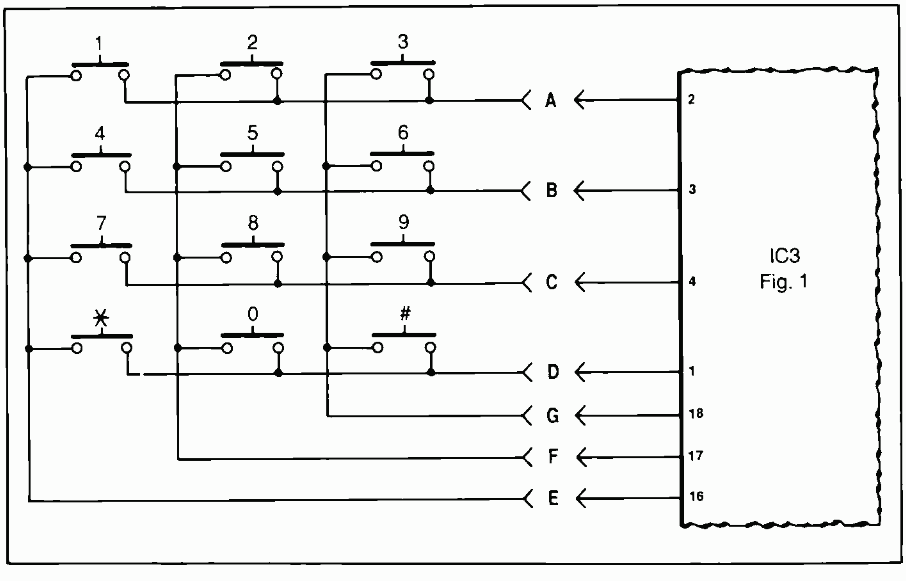


Fig. 2. Schematic and interconnect details for matrix keypad.

any time you set *S2* to MANUAL, automatic radial is defeated.)

When the ring signal is heard through the loudspeaker, you pick up your telephone handset and *then* set *S1* to OFF.

During the 5-second interval the circuit is on-hook, *IC1* through *IC4* are powered by current through *R1*, which maintains whatever number is stored in *IC3*'s on-chip memory for instant recall on redial. Whenever a new number is keyed into the project, it overwrites (replaces) the number previously stored in memory. During the off-hook period, power is applied to *IC1* through *IC4* via *R5* and *D6*.

Audio amplifier *IC5* and diode *D7* provide the proper load to the telephone line and draw sufficient current so that once the line is seized by *IC3*, it remains so during the 35-second calling interval.

Construction

Most of the circuitry that makes up this project can be mounted and wired on a single small circuit board. The circuit is only moderately complex and, thus, is suited to either printed-circuit board or perforated board and soldering or Wire Wrap hardware wiring.

If you wish to fabricate your own pc board, use the actual-size etching-and-drilling guide in Fig. 4. Alternatively, if you prefer, you can obtain a ready-to-wire board from the source given in the Note at the end of the Parts List. Wire the board exactly as shown in Fig. 5, taking care to properly orient the ICs or their sockets, transistors, diodes and electrolytic capacitors before soldering their pins or leads to the copper pads on the bottom of the board. If you are point-to-point wiring, either solder or Wire Wrap, you can still use Fig. 5 as a guide to component placement.

Use sockets for all ICs. Do *not* install the IC themselves until after you have performed the preliminary voltage checks.

When all components have been mounted on the board, prepare 15 (if possible, color-coded) 5″ lengths of insulated hookup wire by removing ¼″ of insulation from both ends. If you are using stranded hookup wire, tightly twist together the fine wires at each end and lightly tin with solder. Then plug one end of these wires into the holes that go to the off-the-board components and solder them into place. There are four wires for *S1*, seven wires for *S2*, two wires for *LED1* and two wires for the speaker. Temporarily set aside the circuit board assembly. If you are using color-coded wires, use black or blue for the cathode and red or yellow for the anode of *LED1*.

Referring to the lead photo, machine the front panel of the enclosure in which the project is to be housed to accommodate the keypad, VOLUME control *R2*, *LED1*, and the two switches. Also, drill a number of small holes in the area in which the speaker will be mounted to serve as a grille to allow sound to escape. If you prefer, you can make a square or round cutout and use cloth-covered screening instead of drilling grille holes. You can make the cutout for the keypad (and speaker grille if you decide to go this route) with a nibbling tool or an electric drill and file. Do not forget to drill the four small holes for the screws that secure the keypad to the panel.

Test fit the components in their various holes to make sure everything is okay. Then remove them and throroughly clean the panel and completely dry it. Label the switch positions and VOLUME control. If you use a dry-transfer lettering kit, spray over the panel and lettering two or more *light* coats of clear acrylic, allowing each coat to dry before applying the next, to protect the lettering from abrasion and scratches. If you use a tape labeler, spray the panel and allow to completely dry *before* applying the labels.

Mount the keyboard, speaker, switches, LED and VOLUME control

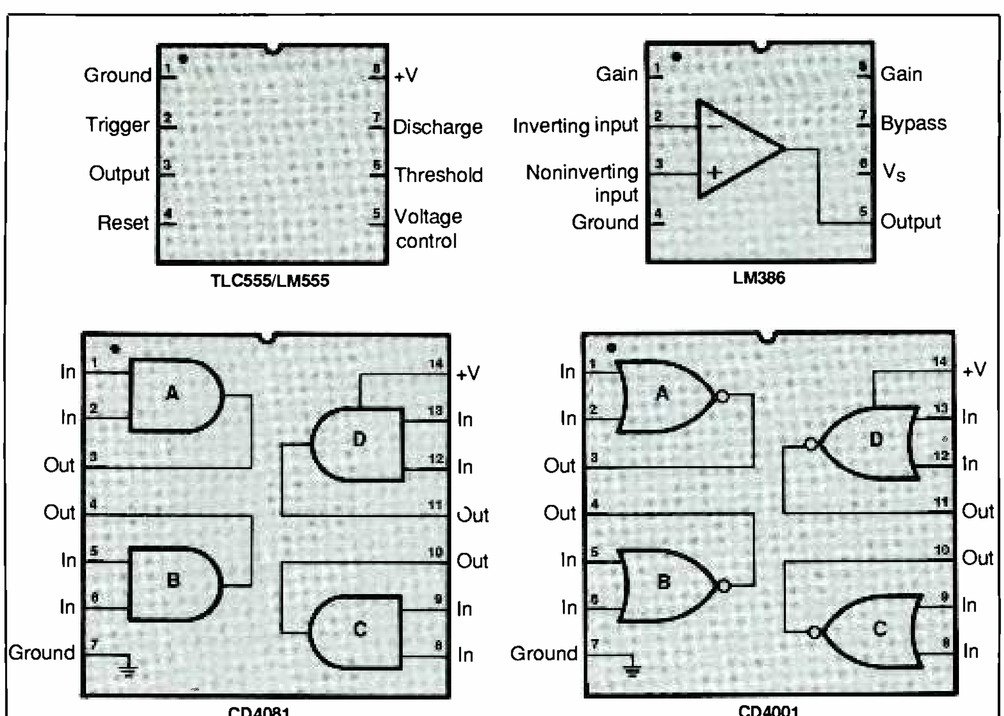


Fig. 3. Pinouts and internal details of ICs used in project.

in their respective cutouts and holes.

The keypad used in this project contains 12 single-pole, single-throw (spst) switches, one for each button, wired in matrix form. Hence there are seven wires coming from it, four row and three column wires, identified in Figs. 1 and 5 as A/B/C/D and E/F/G, respectively. You can use the keypad specified in the Parts List or one salvaged from any low-cost pushbutton telephone. If the keypad you are using has a common wire, ignore this wire.

Note that the seven keypad connections to the pc board are clearly identified in Fig. 5. If you make a wiring error while installing the keypad, the project will generate incorrect number sequences when you dial. To be certain that all wiring goes as it is supposed to and that you know which wire leads are to be used for each row/column pair, use an ohmmeter to check for continuity as you press and hold each keyswitch.

Referring to the table in Fig. 5, plug the seven wires from the keypad into their respective holes in the circuit board and solder them into place. These leads are referenced by row and column, as indicated in the table. Slide a 1" length of small-diameter heat-shrinkable tubing over the anode wire for *LED1* on the board. Trim both leads of the LED to about ⅜" and form a small hook in each.

Form a small hook in the LED wires coming from the circuit board and connect the cathode lead (nearest the flat on the LED's case) to the cathode wire. Crimp the connection and solder. Do the same for the anode lead and wire. Then push the heat-shrinkable tubing along the wire, over the connection and up to the bottom of the LED's case. Shrink the tubing securely in place.

Refer to the detail drawings in Fig. 5 for wiring the VOLUME control and switches into the circuit. Note particularly the differences between the wiring for slide and toggle switches.

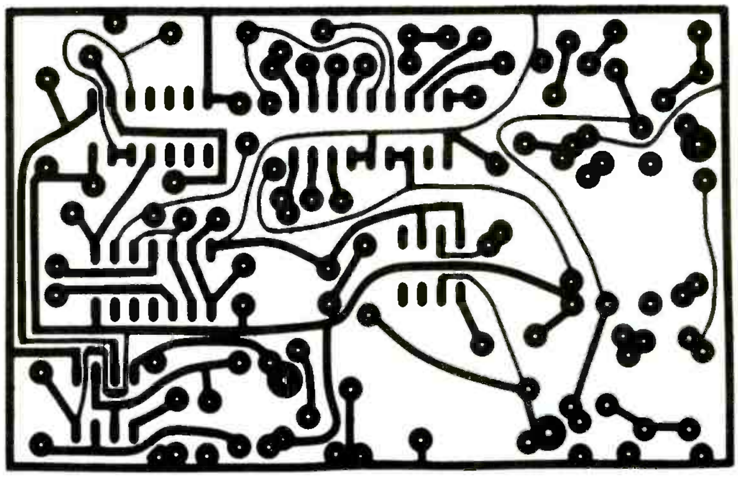


Fig. 4. Actual-size etching-and-drilling guide to be used for fabricating pc board.

With slide switches the selected throw lugs are in line with the switch slider buttons, while with toggle switches the toggles point in the *opposite* direction from the selected throw lugs. Use the appropriate drawings when wiring the switches.

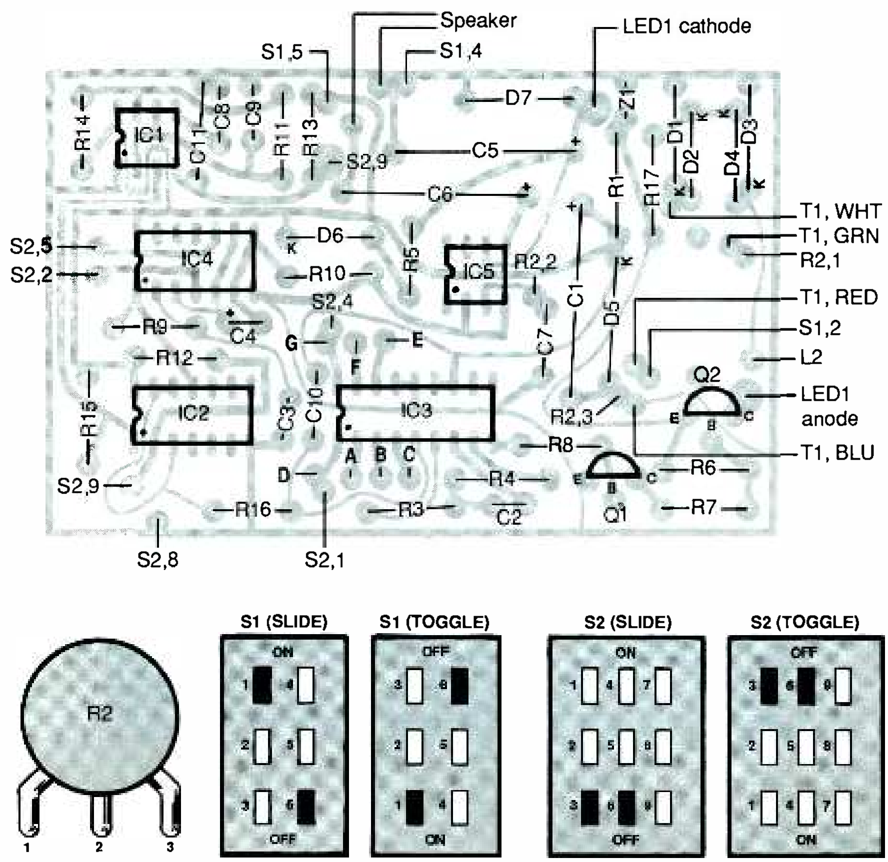
Drill a small hole in one of the walls of the enclosure and line it with a small rubber grommet. If you purchased a telephone cord with modular connectors at both ends, cut off and discard the connector from one end. Pass this end through the rubber grommet in the wall of the enclosure and tie a knot in it about 5" from the end inside the enclosure to serve as a strain relief. Now remove 3" of the outer plastic jacket from the trimmed end and ¼" of insulation from the L1 and L2 conductors (red and green, respectively). If you have a 4-conductor cord, clip off the yellow and black insulated wires that are not used in this project, or wrap them around the plastic jacket and secure in place with a couple of layers of electrical tape.

When all wiring has been completed, carefully check your work for unsoldered or poorly soldered connections and for solder bridges especially between the closely spaced conductors on the pc board. Reflow the solder on any connection that looks suspicious, adding a small amount of solder if necessary. Double check all ICs, transistors, diodes, the LED and electrolytic capacitors for proper orientation and all switches for proper wiring.

Checkout and Use

To be able to use Busybody and your present telephone on the same line, you must have a connector box with two parallel-connected modular sockets. if you do not have this arrangement, you can pick up from Radio Shack or any telephone or electronics accessories store a one-to-two adapter. Plug this into your present single-receptacle box and your telephone into one of the adapter's receptacles and Busybody into the other receptacle.

Set *S1* to ON. Now, using a dc voltmeter with an input resistance of at least 1 megohm, measure the voltage across *C1*. This should be about 3.9 volts, as regulated by zener diode *D5*. If you do not obtain the correct reading across *C1*, check the *D1* through *D4* bridge rectifier assembly, transformer connections and orientation of *D5*. Also check to see if the telephone line connections at *L1* and *L2* are wired into the circuit. Do



NOTES:
1. All views are from rear.
2. Switch lugs that have no connections are shown in solid black.
3. All switch slides and toggles are assumed to be in the ON (up) position for conditions shown.

Keypad Lead	To IC3 Pin Number	Keypad Lead	To IC3 Pin Number
Row 1	2 (A)	Column 1	16 (E)
Row 2	3 (B)	Column 2	17 (F)
Row 3	4 (C)	Column 3	18 (G)
Row 4	1 (D)	Common	Not used if supplied

Note: Letters in parentheses refer to pc board hole locations in wiring guide.

Fig. 5. Wiring guide for pc board and potentiometer and switch lug numbering. Table lists points in circuit to which keypad leads connect.

not proceed with checkout until you have corrected the problem and the potential across *C1* is 3.9 volts.

Set *S1* to OFF and discharge *C1* with a 100-ohm resistor temporarily bridged from the capacitor's + lead to circuit ground. Referring to Fig. 5, install the ICs in their respective sockets, paying strict attention to orientations. Handle the ICs with the same precautions you would exercise with any other MOS device that can be damaged by static electricity. Also, as you insert each IC in its socket, make sure no pins fold under the device or overhang the socket before pushing it home.

Now set *S2* to NORMAL and the VOLUME control to about midposition. Flip *S1* to ON. The LED should light and you should hear a dialtone coming from the project's built-in speaker. Adjust volume to a comfortable listening level.

Using Busybody's keypad, dial your own telephone number or any exchange followed by the digits 9970 to obtain a busy signal. You can key in the telephone number at any speed you like; *IC3* will outpulse each digit in sequence and at the proper pulse intervals, while the LED will flash in step with each pulse transmitted. When the LED stops flashing and you hear the busy signal, set *S2* to AUTO. This enables the *IC1* oscillator so that after 45 seconds or so the LED will extinguish for about 5 seconds.

When the LED comes on again, the circuit should outpulse the same telephone number you keyed in, resulting in a busy signal. This sequence will continue until you set *S1* to OFF.

If you do not obtain the results just described, check the *IC1* circuit to ascertain that it is oscillating when *S2* is set to AUTO. You can do this with a dc voltmeter or an oscilloscope connected between pin 3 of *IC1* and circuit ground. Normal indication is a potential of about 3.9 volts for about 35 seconds, followed by a zero indication for about 5 seconds.

If *IC1* is operating properly, check the logic level at pin 5 of *IC3*. This is the on/off-hook control input to the dialer chip. When this pin is at logic 0, the circuit is off-hook and the LED should be on. An on-hook condition is indicated by the LED being off and a logic 1 (3.9 volts) at pin 5 of *IC3*.

If the LED is operating normally but you do not obtain outpulsing of the dialed-in digits, check the *C2*, *R3* and *R4* network. Also check that your keypad is in working order and is properly wired into the circuit.

When everything checks out okay, disconnect Busybody from the tele-

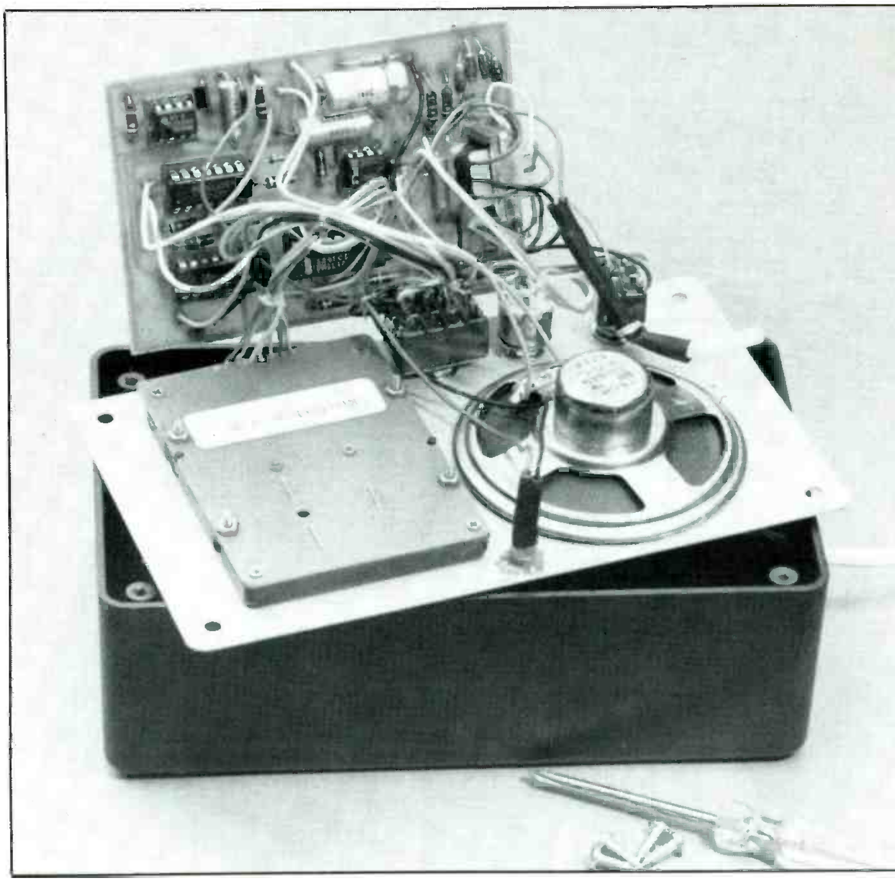


Fig. 6. Interior view of wired project.

phone line and install it inside its enclosure. Before installation, cover the back of the speaker magnet assembly with several layers of masking or electrical tape or adhesive-backed foam rubber to prevent it from electrically touching the rest of the circuitry.

To operate Busybody, plug it back into the modular adapter from which it was unplugged so that it and your telephone are both on-line. Now, do the following:

(1) Leave your telephone's handset on-hook, set *S2* to MANUAL and set *S1* to ON.

(2) Dial the number of the party you wish to reach. Any telephone number, including area code, can be dialed, just as you would dial with you telephone instrument. If you hear a ring signal when the connection is made through the telephone company's equipment, pick up your handset and set Busybody to OFF and proceed with your call in the normal manner.

(3) If when you call you hear a busy signal, set Busybody to AUTO. Now Busybody will automatically and repeatedly redial the number for as long as it takes to get through.

(4) While Busybody is in the automatic mode, when you hear the ring signal from the speaker, pick up your telephone handset before the project disconnects. Turn off Busybody and proceed with your call.

If you wish to operate this project in the manual mode for hands-free listening, leave *S2* set to MANUAL and use the project's keypad to dial the telephone number of the party you wish to contact. **ME**

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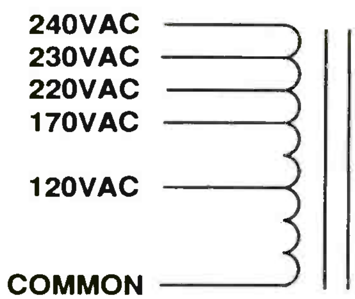

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ELECTRONICS NOTEBOOK

Part-15 Low-Power Radio Transmitters

By Forrest M. Mims

There are many applications for low-power radio-frequency (r-f) transmitters. Moreover, building and experimenting with such transmitters can provide excellent practical experience in the basics of r-f circuit design and operation.

Several kinds of low-power radio transmitters can be built and operated without the need for a license or government approval. I'll describe the design and operation of several such systems below, but first let's review the legal requirements for such devices.

Legal Requirements for Low-Power Transmitters

In the United States, radio-frequency transmitters are regulated by the Federal Communications Commission. The text of these regulations is published in the Code of Federal Regulations, Title 47 (CFR 47), "Communications." Part 15 of CFR 47, which is entitled "Radio Frequency Devices," covers the operating specifications and permissible transmission frequencies of a wide range or unlicensed low-power r-f devices. The complete text of CFR 47 is available from the U.S. Government Printing Office (Washington, DC 20402).

Part 15 is much too long to reproduce here, but it's key features, which are subject to change, are worth reviewing. They include:

15.1 (a) An incidental and restricted radiation device may be operated under the restrictions and provisions set forth in this part without an individual license.

15.3 Persons operating restricted or incidental radiation devices . . . shall not be deemed to have any vested or recognizable right to the continued use of any given frequency . . . operation of these devices is subject to the conditions that no harmful interference is caused and that interference must be accepted that may be caused by other incidental or restricted radiation devices . . . .

15.5 Any equipment or device subject to the provisions of this part . . . [and] any technical data required to be kept on file by the operator of the device shall be made available for inspection by Commission representatives upon reasonable request.

15.104 . . . the use of a low power communication device for eavesdropping is prohibited.

15.152 . . . the operator of a low power communication device . . . which causes harmful interference to an authorized radio service, shall promptly stop operating the device until the harmful interference has been eliminated.

15.133 A person who constructs not more than five low power communication devices for his own use, and not for sale . . . shall attach to each such device a signed and dated label that reads as follows: I have constructed this device for my own use. I have tested it and certify that it complies with the applicable regulations of FCC Rules Part 15. A copy of my measurements is in my possession and is available for inspection.

These regulations are backed by severe penalties for violators. Though FCC regulations are rountinely violated, often unintentionally, the agency's field offices work closely with amateur radio operators and others to track down flagrant violations. It works hardest to locate illegal devices that cause interference with authorized communication devices.

The rules cited above apply to low-power devices in general. Now let's examine some of the transmission frequencies permitted by Part 15.

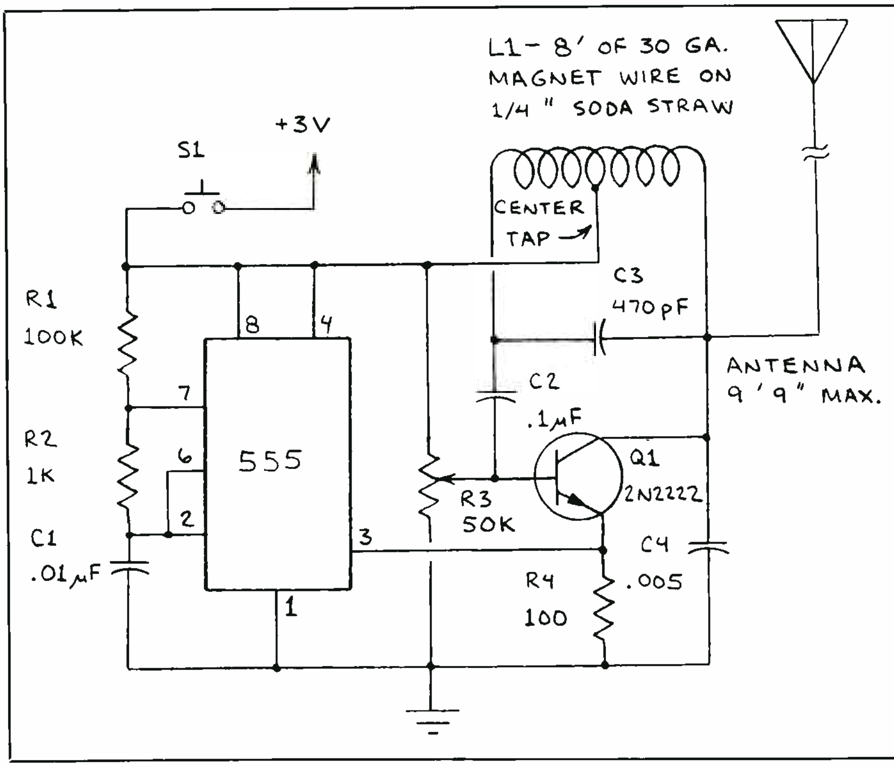

Fig. 1. A low-power broadcast-band tone transmitter.

Authorized Frequencies For Low-Power Devices

The FCC permits low-power devices to operate across a wide frequency spectrum. However, it is important to realize that some frequencies can be used only by FCC approved devices. For instance, a low-power wireless microphone operating in the 88-to-108-MHz FM broadcast band ". . . shall be type approved . . ." by the FCC (15.163 (a))

Fortunately, Part 15 imposes no type approval requirements for several frequency bands. But even these devices must meet specific requirements. The most important frequencies are the broadcast band, the 27-MHz CB band, the 49-MHz walkie-talkie band and a provision for periodic pulse operation at any frequency above 70 MHz.

Devices transmitting on the broadcast band are covered by:

15.113 . . . a low power communication device may operate on any frequency in the band 510-1600 kHz provided . . . (a) The power input to the final radio stage . . . does not exceed 100 milliwatts . . . . (c) The total length of the transmission line plus the antenna, plus the ground lead (if used) does not exceed 3 meters . . . .

Citizens band devices are covered by:

15.116 A low power communication device may be operated in the band 26.99-27.26 MHz provided . . . . (a) The device may not be used for voice communications . . . or for CW communications . . . . (b) The device shall operate on one or more of the following frequencies:

26.995 MHz	27.145 MHz
27.045 MHz	27.195 MHz
27.095 MHz	27.255 MHz. . . .

Low-power walkie-talkies can operate in a 49-MHz band. The applicable portion of the FCC rule is:

15.117 (a) A low power communication device may be operated on one or more of the permitted frequencies . . .:

49.830 MHz	49.875 MHz
49.845 MHz	49.890 MHz
49.860 MHz	

Special-purpose low-power tone transmitters can be operated at any frequency above 70 MHz if their field strength does not exceed specified levels and:

15.122. . . . (b) The device is provided with a means of automatically limiting operation so that the duration of each transmission shall not be greater than one second and the silent period between transmissions shall be at least 30 times the transmission duration but in no case less than 10 seconds.

Low-Power Transmitters

I designed the circuits to be described next for *Engineer's Mini-Notebook: Communication Projects* (Siliconcepts, 1987), a new Radio Shack book. The telegraph, intercom and lightwave communication portions of the book were straightforward. But developing and testing the radio-frequency transmitters required considerably more time than I had anticipated. The chief reason for this was the time required to meet the FCC requirements for radiated power and spurious emissions. I'll discuss this subject in more detail later.

• *Broadcast-Band Tone Transmitter*. The circuit in Fig. 1 transmits a clear audio tone to an AM radio tuned to around 700 kHz. It can send code signals or tone-encoded data (e.g., light level or temperature). It can be used as a tracking transmitter. And it can be concealed and used in a "fox hunt," the object of which is to find the hidden transmitter with the help of a directional receiver.

Referring to Fig. 1, *Q1* is connected as an r-f oscillator that generates a clean sine wave having a frequency determined by the values of *C3* and *L1*. The r-f signal is both amplitude and frequency modulated by an audio-frequency signal supplied by a 555 oscillator. The frequency of the modulating signal is determined by the values of *R1* and *C1*.

Coil *L1* is the only nonstandard component. Begin assembly of *L1* by punching a small hole near one end of a length of ¼-inch-diameter soda straw. Sandpaper the insulation from a 4-inch section at the center of an 8-foot length of 30-gauge magnet wire purchased from Radio Shack or an electronic parts store. Insert 2 inches of one end of the wire through the hole in the straw and wind the remainder of the wire around the straw until the uninsulated portion is reached. Secure the coil in place with tape and form the exposed section of wire into a 2-inch long loop. Then twist the sides of the loop together and insert it through a hole punched in the straw. Wind the remaining wire around the straw and insert the final 2 inches through a third hole. Clip off the excess end of the straw (but not the coil leads).

Test the circuit by connecting an antenna and closing *S1*. You should hear a tone when the radio is tuned to near 700 kHz. Note that the receiver must be carefully tuned, since the transmitter's transmission frequency is very narrow. Adjust *R3* until the sound of the tone is clear and free from any raspiness or other noise. The transmission range will exceed

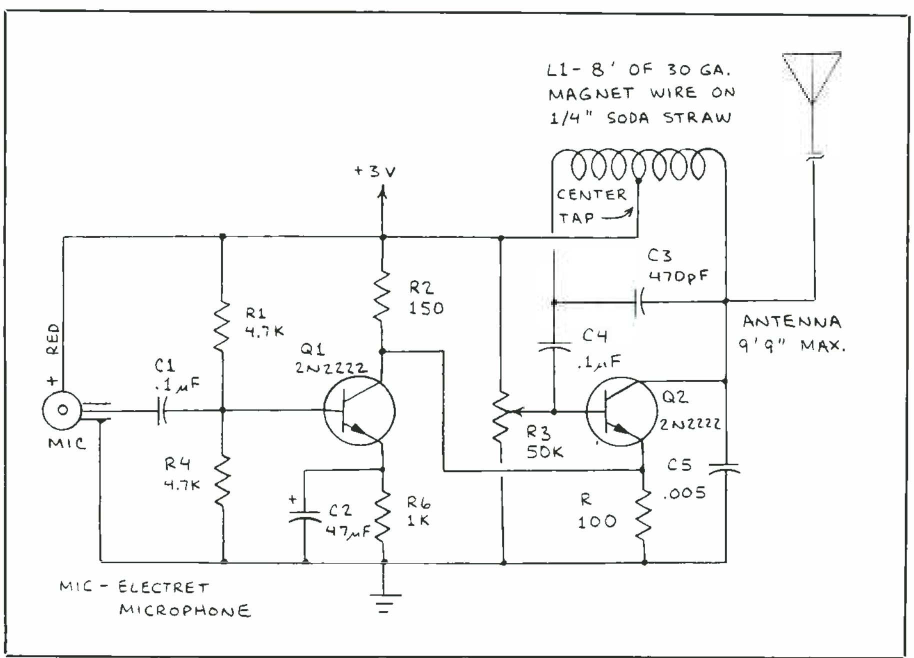

Fig. 2. A low-power broadcast-band voice transmitter.

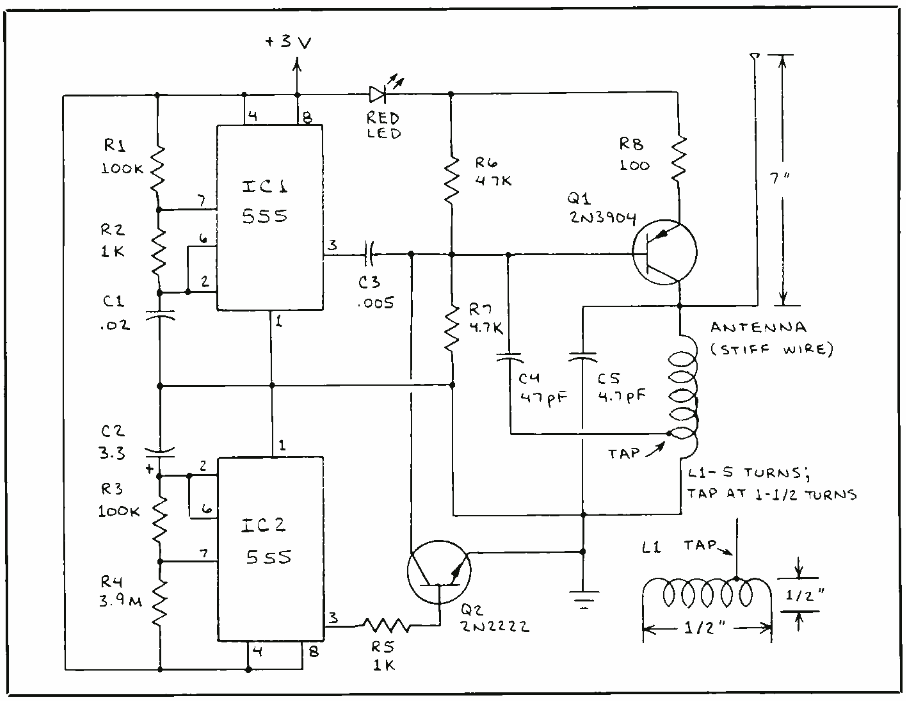

Fig. 3. A low-power vhf pulse transmitter.

20 or 30 feet when a 3-meter-long antenna is used.

If the circuit happens to transmit on the same wavelength as a local station, you will need to alter the frequency of the r-f oscillator. This is best done by substituting a 0-to-365-pF variable capacitor for *C3*.

Recall from the foregoing discussion of FCC regulations that the final stage of low-power broadcast-band transmitters must not consume more than 100 milliwatts. To measure this parameter, connect a current meter between the positive side of the battery and the circuit. The power consumed by the entire circuit is the product of the battery voltage and the current in amperes. If you want to measure only the power consumed by the r-f oscillator, insert the current meter between the junction of *R3* and *L1*'s tap and the positive supply.

For best results, assemble the transmitter in a small metal case. A metal case will make the transmitter less susceptible to the effects of body capacitance that can cause frequency shifts and other undesirable effects. Use a banana jack for the antenna terminal. Connect the ground side of the circuit to the metal case.

• *Broadcast-Band Voice Transmitter.* The transmitter in Fig. 1 can be voice modulated if the audio tone generator is replaced by a microphone and an amplifier, as shown in Fig. 2. Construction and operation of the r-f oscillator portion of the circuit is identical to that of the code transmitter described above. As for the voice amplifier, an electret microphone (Radio Shack Cat. No. 270-092 or similar) will give best results.

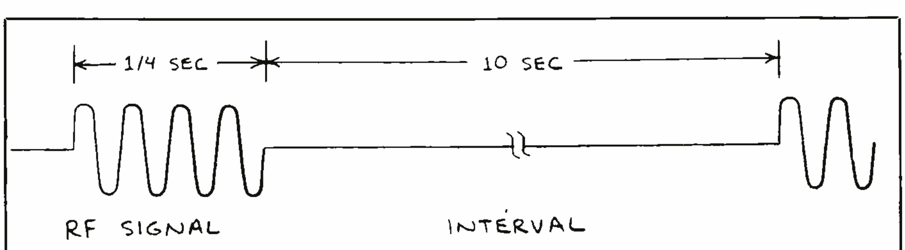

Fig. 4. The transmission format of the vhf pulse transmitter.

Test the assembled transmitter by placing an earphone connected to a tape player near the microphone to provide a source of sound. Tune a nearby broadcast-band receiver until the sound from the tape player is heard. Then adjust *R3* for best sound quality. Retune the receiver if necessary.

The sound from the receiver will probably be somewhat tinny due to the poor low-frequency response of the tape player's earphone. Nevertheless, when you have adjusted the transmitter for the best sound quality, it will be ready to transmit a faithful reproduction of your voice.

As with the previous circuit, the transmitter will give best service if it is housed in a small metal case. Refer to the previous circuit's description for details.

• *A Special-Purpose 100-MHz Pulse Transmitter.* Part 15.122 of 47 CFR permits periodic low-power transmissions at any frequency above 70 MHz. In the band from 70 to 130 MHz, the maximum field strength of the fundamental frequency is restricted to 500 microvolts/meter at a distance of 3 meters, for a transmission range of hundreds of feet.

Under the provisions of Part 15.122, periodic operation means the maximum transmission time is 1 second and the minimum interval between transmissions is 10 seconds. In any case, the silent interval must be at least 30 times the duration of the transmission. Therefore, if a pulse is transmitted once every 10 seconds, it's length must not exceed ⅓ second.

Figure 3 is a circuit I designed specifically for Part 15.122 operation. With the component values shown, the circuit transmits a ¼-second tone burst once every 10 seconds, as shown in Fig. 4. The transmission frequency falls within the 88-to-108-MHz FM broadcast band.

Referring to Fig. 3, *Q1* is connected as an r-f oscillator whose frequency is determined primarily by the values of *L1* and

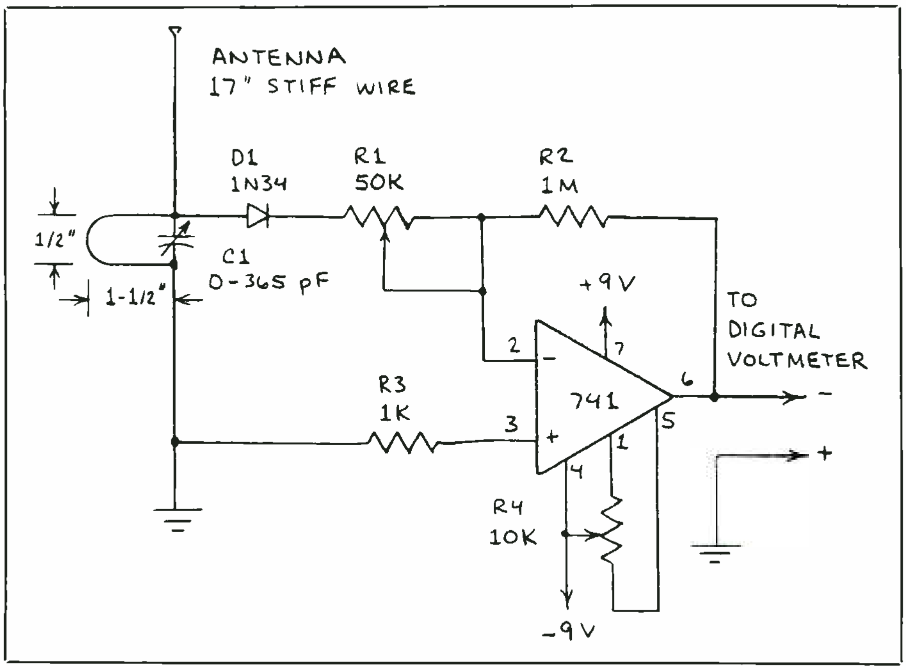

Fig. 5. A radio-frequency field-strength meter.

C5. Timer IC1 is connected as an oscillator that amplitude modulates the r-f carrier signal with an audio-frequency tone. The frequency of the tone is determined by the values of R1 and C1.

Timer IC2 is connected so that it normally keeps Q2 switched on to disable the r-f oscillator. Once every 10 seconds, IC2 switches Q2 off and the r-f oscillator is enabled for 0.25 second. Transistor Q2 is then switched on again and the cycle repeats. Resistors R4 and R3 and capacitor C2 control IC2's timing interval.

With one exception, both standard and low-power 555 timer chips can be used for IC1 and IC2. Or a single 556 can be used to replace both 555s. The exception is that when the Texas Instruments TLC555, a low-power version of the 555, is used for IC1, the carrier wave will not be tone modulated. Other CMOS and low power 555s I tried worked in this circuit.

Note the red LED inserted between the positive supply and the r-f oscillator. Though this LED glows when the r-f oscillator is transmitting, its primary purpose is to drop the voltage to the oscillator to around 1.5 volts. This proved necessary to keep the transmitter's power output within Part 15.122 guidelines.

Coil L1 is the only special component in Fig. 3. This coil is simply 5 turns of solid wire wound around a ¾-inch-diameter form, such as a wood dowel. When the form is removed, the coil will spring outward slightly and assume an outside diameter of ½ inch. The tap is a wire soldered 1½ turns from the ground end.

To test the transmitter, first connect a 7-inch-long stiff antenna wire to the junction of L1 and Q1's collector. (A longer antenna will violate Part 15.122 field-strength restrictions.) Then temporarily disconnect Q2's collector from the circuit, switch on the power and tune a nearby FM radio until a strong, steady tone is received. If the signal competes with that from a broadcast transmitter, you will need to alter the transmission frequency. One way is to slightly squeeze or stretch the turns of L1. Another is to add one or more 1-pF capacitors across C5. Still another is to replace C5 with a small variable capacitor like those used in digital watches and other miniature crystal-controlled oscillators. You will need an insulated tuning tool to adjust the variable capacitor, since body capacitance will make substantial frequency changes.

When the circuit is working properly, Q2's collector must be reconnected to meet the requirements of Part 15.122. There are many applications for the transmitter. It can be connected to a pressure-sensitive switch that switches the circuit on when mail is placed in your mail box. It can be used as a wireless doorbell or a tracking transmitter. It can even be used as a telemetry transmitter that transmits light-level, temperature or other data. All that's necessary is to replace R1 with a suitable variable-resistance detector.

For best results, assemble this transmitter in a metal case. Be sure that L1 is mounted firmly to the circuit board and that it doesn't touch the case. If L1 vibrates, the transmission frequency will be frequency modulated.

Determining if the broadcast-band transmitters described above meet FCC guidelines is simple. That's because Part 15 permits the r-f oscillator's power consumption to be measured in lieu of an actual field-strength measurement. Unfortunately, Part 15.122 devices are characterized only according to maximum permissible field-strength levels. To comply with this requirement, I designed the simple field strength meter described below.

Simple Field Strength Meter

Figure 5 shows a simple field-strength meter. In operation, L1 and C1 select an r-f frequency flowing in the antenna. The selected signal is rectified by germanium diode D1 and amplified by a 741 operational amplifier. The output from the 741 is fed directly into a digital voltmeter.

Even with no input signal, a small offset voltage will appear at the output of the 741. This can be nulled by carefully adjusting offset potentiometer R4.

For best results, the circuit should be installed in a metal case. A banana jack can be used to provide an antenna terminal. Coil L1 is simply a wire bent into a hairpin loop as shown in Fig. 5. A standard 0-to-365-pF variable capacitor is used for C1.

While simple field-strength meters such as this one can provide a relative indication of field strength, they are not calibrated. I discussed the need to measure the field strength of the Part 15.122 device described above with Harry

Helms, an Extra Class amateur radio operator (KR2H) and a prolific writer of technical books and articles. Harry suggested a simple method for making ballpark estimates of actual field strength using my do-it-yourself meter. His suggestion was to monitor the signal from an FCC type-approved transmitter and compare this signal with that from the Part 15.122 unit.

I tried Harry's suggestion with the help of a pair of identical 49-MHz transceivers, both of which, according to the manufacturer, meet Part 15 specifications by emitting a maximum field strength of 10,000 microvolts/meter at 3 meters. The transmitters gave peak readings of 2.4 and 6 millivolts. The do-it-yourself Part 15.122 device (in continuous-transmission mode) gave a peak reading of 0.1 millivolt. When compared to the two type-approved devices, the Part 15.122 unit has a field strength of either 167 or 416 microvolts/meter at 3 meters. The legal maximum is 500 microvolts/meter. When the antenna wire of the Part 15.122 device is lengthened, the field strength increases dramatically. Therefore, be sure to keep the antenna length at 7 inches.

Going Further

For more information about the design of radio-frequency transmitters, see *The ARRL Handbook For The Radio Amateur*. This outstanding publication, which is updated yearly, includes detailed information about the design and operation of many kinds of transmitters. These principles can be applied to the design and operation of both unlicensed (low-power) and licensed transmitters. For example, the Handbook discusses the use of r-f filters to reduce the strength of unwanted harmonics.

The ARRL Handbook can be purchased from some electronics stores or purchased by mail order. For additional information about this and other publications of the American Radio Relay League, write the ARRL (Newington, CT 06111). ME

HARDWARE HACKER

Apple IIGS Disk-Drive Adapter; Surplus Electronic Parts Sources; Current Mirrors; Microcomputer Voltage Inputs; More

By Don Lancaster

I just got word on a brand new *National* sync separator chip called the LM1881. This dude costs around $3, works off a single +5-volt supply, and needs only three external parts. It can handle NTSC, PAL, and SECAM, as well as nonstandard video. It even has a special logic output for even/odd fields. The LM1881 should be great for converting computer composite-video for split sync monitors and such.

I haven't had a chance to work with it yet, but I thought you might like to get a head start on a most-needed and most-asked-for new hacker component.

Moving right along . . . .

How can I use older disk drives on the Apple IIGS?

The Apple IIGS has an incredible variety of disk-drive options. For instance, there is a plug-in SCSI card that can access any number of floppy- or hard-disk drives that make use of this optional interface.

Then there are all the RAM-disk plug-in card options. Today, you could go as high as 8 megabytes of RAM disk. Just as soon as the prices drop a tad more on the 1-megabyte RAM chips, you can quadruple your storage to 32 megabytes.

In fact, you can do it today. One-megabyte RAM chips are certainly available, but they are not yet cost competitive with those older 256K dynamic RAMs.

And, should you attach a single "intelligent" drive to the usual DB-19 disk connector on the IIGS, you can control up to 128 different drives at once. This would, obviously, take a beefed-up power supply, but it can definitely be done. Astoundingly, the present firmware (but not the drives themselves) are capable of supporting up to 5 gigabytes per drive, for a mind-numbing total of *half a terabyte* of data on line at once! Which is not too shabby for a personal computer. Particularly since next year's CD ROMs should drop in just fine, thank you.

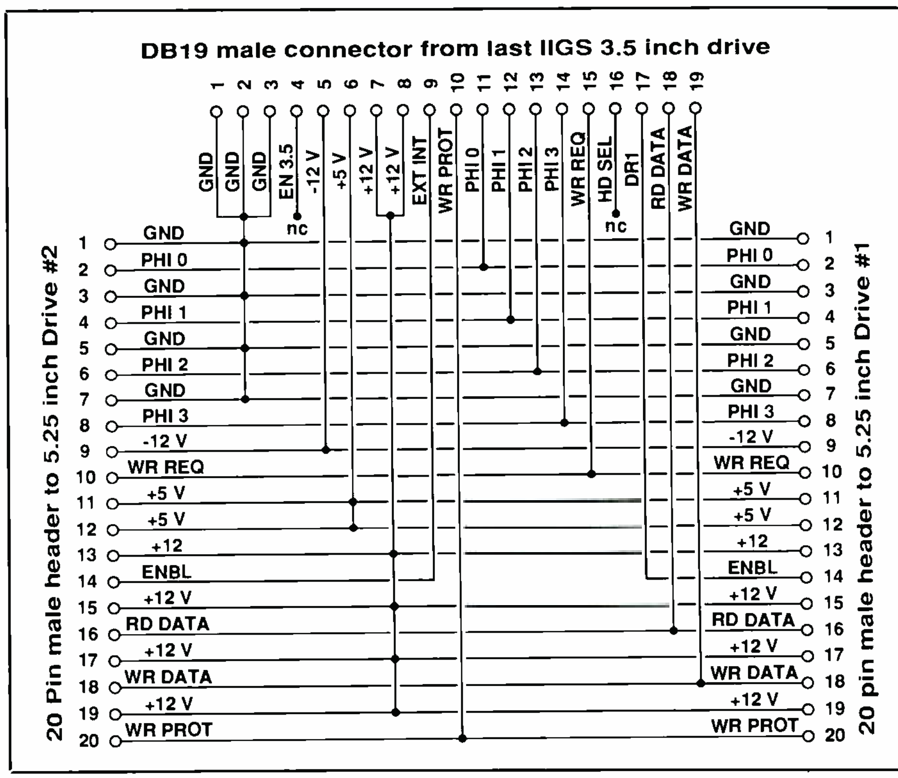

Fig. 1. This adapter lets you use older disk drives on an Apple IIGS.

The normal and usual setup for most IIGS users is to daisy chain four dumb disk drives, placing a pair of 3½-inch drives nearest the IIGS and using a pair of 5¼ inch drives as tail-end Charlies.

The only little problem here is that all of the newer Apple drives use a DB-19 connector. But, many of the much older Apple drives used a 20-pin DIP header connector that has wildly different pinouts. What can be done here?

There are at least two ways you can use these older 20-pin drives on the IIGS. The quickest and simplest is to go ahead and use an old slot six controller card, and change the IIGS front panel selection to "your card" for slot six.

Instead, Fig. 1 shows a simple adapter that you can build that will let you connect a pair of older 20-pin drives to a single DB-19 connector. This connector can either be plugged into the IIGS itself for a 5¼-inch-only system or into the last 3½-inch drive in use.

This adapter is certain to become commercially available soon, but for now, you might want to build your own. I would use a small printed-circuit board, being sure to use the type of 20-pin DIP header that has a plastic box around it.

Countless early Apple drive cards have been destroyed by plugging in this connector offset by one pin or even offset by one entire pin row. Make sure your adapter does not allow this.

Unfortunately, that DB-19 connector has been a bear to find. One good source is *JDR*. These are usually available in solder-tail only, so a short cable may be needed between your printed-circuit card and the DB-19 connector.

If you are only going to use one older drive, be sure it goes in the first slot on this adapter.

What are the best sources of surplus electronic components?

I guess I always have been a surplus junkie, and have been buying bargain and odd-lot mechanical and electronic stuff for longer than I care to remember. There's no better way to get hands-on electronic experience at low cost than by adapting and then reworking surplus components and systems to meet your own needs.

My all-time favorite surplus house has to be *Jerryco*. If not for their outrageous catalog, then for their incredible selection and bargain prices. They are not strong in the electronic area, but they more than make up for it in unusual materials, mechanisms, motors, far-out goodies, electromechanicals, and such.

For old-time, old-line military WWII surplus electronics, *Fair Radio Sales* is an excellent choice. One of the first surplus items I ever bought was from them. It was a complete APN-1 radar altimeter for $2.95. I sure was surprised when the Railway Express (Uh—I guess I may have been at this for a while) charges were a budget-breaking $8. During my college days, I earned some quick cash by buying surplus electronic castings from these people and converting them into far-out decorator lamps.

The yuppie reign of terror has mercifully ended over at *Edmund Scientific*. In fact, there is not one single Perrier-filled birdbath in its entire catalog these days. While they are the merest shadow of their former selves, they do have a fairly wide selection of optics, mechanics, and pneumatics on hand.

For "raw iron" in the form of motors, actuators, hydraulics, transformers, clutches, and such, *C&H Sales* has some fine offerings. No robotics hacker can afford to miss out on their catalog.

While not strictly surplus, a fine source

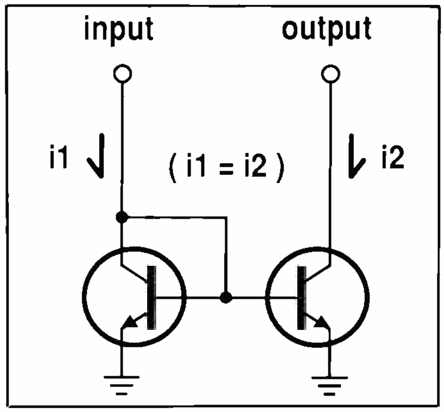

Fig. 2. An npn current mirror.

of low-cost electronic components is *Mouser Electronics*. They have a lot of brand-new stuff that is super hard to find elsewhere.

And those are pretty much my favorites. Besides these, while fairly pricey, *Herbach and Rademan* do occasionally has some real bargains. They are very strong in broadcast television surplus. *Marvin Jones* typically has outstanding electronic whatevers at very low prices. Good old *BNF Enterprises* have bargain priced assorted floor sweepings available, with an occasional gem buried in its

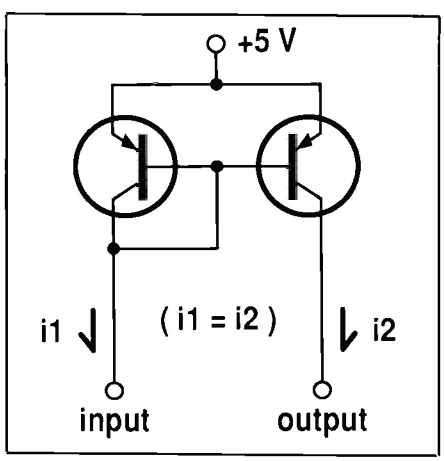

Fig. 3. A pnp current mirror.

big tabloid catalogs. Their prices are so low that "you buys your ticket and takes your chance."

Some newer outfits to look into include *Circuit Specialists, American Design Components*, and *Electrovalue International*. I'm sure you'll find other favorites of your own.

Finally, of course, there are the many fine advertisers right here in *Modern Electronics*.

What is a current mirror?

A current mirror is a very important and very powerful electronic circuit that sees very wide use in many integrated circuits. Yet it's almost unknown as a hacker tool.

Figure 2 shows a typical npn current mirror circuit. A current mirror lets you "bounce" a current off either a supply line or ground, while still having a very minimum voltage drop across itself. This is most handy for translating voltages or currents, for very-high gain amplification stages, for signal-level translation, for multi-current distribution including D/A conversion, and for letting you get by with much lower supply voltages than is normal.

The circuit behaves as follows: You set the current that is going into the left end, and the current mirror will then draw nearly that identical current into its right end. For the circuit to work properly, both transistors must be carefully matched and, preferably, on the same piece of silicon.

In theory, two matched transistors of identical gain and temperature will produce identical collector currents for any given base voltage input.

Now, what seems to be a dead short on the left transistor is really the key to the operation of the whole circuit. Believe it or not, a transistor can actually "transist" when it is connected this way. How? Well, a transistor only needs 0.2 or more volts at its collector to stay out of saturation. Since the base of a silicon transistor usually has a 0.6-volt drop across it, the left transistor is clearly in its active region, and is capable of amplification.

With a dead short from collector to base, the transistor cannot do much in the way of voltages. But it most certainly can decide the ratio of the base current to the collector current. What the dead short does when helped by the transistor is this: it adjusts the base voltage as a function of the transistor's current gain. The higher the gain, the lower the voltage, and vice-versa.

Since a transistor's gain will change with temperature, this circuit will automatically adjust the base voltage for both transistors in a way that gives a constant output current over temperature. Thus, an apparent dead short magically and automatically adjusts the output current so it exactly matches the input current over a wide temperature range. By the way, this is called a Wilson current mirror, after its inventor.

Figure 3 shows an "upside-down" current mirror, this time using a pair of pnp transistors. In the pnp mirror, the amount of current purposely sunk to ground on the left will cause an identical current to be sourced on the right.

For hacking, you can take a bag of bargain transistors and keep trying pairs until the mirrored currents end up fairly near each other. Clip the two transistors to the same heat sink, and glop them with silicon rubber for added thermal insulation.

It is far better to pick up a transistor array of some sort so you start out with matched devices. The Motorola MC3346 is an interesting choice. It is available from *Circuit Specialists* for $1.25 each.

Other sources of transistor arrays include *Sprague*, *National*, and *RCA*. These are usually best found as odd-lot bargains from the usual places.

Show me a hacker use for a current mirror.

What good is a current mirror to a hacker? Well, you could obviously put one on a 555 timer or an 8038 voltage-controlled oscillator to let you input a conventional 0-to-5-volt dc controlling signal. While this will certainly work, that single-chip voltage-controlled oscillator (vco) circuit we looked at last month might be a better choice.

Instead, Fig. 4 shows you an interesting concept for a current mirror circuit. Four current mirrors can convert an Apple II game input into a quad digital voltmeter, usable for any number of fairly non-precision measurement tasks.

An input of 0 to 5 volts dc is converted into an output current that, in turn, charges the game paddle timing capacitors internal to the Apple. The lower the input voltage, the higher the current through the current mirror, the faster the game capacitor will charge, and the lower the measured charging time.

Thus, low voltages give low numbers and vice-versa, varying in a linear manner. A simple X = PDL(0) can be used from Applesloth to read voltage inputs. As a more advanced project, you could easily write a "double-precision" game paddle routine in machine language. This would increase input resolution, but it is doubtful if you could get an overall "real-world" accuracy better than a few percent.

This circuit could obviously be extended to any personal computer that uses variable resistance ("volume-control") inputs. Let me know your experiences on this.

Aren't those current arrows backwards?

Hmmm. Here we go again.

Many years ago, somebody like Franklin or Faraday decided in which direction they thought current actually flowed in

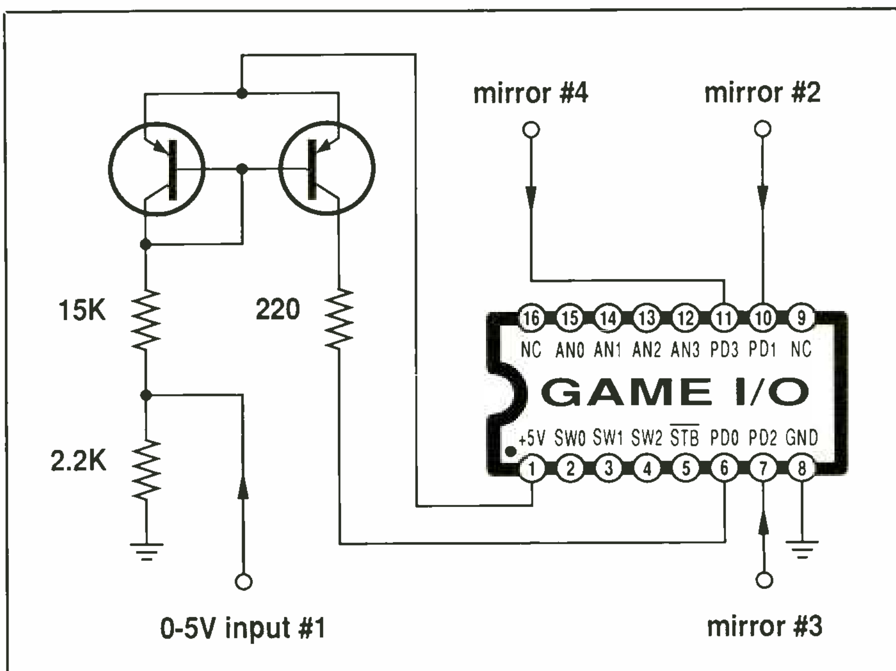

Fig. 4. Current mirror quad voltage inputs for an Apple computer.

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Circuit Specialists Box 3047 Scottsdale, AZ 85257 (800) 528-1417	**Herbach & Rademan** 401 E. Erie Ave. Philadelphia, PA 19134 (215) 426-1700	**Motorola Semiconductor** Box 20912 Phoenix, AZ 85036 (602) 244-6900	**Sprague Electric** PO Box 9102 Mansfield, MA 02048 (413) 664-4411

an electrical circuit. It turns out they made the wrong guess.

Today, all engineering schools, all graduate engineers, all electronic standards, all electronic manufacturers, all math equations, all "right-hand rules," and especially all of theose arrows on all of those schematic symbols make use of this "wrong" notation. This "wrong" method is called "conventional" current.

With conventional current, current flow in a load goes from positive to negative. With conventional current, current flow in a transistor or a diode goes in the direction shown by the arrows. The "hole" current in a semiconductor is the same as conventional current. Why, even that IEEE tie clasp is "wrong"!

Unfortunately, during World War II, some military types decided it would be easier to explain how a 35Z5 vacuum tube works by using the concept of the "electron" current. While technically correct, electron current runs backward from all of the symbols, changing all of the math equations, converting the "right-hand rules" into "left-hand rules" and creating various other absurdities.

In solid-state electronics, electron flow and hole flow are equally important and complimentary concepts. Trying to explain or understand transistors or integrated circuits by using only electron currents introduces all sorts of silly problems.

To this day, there are still a very few service schools and technician-level books that insist on the use of the electron-current concept. What happens when their students and readers graduate and go on to the real world? They end up both hopelessly confused and mystified as to why the entire rest of the world is doing things in exactly the "wrong" way.

As to having the entire electronics industry "correctly" convert to the "proper" current direction, it would take "extremely frigid conditions in a rather unpleasant locale" for that to ever happen. And there is no point whatsoever in even doing so.

The bottom line to all this? "When in Rome..." as the saying goes. 'Nuff said.

We will end up with a reminder about two of my newest products—my unlocked and unprotected Postscript Show and Tell for Apple, Mac and IBM that show you some laser printing tricks that others swear cannot even be done, and a new and complete set of reprints from my "Ask the Guru" column.

As usual, this is your column and you can get technical help per the "Need Help" box. If you haven't done so already, be sure to write or call for your copy of my brand-new free-stuff list. I do try to add one or two new items each month. **ME**

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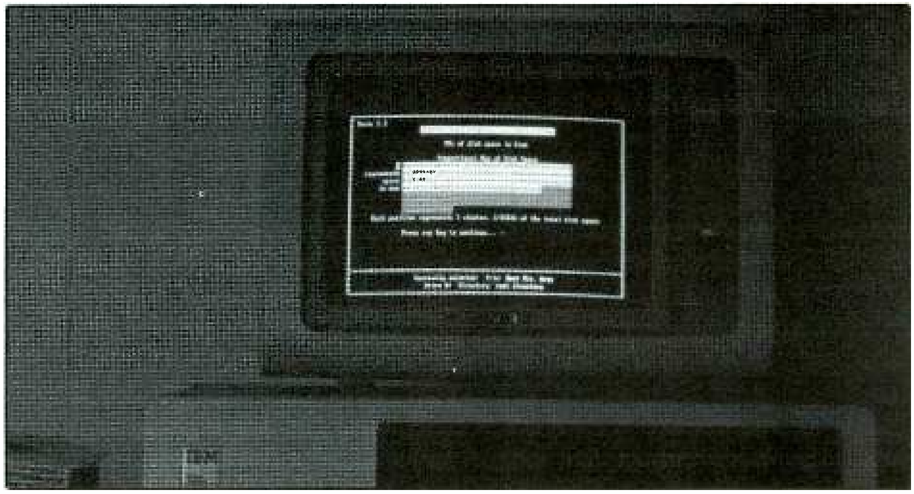
The Disk Optimizer

Program Can Increase Disk Access Speed

By Art Salsberg



The "Disk Optimizer" from SoftLogic Solutions, Manchester, NH, consists of an ingenious program that overcomes a deficiency of PC and MS disk operating systems—using file space on a disk on the basis of what's available first instead of sectors that are near each other.

For example, you might have erased a file, leaving an empty sector, while the next available space may be far away. DOS will blithely commence writing in the empty area and then jump all the way to another part of the disk with fresh space and continue writing. As a result, the disk data is "fragmented," causing the drive's recording head to travel much farther when you access the material for data reading, writing or back-up purposes. This slows up the computer's operation, as well as adds wear to a stepper motor.

Disk Optimizer rearranges the data so that they are next to each other. If your disk files are heavily fractured, which will occur as time passes and you delete and change more and more file data, the whole mechanical operation will start slowing down, turbo boards or no.

The program is designed for hard disk use with DOS (PC or MS-DOS) 2.0 or higher. It's easy to install, is copy protected (drat!), simple to use, and costs only $49.95.

In addition to this program, the disk also contains an optimization analysis program that indicates the percentage of file discontinuity (100% means that all files are contiguous, while 0% indicates that files are scattered all over the disk), file security lock and unlock, and a file peeker program for debugging purposes.

How It Worked

After loading the program, I typed "Analyze," answering a few questions such as which drive, which directory or all directories, specific files, etc. Each file's degree of optimization is then displayed in percentage, with an overall percentage listed for all files chosen.

I chose "All Directories" and watched the files and their respective percentages displayed screen after screen. A number of files earned below 100%, with a few not far from the zero mark. Yes, indeed, I had a handful of fractured files, so I chose to type "Optimize." Pressing the Enter key, since Drive C, the hard disk, was my default drive, the program started.

The program is divided into two parts: directory reorganization and disk cluster reorganization. You don't do a thing except watch the screen to see what's happening. You can interrupt the process if you wish by pressing the space bar, though. The company says you won't lose any data by doing this, but I was not inclined to take a chance so I let the program have its way. (There's no reason why it could not safely be stopped, however, since nothing is in memory during the optimizing process.)

Disk Optimizer's designers cleverly set up the program so that you won't just sit there and wonder if something's being done or not. The display, which represents a proportional map of disk space, has animated illustrations in the form of squares, dashes and dots, each relating to what's being done. When one group is finished displaying the directory reorganization in the form of squares, the next process, hyphens, moves along and wipes out the squares, and so on. The percentage of clusters being organized and the percentage left to finish the job are continuously displayed.

The whole repacking process took about 30 minutes or so the first time. A few weeks later it took less than 10 minutes. Did I notice a difference in operating speed? I certainly did the first time when loading and working with a word-processing system and a database system. I couldn't distinguish any difference the second time around, when disk file's were less fractured, though it likely speeded up things a bit here, too.

I did not try the Password Lock and Unlock program, as I don't really have a need for this and, besides, have other programs that are similar (and unused). If you need such a program, though, and don't have one, then this becomes a bonus. The same goes for the File Peeker program, which I did investigate. I like Norton's disk better for this purpose.

For me, then, the two key programs are Optimize and Analyze. I found both to be very effective. I'll be using them from time to time, I know, just as I use head cleaners regularly but sparingly. So even though you'll be able to live without the Disk Optimizer, you'd be foolish not to spring for its $50 and gain the benefits of speeding up read and write disk access time discernibly after a period of heavy computer use and prolonging the life of your drive.

CIRCLE 50 ON FREE INFORMATION CARD

More Clones, Smart Spelling, Cheap Writing

By Eric Grevstad

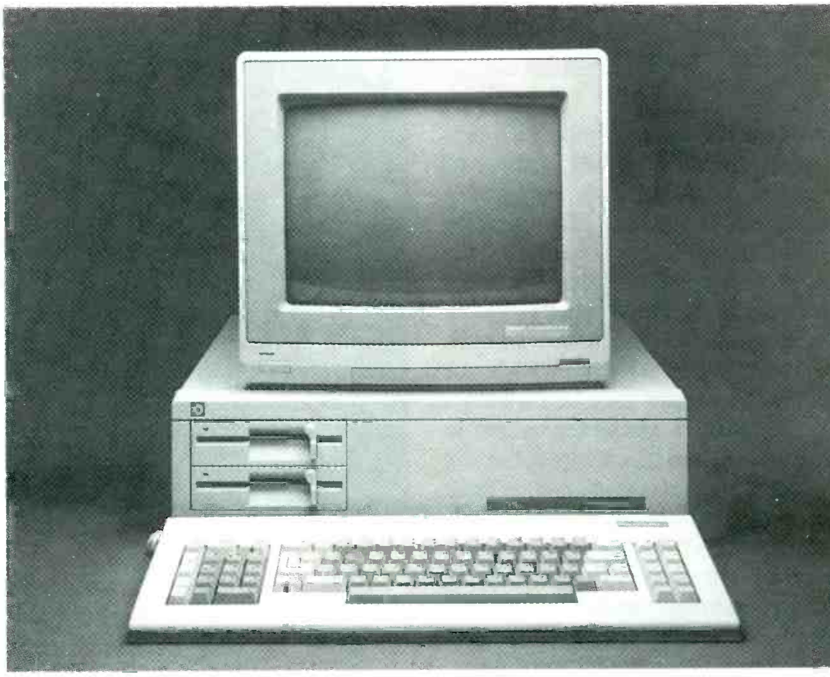
You think I'm not punished for my sins? Last month I complained about going to Las Vegas and seeing so many low-cost clones that "I might have been at the Kitchen Appliance Expo." This month, I went back to grisly Glitter Gulch—for the Consumer Electronics Show, just weeks after Comdex/Fall—and saw even more cheap compatibles. At least this time I had a nice hotel.

The biggest news on the clone patrol is that you can now buy one from any microcomputer manufacturer except Apple. Atari and Commodore have joined the club, even if only to pick up some stray sales rather than downplay their 68000 systems.

Commodore's PC10 follows the conventional design favored by Leading Edge, Epson and, more recently and cheaply, the Hyundai Blue Chip and Victor Champion. Actually, it's an old dog. It was introduced three years ago in Europe, a big lug the size of an AT with an outdated 4.77-MHz 8088 chip, though Commodore throws in an ATI video card and 512K for a steep $999 (with one disk drive). As an MS-DOS market contender, the PC10 is too little and too late—actually, too big and too late.

The Atari PC is more interesting, an application of the ST's closed-box concept to a slotless compatible the size of a monitor stand. It promises 512K RAM, an 8088 running at 8 MHz, parallel and serial ports, one floppy drive, a mouse, and built-in EGA and Hercules video modes for $699 with monochrome monitor. Presumably, you'll be tied to plug-in Atari options if you want a second drive or hard disk.

Finally, Britain's popular Amstrad PC1512 hopes to conquer the U.S. by offering a compromise between open boxes and the airtight Atari: three expansion slots along with the standard stuff (512K, an efficient 8-MHz 8086, parallel, serial, clock, mouse, GEM Desktop and Paint), but a power supply built into the monitor to discourage video upgraders. With prices ranging from $799 (monochrome monitor, one floppy-disk drive) to $1,499 (RGB monitor, 20-MB hard disk system), I like its style.



Commodore's PC clone: Halfhearted entry, outdated machine.

I can't hope to review more than a few of these new clones, but I'm intrigued as I watch the market—it seems a match for the boom of 1983-84, when hundreds of companies like Eagle, Seequa, and Tava each hoped to win 10 percent of IBM's sales. Today, however, three things have changed: prices are less than a third what they were, compatibility is no longer a stumbling block, and today's vendors aren't small hopefuls but good-sized international firms. That may be grounds for a fourth change, the fact that people aren't yet predicting a bloody shakeout like 1984's. Let's keep watching, anyway.

Psychic Technology

There are two kinds of computer typists: those who need all the spelling help they can get, and those who don't need spelling checkers but consider themselves power users, eager to improve efficiency. Both can benefit from the input monitoring technology developed by Airus Inc. for its 1985 spelling checker AI:Typist, now adapted to a word processor called Write Now and a DOS accessory named Detente. Execution isn't perfect, but the idea is the darndest thing you ever saw.

Write Now ($150) does more than those real-time spelling checkers that beep when you make mistakes, though it can do that if you like. Along with a word processor, it loads one of two dictionaries into memory (about 15,000 or 35,000 words plus your additions, depending on available RAM). After that, Write Now watches like a hawk, ready to pounce the instant you misspell a word—more accurately, the instant you form a string not found in the dictionary, such as turning *hou* (which could be part of *hound* or *house*) into *houf*. If you played the word game Ghost, Write Now would never let you cheat.

Depending on your preference, Write Now does one or more things when you make an error—ignoring it, highlighting it, beeping, or popping up a window of suggested words that begin with the correctly typed letters. Moving the cursor to one and pressing Enter replaces the word in your text. Really bad typists can ac-

The Amstrad PC1512: From Hong Kong to Britain to America.

tivate Spell Guard, a slightly fascist feature—it simply won't let you make mistakes, ignoring any keystrokes that would form an unrecognized word.

Write Now's ultimate trick is Clairvoyance, an option which automatically finishes a word for you as soon as you've typed enough for a unique identification —type *notw* and your screen shows *notwithstanding*; *obv* and it's *obvious*. It's utterly *biz (bizarre)*, but it works, and it's fast enough not to interfere with even a quick typist on a slow 8088 system.

You'll need a few days to get accus-

```
WriteNOW 1.13 Page 1   Line 25   Column 29 (98%)   HOAX.LTR
-1-
April 1, 1987¶
¶
Mr. Charles Parks¶                                  SUGGESTIONS
3440 Lincoln Street, Apt. 23¶
Chicago, Illinois 60011¶                         ceramic
¶                                                ceramics
Dear Mr. Parks:¶                                 cereal
¶                                                cereals
    You can imagine how pleased I was to receive cerebral
today regarding my "PC Papers" column.  The word cerebrally
computer users' group has named me "Man of the Y ceremonial
a fan club in my honor is most rewarding.¶       ceremonially
¶                                                ceremonies
    However, I must admit that today's date has  ceremony
as I reread portions of your tribute.  For examp certain
that 12 million Americans faithfully read "PC Pa certainly
more than the entire circulation of Modern Elect certainty
the insistence that I fly to Chicago at my own e certificate
ceremony?  While I could cer
1 Help  2 File Menu  3 Search & Replace  4 Cut & Paste  5 Format Menu  6 Print Menu  7 Spelling Menu  8 Exit WriteNOW
```

Write Now knows (sort of) what you wanted to spell.

tomed, teaching Write Now your favorite words and names and deleting others (the dictionary includes oddballs like *zaslaw* and *varlaam*), and teaching yourself to skip the ends of words to avoid duplicate typing (*obviousious*). More important, the program is useless for catching mistakes made before the triggering letter—the common error *wierd*, for instance, brings the suggestions *wield* and *wielding* instead of the correct *weird*. Still, I quickly got used to Write Now's keystroke savings, even expecting words to finish themselves when I returned to other programs.

I returned to other programs, unfortunately, because Write Now's word processing is no match for its intelligence. There are helpful function-key menus and submenus, some nicely tuned to anticipate alternatives (Y or N as well as F3 for "Yes, Save" or F4 for "No, Discard"), and you can enter text from submenus instead of laboriously returning to the main level. But editing commands are limited. Neither the left arrow nor backspace can wrap around the left margin, and the program is as slow as the speller is fast. After a few paragraphs, you'll give five cursor movement or text highlighting commands before you see the effect of the first.

By contrast, the Airus technology has nothing to hinder it in Detente ($75), a DOS timesaver that takes about 34K of memory plus 14K in command and directory dictionaries for my 10-megabyte hard disk. You can use Spell Guard and beeps or just enjoy the word-processing functions added to the DOS command line, but Detente shines at finishing commands after you type a few letters of a CHDIR directory or a filename (in any directory) to copy or delete.

I wish it didn't copy items from the pop-up suggestion window to the command line with Ctrl-Enter instead of Write Now's more instinctive Enter, but Detente is both a neat gimmick and a slick hard-disk navigator. It's fun to forget about "File not found" and "Bad command or file name."

Names and Addresses

Commodore Business Machines
1200 Wilson Drive
West Chester, PA 19380

Atari Corp.
1196 Borregas Avenue
Sunnyvale, CA 94086

Vidco Inc. (Amstrad)
1915 Harrison Road
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214-297-4898

Airus Inc.
10200 S.W. Nimbus Avenue, Suite G5
Portland, OR 97223
503-620-7000

Ann Arbor Software
313-769-9088

Rave Review Revisited

Forgetting my objectivity as a reviewer, I recently wrote a fan letter to a software company. What's more, forgetting that manufacturers usually give or loan me products for free, I paid for the program involved. That tells you two things: the software's got to be special, and it's got to be cheap.

It's Textra 4.0, the final version of the word processor I first praised in the January 1986 column as prototype 3.1A. Ann Arbor Software's Scott Anderson isn't the world's fastest developer—I'd forgotten Textra over the 14 months from prerlease to production—but 4.0 was worth waiting for the last tweak and printed manual. I've even bought AAS' novel offer of a "subscription" to Textra 5.0, which promises mail merge, spelling correction, and other enhancements in about a year, with partial updates and disk-based documentation every three or four months in the interim.

What Textra offers hasn't changed since my last review: effective word processing, controlled by easy function-key menus (you cycle through them with the F1 key or execute commands directly with Shift or Alt). Documents are limited to 60,000 characters, headers or footers to 39, and you either use the generic printer or customize your own.

But Textra has practically all the editing power you'd ever want, from undelete and timed backup to automatic reformatting and page preview, at up to 20 times the speed of programs costing 10 times as much. Version 4.0 does 4,600 single-character search-and-replaces in five seconds on an old PC, and costs $22.45 without telephone tech support ($42.45 with support; subscriptions to 5.0 are $54.95 or $84.95).

To quote my fan letter, "Textra 4.0 has one of the best, smoothest command structures, the best on-line help, and the most amazing price/performance ratio I've seen in four years of reviewing software." I also wrote to complain that reformatting deletes an occasional hyphen, but once I give a company $50 I think I own the place. **ME**

Microcomputer Operation, Troubleshooting and Repair by Robert T. Payneter. (Prentice-Hall. Hard cover. 413 pages. $29.95.)

This book's objective is to provide an understanding of how microcomputers operate and show how this knowledge can be used in troubleshooting and repair work. The large (8½" × 11¼") book is amply illustrated with drawings and schematics. Its major strength, discussions of the inner workings of the microcomputer, concentrates on an old-technology 8-bit Z80 computer and 6800 trainer, with only a short "introduction" to 16-bit machines.

Though the computer-specific material represents a comprehensive course in 8-bit microcomputer technology, it is less useful in a world where 16-bit machines take center stage. On the other hand, it does provide groundwork training for understanding microcomputers, whatever the system, and the sections that deal with peripherals and interfacing hold true regardless of the processor's structure and, thus, are much more useful.

Troubleshooting information is not as comprehensive as the other material. In fact, it is bare bones. Few types of problems are discussed, essentially being the hand-holding variety in which scenarios are given and then analyses and then possible solutions. In sum, this book does not live up to the mark of its full title, since it focuses so heavily on operation. Nonetheless, the depth of its coverage can set up the reader for truly understanding how a microcomputer works. Thus, it can serve very well as a jumping-off point for troubleshooting a microcomputer.

62 Home Remote Control and Automation Projects by Delton T. Horn. (Tab Books. Soft cover. 272 pages. $12.95.)

True electronics experimenters will find this book to be a source of projects and ideas that can make life just a bit easier and/or more exciting. It contains a host of electronic projects designed to control everything from electric lights and appliances to automatically greeting guests at the front door to killing TV commercials.

Where appropriate, basic electronics theory is provided, though this is basically a projects book. For example, if a project has a timing circuit that can be adjusted for different periods, the text explains how this is done and gives the formula(s) for doing it. There is a nice opening chapter that deals with the basics of remote control and automation to get the ball rolling. The momentum is maintained in chapter 2, which discusses the building and customizing of the projects. From then on, it is projects, projects, projects!

The 62 projects described are grouped according to category. There are 11 individual control categories, which make up separate chapters. These include lighting, windows and doors, temperature, liquid, audio and video, telephone, motor, wireless, computer and more. These represent a variety of useful projects, such as, an entry alarm system, boiler controller, plant monitor, recorder timer switch, off-hook telephone alarm, and automatic-off circuit, to name just a few.

Television Theory and Servicing by Charles G. Buscombe. (Reston Publishing Co. Hard cover. 838 pages. $34.95.)

Here is a book written to help the TV service technician do a complete, efficient job of troubleshooting and repair of TV receivers of all kinds. It is not just a manual that deals with a few representative chassis, as so many TV servicing books are. Rather, it is structured to give him an intuitive feel for problems and cures for any TV receiver chassis. The first two chapters present fundamentals at the broadcasting and receiving ends. Following this come test equipment and the troubleshooting approach that leads up to fault isolation. The remainder of the book discusses various subsections that make up a TV receiver, concluding with a final chapter on sample circuits from a typical modular color TV set.

Easy-to-read text is profusely illustrated with schematics, block diagrams, waveforms, line drawings and photos. Where helpful, the text is further supported by troubleshooting flow and problem/probable-cause/solution charts that maximize troubleshooting and repair productivity.

The book is also a procedures training manual. Each chapter ends with a series of review questions and most with a troubleshooting questionnaire as well. Treatment of TV servicing is unusually well-rounded, placing this in the top 10 percentile of books devoted to the topic.

How to Read Schematics, Fourth Edition, by Donald E. Herrington. (Howard W. Sams. Soft cover. 258 pages. $14.95.)

Knowing how to read schematic diagrams is essential to understanding electronics, of course. If you're weak in this area, this book provides in text, schematic, drawing and photo form much of the information you need to learn how to read schematics. It does so with the aid of easy-to-understand text and schematic symbol identifiers. Every component symbol introduced is shown in virtually every possible configuration you are likely to find.

This book is mistitled—to the reader's benefit, we hasten to add—because it is much more than its title implies. It is not merely a book that shows you how to follow th electronic "road map." With the aid of photos and drawings, it helps you to identify electronic components by physical characteristics as well as by schematic symbol. Along the way, it covers just enough electronics theory to help you understand why the various components are arranged in specific ways in schematics. (Review questions are at the end of each chapter.) Thus, it takes you beyond simple reading of schematics into the related realms of servicing and troubleshooting of electronic equipment.

From the foregoing, it should be obvious that this is an introductory book. After fulfilling its primary objective, it appears to have a secondary objective, that of motivating the reader to pursue electronics in more depth. If this was indeed the intent, this book succeeds.

NEW LITERATURE

Process Measurement Handbooks. Omega Engineering has released its complete slip-cased five-volume 1987 technical library of Process Control Measurement Handbooks that contain more than 1,700 full-color pages and list thousands of off-the-shelf products. The Handbooks cover the following categories: Temperature, Pressure, Strain and Force, Flow and Level, pH and Conductivity, and Test Instrumentation and Tools. The Handbooks are free by writing to: Omega Engineering, Inc., One Omega Dr., P.O. Box 4047, Stamford, CT 06907.

Solid-State Replacement Guide. A new edition of the RCA "SK Guide to Reliable Replacement Semiconductors" has been announced. It contains listings for 2,900 SK and KH semiconductors that reportedly replace more than 214,000 different brand-name/number devices. Included for the first time are QMOS logic and an extensive line of r-f devices. The RCA SK Replacement Guide, No. SKG202E, is available for $3.25 per copy from RCA SK products distributors or by mail by writing to: RCA Special Prods. Div., Box 597, Woodbury, NJ 08096-2088.

CB Radio Accessories Catalog. Midland's new full-color "Hot Line for 1987" catalog lists the company's full line of base-station, mobile and portable CB radios. Highlighted in this 24-page catalog are full details for 19 different CB radios, an extensive line of mobile CB antennas, and accessories. For a free copy of the catalog, write to: Midland International, Consumer Prods. Div., 1690 N. Topping, Kansas City, MO 64120.

Surface-Mount CMOS Brochure. Availability of a surface-mount brochure for CMOS Special Functions has been announced by Motorola. The brochure details the different package dimensions and capabilities available for the company's CMOS Special Function devices: A/D and D/A converters, PLL/frequency synthesizers, decoders, display drivers, smoke detectors, remote controls, op amps and comparators. It describes plastic leaded chip carrier (PLCC) and small-outline IC (SOIC) package structures and advantages. For a free copy of Brochure No. BR503, write to: Motorola Literature Distribution Center, P.O. Box 20912, Phoenix, AZ 85036.

RF Data Book. The fourth edition of the Motorola *RF Data Manual* has been updated to include more than 100 new parts and four additional application notes. For the first time, small-signal plastic parts have also been included. The nearly 1,500-page manual has been reorganized for ease in locating particular devices. A revised selector guide and a cross-reference further simplify selection of r-f products. The manual is divided into six sections: Index and Cross-Reference; Selector Guide; Transistors; Amplifiers; Tuning; Hot Carrier and PIN Diodes; and Technical Information. To obtain a copy of *RF Data Manual* No. DL110/D, send $4.75 to: Motorola Literature Distribution Center, P.O. Box 20924, Phoenix, AZ 85063.

Bar Code Network Pamphlet. Intermec's new "Making the Bar Code Connection" pamphlet discusses bar-code collection networks. It details stand-alone, on-line, fully integrated and hybrid bar code networks and discusses the advantages and disadvantages of each. Also reviewed are simple collection networks that use personal computers and more advanced networks that rely on bar-code readers for preprocessing data before transmission to a mainframe computer. Typical network configurations, using Intermec's CrossBar™ data collection network, illustrate each section. For a free copy, write to: Intermec Corp., 4405 Russell Rd., P.O. Box 360602, Lynwood, WA 98046-9702.

Valuables Minder

Active Reminder is a two-piece system from CW International Corp. (Dallas, TX) that provides an invisible link between you and your valuables. Its transmitter goes on or in whatever (or whomever) you wish to keep tabs, while the receiver remains with you. Whenever the transmitter and receiver are separated by more than 15 to 30 feet, the latter will beep to remind you that you forgot to take your valuables (or a thief has taken off with them) or your child has strayed away. The system features automatic power on/off and low-battery warning. The two components can be locked together when not in use. $28.

CIRCLE 34 ON FREE INFORMATION CARD

Mini Radar Detector

Radio Shack's smallest and its most sophisticated radar detector is the dual-conversion superheterodyne X/K-band Micronta Road Patrol XK (Cat. No. 22-1617). The detector is small enough to fit into a shirt pocket. It has False Alert Suppression Technology (FAST) to guard against annoying false alarms triggered by some other radar detectors.

The Road Patrol XK gives warning of both X- and K-band radar with separate tones and LEDs that automatically adjust for day and night driving conditions. Included is a switch for selecting city and highway conditions. A gallium-arsenide Schottky diode front end is claimed to assure superior detection of low-level and pulsed radar systems.

Supplied with the Road Patrol XK is a dc power cable that plugs into the cigarette lighter socket, a sunvisor clip, hook-and-loop tape, double-faced tape, a wire clip and a soft carrying case. $199.95.

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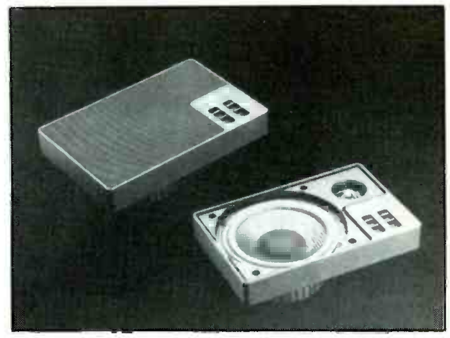

Adjustable Crossover Car Speakers

Two new "Voice of the Highway" automotive speaker systems are available from Altec Lansing. The ALS-500 and ALS-525 two-way speaker systems can handle high power at low distortion with extended low- and high-frequency response. Adjustable crossovers allow the user to tailor the sound to his preference or the car's acoustical environment. The ALS-500's passive crossover and ALS-525's crossover module provide 6- and 12-dB/octave midrange frequency control with 3 dB of boost at 3.5 kHz, and 3-position high-frequency level control provides high-pass ajustments at 12 dB/octave.

The ALS-500 can be mounted in a standard 6″ cutout. More flexibility is provided by the ALS-525's separate woofer, tweeter and crossovers, which can be mounted in different locations. All speakers have high-energy strontium magnets. Carbon-fiber cloth long-throw, high-compliance 5¼″ woofer cones and ¾″ polymide dome tweeters with ferrofluid cooling are featured in both models. The woofers have double-damper construction and 1¼″ voice coils with four layers of flat ribbon wire.

Rated power handling of both models is 100 watts maximum (50 watts nominal); frequency response is 60 Hz to 22 kHz, ±3 dB; efficiency is 89 dB at 1 watt/meter; and distortion is less than 1% from 100 Hz to 7 kHz. $250 per pair for ALS-500; $270 per pair for ALS-525.

CIRCLE 36 ON FREE INFORMATION CARD

LETTERS . . . *(from page 5)*

from each channel is 100 watts into 4 ohms (200 watts total with both channels driven). There is no distortion specification because a normal linear distortion measurement just does not work with an amplifier whose output is a 64-volt peak-to-peak square wave.

One reason the sound produced by the digital amplifier is better than with a linear amplifier is that 64 volts is instantaneously delivered to the speaker's voice coil. Current flowing in an inductor is proportional to time; driving the speaker with a large-excursion square wave forces the voice coil into the desired position, so the circuit does not have to wait for the field to build up when a voltage is applied.

Updates: CR1 through CR4 should be unitrode diode type BYM29—not the BY299 given in the schematic; the correct type number of the p-channel power MOSFET is IRF9530; CR1's cathode goes to the +35-volt supply (as shown for CR3/Q3); all npn transistors are 2N2222 types, and the output inductors should be wound with 21 turns each.

—C. Barry Ward.

• My apologies to readers who have had problems with the program in AC-to-DC (May 1986). The remark in line 1 should read "REM LOAD CURRENT Conversion". The variable VO in line 550 should be V0. The = in the last statement of line 2060 should be >. The statement should read "IF ZX>0 THEN 2060". The program will run faster if an ARCSIN function is substituted for the subroutine beginning A0 = ATN(S0/SQR(1 – S0*S0)).

Duane M. Perkins

• In the September '86 Letters column, a reader wrote about a problem running the "AC to DC Conversion" program (May '86). The author pointed to the ARCSIN routine as the likely culprit. I had similar problems. I found that, indeed, the problem was the ARCSIN routine. After carefully checking that it was input properly, I tested the subroutine separately and found that the results were significantly in error on my C-64. Luckily my C-64 has an ARCTAN function from which the ARCSIN can be derived. After deleting lines 2050 through 2080 and substituting the following lines, the program worked perfectly!

```
2050 A0 = ATN(S0/SQR(1 - S0*S0))
2080 RETURN
```

Readers who don't have the ARCTAN function can use the following:

```
2050 AZ = P/4
2060 SZ = SIN(AZ):IF ABS(S0 - SZ)
  <1E - 5 THEN A0 = AZ:RETURN
2070 AZ = AZ + (S0 - SZ)/COS(AZ):
  GOTO 2060
2080 RETURN
```

This successive approximation method slows things down only a little.

Bill English
Orinda, CA

EPROM Burnout

• The "EPROM Programmer for the Commodore 64" in the November 1986 issue had some errors: in the Parts List, D4 should be a 1N4148, and in Fig. 2, pin 18 of IC2 is actually pin 15 and the pin 16 that goes to +5 volts is actually pin 20. The program listing had no errors, making life much easier. Thank you for publishing projects dealing with EPROMs, and keep up the good work!

Brian L. Miller
Johnson City, TN

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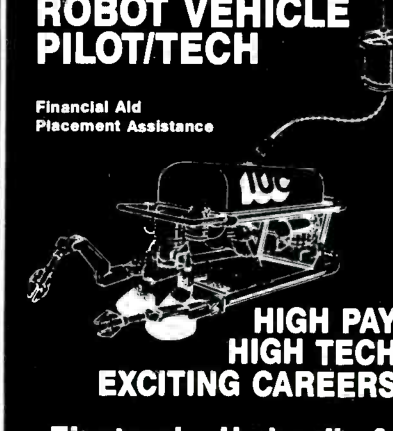

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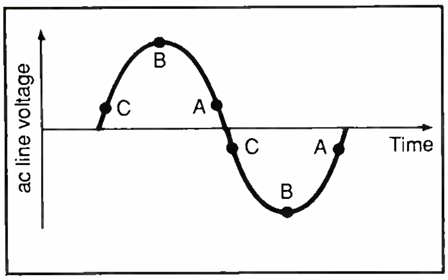

Fig. 7. A, B and C indicate voltage trigger points for Fig. 6. circuit.

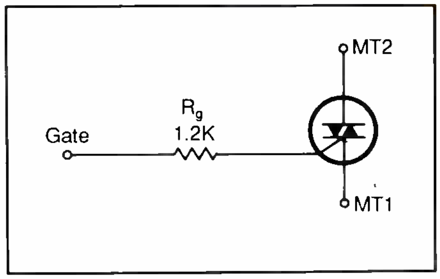

Fig. 8. Series gate resistor R_g is added to stretch gate-trigger pulse.

discharges through it and the triac's gate. When this happens, the thyristor triggers on and remains that way for the remainder of that half-cycle of line voltage.

If a diac were not used, the Triac's gate would act as a diode in parallel with *C2*. Therefore, *C2* would charge enough to forward bias only this diode (MT1 to gate) before triggering the triac and discharging. You could substitute a neon lamp for the diac, though this would cause the minimum trigger point to be closer to point B than to point A.

In addition to giving *C2* more time to charge, the diac serves another purpose. By letting *C2* store a large charge, it allows triggering current to be a high-magnitude pulse instead of a gradually increasing ramp. Manufacturers recommend this type of triggering because it reduces the switching time, which minimizes the power dissipated in the triac.

Loose Ends

When a thyristor is triggered on, it immediately connects the ac line voltage to the load connected in series with it. If the load happens to be inductive, such as an electric motor, current will lag behind by as much as 4 milliseconds. Without an initial flow of current, called the "latching" current, a thyristor will immediately shut off. The latching current is usually less than twice the holding current. Therefore, when the load is inductive, a longer-duration gate trigger pulse is required to keep the thyristor on until a latching current is reached. This is generally accomplished by increasing the time constant of the gate circuit. In Fig. 8, a series 1,200-ohm resistor stretches the pulse of gate current discharged from the gate capacitor.

When a thyristor is constantly switching on and off, it generates radio frequency interference (rfi). This electrical noise travels along the ac power line, radiating undesirable interference. By using a 100-microhenry r-f choke and a 0.1-microfarad capacitor in the circuit, as shown in Fig. 6, rfi is reduced. If a thyristor is used as a full-on/full-off switch (not as a variable power control), an rfi filter is seldom required.

Now that you know how thyristors operate and how they can be used, it is time to think up applications of your own. Keep in mind that thyristor applications are not limited to high-voltage switching and control. You could just as easily build a circuit to control power delivery to a load from a 12-volt transformer. **ME**

Sinclair/Timex *(from page 29)*

commence immediately based only on that information already stored in the Buffer.

If during downloading the information exceeds the capacity of the Printer Buffer, the Buffer automatically switches back to Buffer Mode and printing commences immediately. Only one copy will be printed.

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Conclusion

This reworking of the basic ZX81/TS1000 gives new life to these computers. With just a few dollars and a few hours of your time, you'll restore an idle computer to useful service and more than recoup whatever monetary investment you made for it in the first place. **ME**

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