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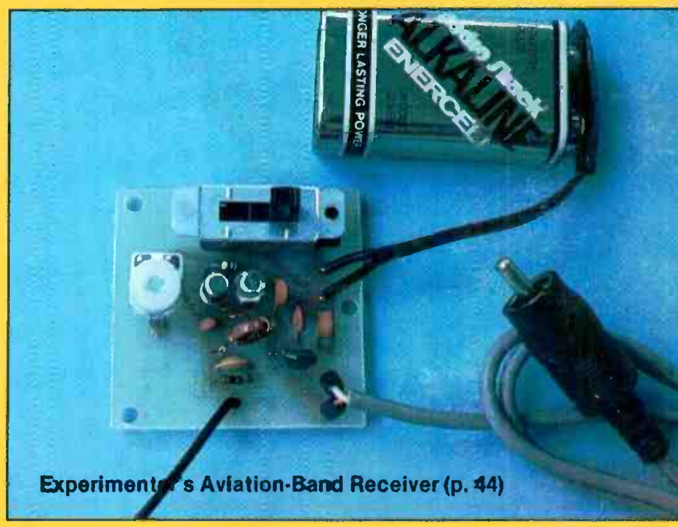
- **Upgrading Radio Shack's Color Computer**


Experimenter's Aviation-Band Receiver (p. 44)

Complete Construction Plans:

- **Electronic Dice**
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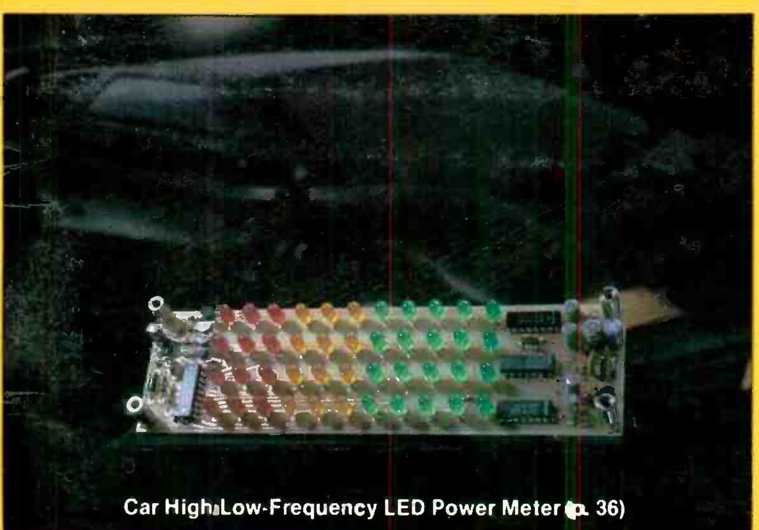
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Plus: Forrest Mims on Piezoelectric Buzzers • Eric Grevstad previews Epson and AMQ Compatibles, Personal Publisher • Don Lancaster answers readers' questions • Glenn Hauser reports from the Caribbean • New Technical Books • Electronic & Computer News . . . and more.

New GPS Series: Tek sets the pace with SmartCursors™ and push-button ease.

Work faster, smarter, with two new general purpose scopes from Tektronix. The four-channel, 100 MHz 2246 and 2245 set the new, fast pace for measurements at the bench or in the field. They're easy to use and afford, by design.

On top: the 2246 with exclusive integrated push-button measurements. Measurements are accessed through easy, pop-up menus and implemented at the touch of a button. Measure peak volts, peak-to-peak, ± peak, dc volts and gated volts with new hands-off convenience and on-screen readout of values.

SmartCursors™ track voltmeter measurements in the 2246 and visually indicate where ground and trigger levels are located. Or use cursors in the manual mode for immediate, effortless measurement of waveform parameters.

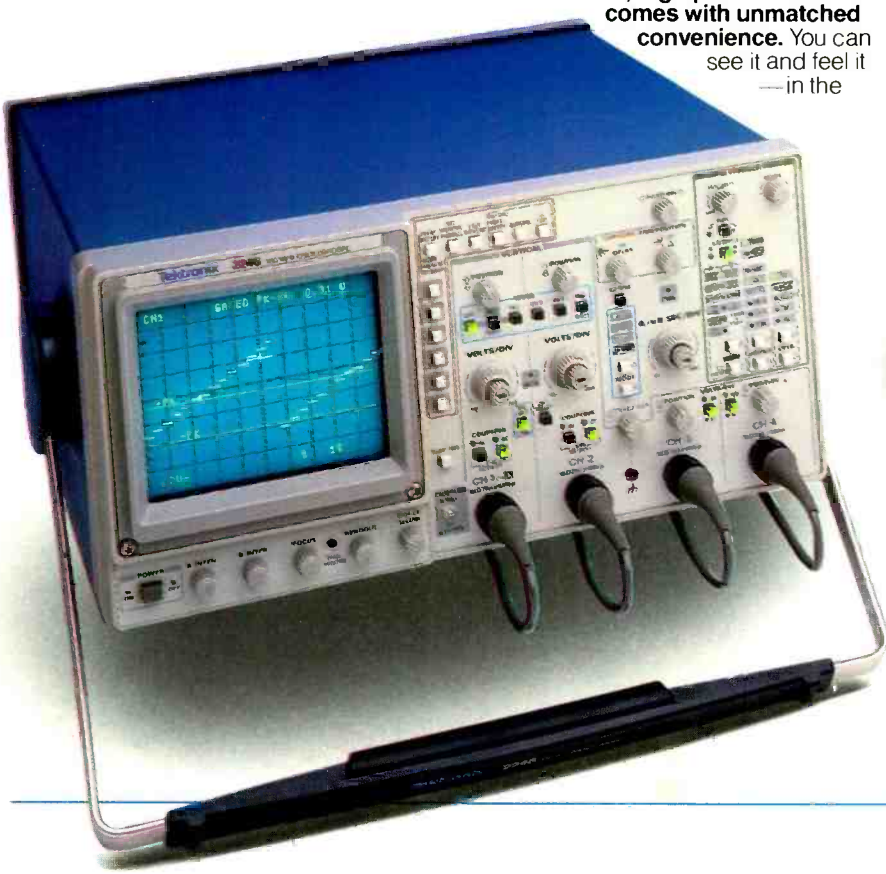
Both scopes build on performance you haven't seen at the bandwidth or prices. Lab grade features include sweep speeds to 2 ns/div. Vertical sensitivity of 2 mV/div at full bandwidth for low-level signal capture. Plus trigger sensitivity to 0.25 div at 50 MHz, to 0.5 div at 150 MHz.

Accuracy is excellent: 2% at vertical, 2% at horizontal. And four-channel capability includes two channels optimized for logic signals.

Best of all, high performance comes with unmatched convenience. You can see it and feel it — in the responsive controls and simple front-panel design, in extensive on-screen scale factor readouts, and in simplified trigger operation that includes Tek's Auto Level mode for automatic triggering on any signal.

Contact the Tektronix office or sales representative nearest you for complete details. Each scope is backed by Tek's three-year warranty, plus excellent documentation, training programs and outstanding service support — worldwide.

Features	2246	2245
Bandwidth	100 MHz	100 MHz
No. of Channels	4	4
Scale Factor Readout	Yes	Yes
SmartCursors™	Yes	No
Volts Cursors	Yes	No
Time Cursors	Yes	No
Voltmeter	Yes	No
Vertical Sensitivity	2 mV/div	2 mV/div
Max. Sweep Speed	2 ns/div	2 ns/div
Vert/Hor Accuracy	2%	2%
Trigger Modes	Auto Level, Auto, Norm, TV Field, TV Line, Single Sweep	
Trigger Level Readout	Yes	No
Weight	6.1 kg	6.1 kg
Warranty	3-year on parts and labor including CRT	



Featuring four channels, flexible triggering, extensive CRT readouts and push-button ease of use, the new Tek 2246 (left) and 2245 (above) bring high-quality, low-cost analysis to diverse applications in digital design, field service and manufacturing.

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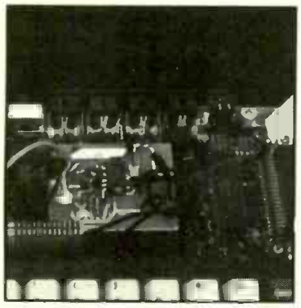
THE MAGAZINE FOR ELECTRONICS & COMPUTER ENTHUSIASTS

SEPTEMBER 1986 **VOLUME 3, NUMBER 9**



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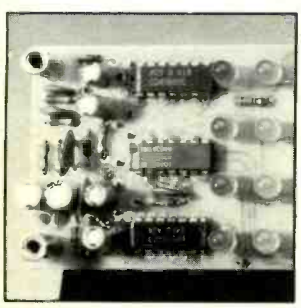

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EDITORIAL

Surging Back

You can't always count a product out when it loses favor. For a brief time, stereo hi-fi components seemed to have lost their appeal to some extent. In 1984, for example, factory sales dropped some 28 percent in dollars. We all heard that video was usurping its steady growth position, that personal computers had captured everyone's interest in its place, and so on. But as soon as the compact disc and player fired consumer interest, separate audio component sales surged back.

Some electronic products have "died," resurged, and then lost their appeal for one reason or another. CB radio is an example. Others showed enormous promise, such as videodisc players, going toe to toe with competing systems—in this case, videocassette recorders—only to lose out in the sales numbers game. Will it have another day? Then there are products that display cyclical appeal, such as personal computers. These machines had a relatively bad year in 1985, though the word "relatively" has to be underscored when talking about unit sales that exceeded four-million (down about one-million from the previous year).

Cordless telephones were "hot" in 1983 and 1984, the latter year peaking at 6.3-million units sold to dealers. Sales dipped appreciably to 4-million units in '85, though better designs that used dual frequencies and security codes were introduced to spur sales. So far, however, they haven't reached their previous popularity level.

Audio tape recorders are taking a back seat to CD players in the hearts and minds of people nowadays. But looming in the background, probably scheduled for 1987 introduction, is digital audio tape (DAT), which promises sound quality that approaches that of a laser-generated CD disc system, while adding recording capability. So here's a product that could, indeed, surge back.

Will cheap computers enjoy a resurrection? With low-cost IBM clones in abundance today and a greater awareness on the part of the public concerning what inexpensive computers can—and cannot—do, it's doubtful. Even Commodore International, which moved about 2¼-million computers last year, is facing financial troubles. Low-cost computers declined by one-third last year on a world-wide basis. Nevertheless, Commodore has introduced an upgraded model C-64 with a graphics video environment—icons, mouse, pull-down menus—to stem the tide. Will this lead to a resurgence? Time will tell.

Household penetration is an indication, too, as to how popular a product is and how much play there is in sales potential. For home computers, 15% penetration is the estimate. So it's still a business/professional-oriented world for computers. Even VCRs, as popular as they are and as low as their selling prices have become today, were only in about 30% of U.S. homes by the end of 1985. At that juncture, it's interesting to note that 64.7% of *Modern Electronics* readers owned VCRs. Sony tried to bolster Beta-format sales by introducing hi-fi stereo sound, only to be matched by a similar development by VHS makers, so a resurgence there is unlikely. Now 8-mm and VHS-C camcorders are jockeying for position.

Will breadboarding of circuits slide away due to the rising star, computer-aided design (CAD)? More and more professional design engineers now sit in front of a computer workstation to design circuits instead of going to the breadboard/solder iron route, so it's possible. Prototypes will eventually have to be breadboarded, though. On second thought, this might be done directly on a pc board whose foil pattern was generated by computer.

It's rare to find a product that lost favor bouncing back unless some special advance calls for this to happen. Amateur radio, for example, does not exhibit growth in this country. But if the Morse Code test requirement was lifted, as it has been in many other countries, burgeoning equipment sales will surely follow.

Meanwhile, we'll all watch the moves that manufacturers make in enhancing older technology to capture our imagination as well as new technology that's implemented in a way that induces us to upgrade whatever we own.

Art Salsberg

LETTERS

Glitches

• There appears to be a problem in the V(MIN) segment of the program for the "AC to DC Conversion" article (May 1986). Any help you can give me in getting this program up and running will be greatly appreciated.

Charles Harter
Rock Spring, WY

The author replies: If you've correctly entered the program and routine and find V(MIN) isn't working correctly, most likely the arc sin is being entered incorrectly. The article notes that the arc must be in radians, not degrees. If you're using the ARC SIN subroutine starting at line 2000, it will return the arc sin in radians. Test the subroutine independently of the rest of the program to be sure it's working correctly. If you call it with S0=.7071, it should set A0=.785398. The subroutine iterates until it finds the point at which the secondary voltage equals the voltage across the capacitor plus the diode drops; that is, the point at which the charging interval begins, which is V(MIN).

In Fig. 3, Vsupply should connect to Q2's drain and Q1's collector, not as shown to Q2's source. Also, the end of the fourth line in the box on page 34 should read "0.6 volt."—Duane M. Perkins.

• Several glitches appear in the published version of the BASIC listing for my article "This is Your Computer Speaking" (June 1986). In line 75, the number 824 should be 8243, and line 192 should start "DATA2 . . ." and continue from there as shown. Also, to prevent a carriage return after each letter, line 135 should read: "135 PRINT A$;" (note the closing semicolon).

Barry L. Ives
Binghamton, NY

OS-9 Info

• In the June 1986 "Hardware Hacker" column, some ambiguous and incorrect information was reported from *Infoworld*. The CD-I system cited is based on the 68000 version of Microware System Corporation's OS-0 operating system. OS-9 has been around since 1980 and runs on a considerable variety of 6809 and 680xx-based computers, so it isn't quite right to characterize it as "the Tandy Color Computer operating system."

OS-9 is a good system for hackers (among others); its modular design and wide variety of hardware configurations it can run on make it possible to develop software on a large system and then move the very same executable code to a much smaller system. Thus, one can quite easily have a dedicated multitasking system with only the modules one needs to get the job done. To find out more about OS-9, contact the CompuServe OS-9 SIG and the OS-9 Users Group, 9743 University Ave., Suite 330, Des Moines, IA 50322.

James Jones
Norman, OK

MODERN ELECTRONICS NEWS

ANTI-STATIC SEATING. With electronic devices and computer susceptible to damage by electrostatic discharges, anything that can be done to minimize this problem is welcome. Uniroyal's recently introduced anti-static NaugaStat U® upholstery fabric is an interesting step in this direction. The special grade of vinyl-coated material is said to help control static generated by chair and operator movement. According to the company, the new material has the capacity to dissipate a 5,000-volt charge in less than two seconds when using a suitable grounding path.

ROBOT SAFETY STANDARD. The first American National Standard for industrial robots has been approved by ANSI, establishing guidelines for construction, installation, and use of robots to safeguard people who work with them. There have been few robot-related accidents to date, but as the U.S. robot population increases from about 20,000 to an expected 75,000-100,000 in the next decade, proper safety procedures will be essential. Robot shipments in 1985 rose 33 percent to about $443 million.

ELECTRONIC CAR NAVIGATION. An automotive navigation system concept is not new. There have been a host of developments, all very expensive; all depending on external assistance schemes such as satellite transmissions and road induction loops. Now, however, a European company, the largest supplier of automobile dashboard instrumentation, might change all this. The company, VDO Adolph Schindling, has developed a $400 navigation system that employs the earth's natural magnetic field as a guidance reference point. Called Citypilot, the system is said to provide guidance accuracy to within 3 percent of the distance traveled. A light pen is used by the driver on a bar-coded map to plot the journey, which is inputted to an onboard microcomputer that displays distance and location information on a liquid-crystal display.

THE OLDEST MICROCOMPUTER? In a contest held by the Computer Museum located in Boston, Mass., the Kenbak-1 8-bit micro built in 1971 won. The designer, John Blankenbaker, said that about 40 machines were sold to schools with 256 bytes of memory, a 1-MHz clock and a serial memory organization. It only provided 1000 instructions per second, so was really an educational machine--not one that could be used, even if expanded, for applications programs. The MITS Altair 8800 was really the landmark computer, though, using a CPU that could address a lot of memory and a bus structure, the Altair bus, eventually dubbed the S-100, coupled with BASIC created by Bill Gates who later formed Microsoft.

VHS/8-mm COMBO VCR. Samsung Electornics created a storm at the Summer Consumer Electronics Show when it showed a prototype dual VCR deck that had VHS and 8-mm provisions on board, permitting dubbing from one to the other. The rub, to the Motion Picture Association of America (MPAA) was unauthorized copying prospects.

SHOCK ABSORBER.

RCA's Power Safe surge suppressors absorb voltage surges before your customers' electronics get damaged.

Now you can help your customers protect their expensive electronic equipment from sudden shock with two new surge suppressors from RCA.

The Power Safe (SK406) protects TVs, computers, microwaves and more by absorbing transient voltage surges resulting from nearby lightning strikes, load switching and other causes before the surge hits the equipment. Handsomely designed and easy to install, this handy six-outlet strip simply plugs into any grounded wall outlet.

The Power Safe Plus (SKF406) protects every way the Power Safe does, plus it filters out electronic noise interference. The suppressor's high-frequency bi-directional filter senses, absorbs, and dissipates noise interference before it can reach the equipment.

Together, they have the potential to become powerful profit builders for you.

To learn more about this shock-absorbing team, see your RCA Distributor. Or contact RCA Distributor and Special Products Division, Deptford, NJ 08096-2088.

RCA Distributor and Special Products Division

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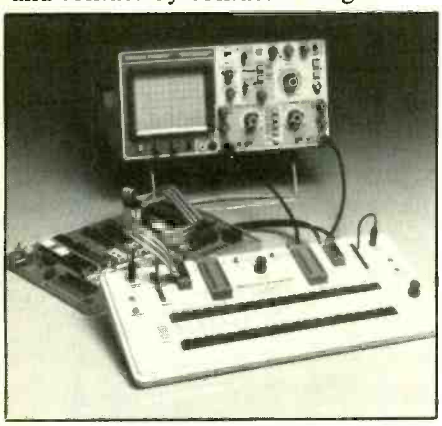
For more information on products described, please circle the appropriate number on the Free Information Card bound into this issue or write to the manufacturer.

Component Tester Accessory

Beckman's new Scopemate 2 oscilloscope IC and component tester accessory offers both in- and out-of-circuit test capabilities. It can be used with all types of analog, digital and hybrid components. The accessory compares a suspect device against a known good one, eliminating tedious pin-by-pin and contact-by-contact testing.



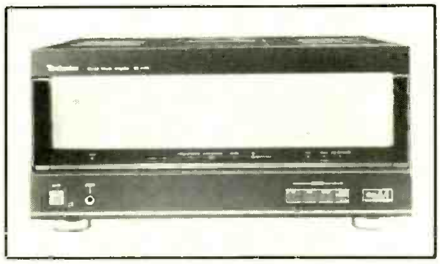
Connected to any dual-trace X-Y oscilloscope, Scopemate 2 tests for shorts opens, diode action and leakage by applying up to 14 volts rms at 300 mA to compare unpowered devices. It displays both good and bad signatures of the component being tested. Results are displayed as a graphic waveform, rather than in a numeric format that requires interpretation. Major differences in component signatures indicate a malfunction in the device being tested.

Supplied are an operators manual, two scope interconnect cables, four banana-to-clip leads, four banana-to-ground leads, 20- and 40-pin extenstion test cables and a plug-in power transformer. Scopemate 2 measures 14.5″ × 7″ × 1.5″ and weighs 3.1 lbs. $395.

CIRCLE 1 ON FREE INFORMATION CARD

Power & Control Amplifiers

Technics has a pair of premium-



quality stereo products built around new class-AA circuitry. The Model SE-A100 stereo power amplifier develops 170 watts/channel into 8 ohms, 20 Hz to 20 kHz, at 0.0007% THD. Separate transformers in each current drive amplifier and a third transformer for the left and right channel voltage control amplifiers are said to help eliminate interchannel interference through the power supply. Two large power meters give readings from 0.0001 watt to 300 watts. $1,500.

Class-AA technology in the Model SU-A200 control amplifier's phono equalizer and output circuit provide a rated S/N of 80 dB for MM and 73 dB for MC cartridges at 0.0008% distortion, 20 Hz to 20 kHz. Eight audio inputs are supplemented by one set of VCR input/output jacks, front and rear audio outputs and a video monitor output. CD signals can bypass the filter circuits and go directly to the volume control. A background video function allows the user to listen to one source while viewing another. $1,000.

CIRCLE 2 ON FREE INFORMATION CARD

Floppy-Based Handheld Computer

Sharp's new Model PC-1600 handheld computer features storage on 2.5″ disks with an optional microfloppy drive. The tiny computer features the first fiber-optic interface to be used in a handheld. A Z80A-like proprietary microprocessor is about 2.5 times faster than that used in Sharp's PC-1500 computer. The PC-1600 is software compatible with the PC-1500 and accommodates many of the peripherals designed for the PC-1500.

Featured are: 16K of RAM (expandable to 80K); a 4-line by 26-character LCD display; the fiber-optic interface; an analog input; an RS-232C serial interface; separate alphabetic keyboard and numeric keypad; a 60-pin I/O bus; and BASIC interpreter in ROM. Options include the microfloppy drive with 128K capacity; a 4-color pen plotter/cassette interface and a 32K RAM module. The computer measures 8″L × 3.5″W and weighs less than 1 lb. $345.

CIRCLE 3 ON FREE INFORMATION CARD

Deluxe Handheld Scanner

Regency's new Model HX1500 handheld programmable scanner provides a 55-channel capacity, 11 popular bands and selectable chan-

nel banks. Designed to compete in versatility with basestation units, it is claimed to offer more channel capacity than any other scanner on the market. Band coverage includes 10-meter Amateur; vhf low; vhf AM; vhf/AM Aircraft; Space Research; vhf Amateur; vhf high; Federal and Government Land Mobile; uhf Amateur; uhf; and uhf-T.

A sealed rubber keypad beeps when keys are pressed, and an LCD window displays the frequency entered and flashes messages that aid in programming. Channels can be grouped into any of four banks for fast scanning and easy access. A top-mounted control allows the user to activate the scan mode without removing the scanner from his belt. Included are dual scan speeds, priority channel, scan delay, search, direct channel access, earphone, flexible antenna and diecast aluminum chassis. $369.95.

CIRCLE 6 ON FREE INFORMATION CARD

Tiny 8-mm Camcorder

Claimed to be the world's smallest 8-mm camcorder, Olympus's 3.3-lb. Model VX-801 provides a 6× power zoom lens with auto focus, auto exposure and automatic white balance; dubbing and editing capabilities; and the ability to record from other video sources. An f1.2 lens and CCD image sensor allow recording under ambient lighting down to 10 lux.

Up to two hours of recording time is possible on a single cassette. Auto focus can be manually overridden, and two programmed white balance positions can override automatic white balance. Focus lock permits the user to pan, zoom in or out of a scene, and maintain sharp focus on one stationary object. A macro setting is provided for close-up shooting. The zoom lens has a 9-to-54-mm focal length range.

A flying erase head provides smooth transitions between scenes and other editing effects. An insert button makes editing from another

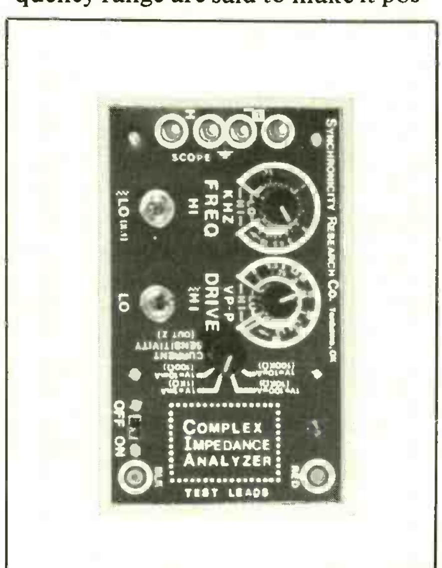
video player as easy as pressing a button. Two rotating heads in the FM recording system produce hi-fi monaural sound. The built-in electronic viewfinder can be adjusted to satisfy individual vision. Supplied are a unidirectional microphone, an ac adapter/charger and a 2-hour rechargeable battery pack.

CIRCLE 7 ON FREE INFORMATION CARD

Complex Impedance Analyzer

An advanced component analyzer that retrofits to an ordinary oscilloscope to display the E-I signature of components under test has been announced by Synchronicity Research (Tonkawa, OK). Called the Complex Impedance Analyzer, it uses a triangular instead of the usual sinewave test signal. Test signal frequency can be varied up to 10 kHz, its amplitude up to 30 volts peak-to-peak.

In addition to providing improved semiconductor tests, the instrument's triangle wave and wide frequency range are said to make it pos-



sible for the CIA to perform accurate inductance and capacitance measurements from less than 2 mH to beyond 200 H and from less than 100 pF to beyond 20 μF. The impedance of complex networks and transducers can also be measured. The CIA is battery powered for convenient field-service use, but it can also be used on a testbench.

CIRCLE 88 ON FREE INFORMATION CARD

Soldering Station

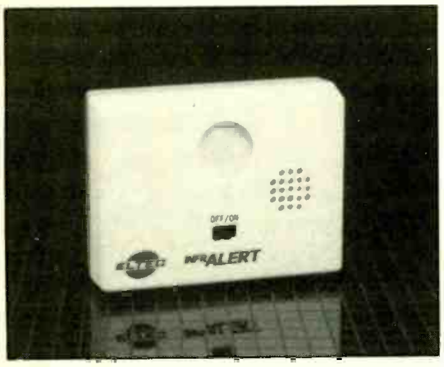
OK Industries introduced a new soldering station with recessed temperature-selection switches that allows you to choose between 650, 750 and 850 degrees F. soldering temperatures without having to change tips. The tri-temperature Model SA-10's zero voltage heater power switching, low leakage and fast heat-up and recovery time features make this an ideal tool for a broad range of soldering applications.

The tri-temperature station uses J-type thermocouple sensing to provide stable and accurate temperature repeatability within ±5 degrees Fahrenheit. The CMOS-safe plug-in soldering iron features a comfortable, cool grip and a non-burn cord. It includes the soldering station with switches and indicators, soldering iron, long-life tip and tip cleaning sponge. Both 117- and 230-volt ac models are available, each with 24-volt, 48-watt handpieces.

CIRCLE 83 ON FREE INFORMATION CARD

Portable Motion Detector

The Model 870 "Infralert" from Eltec Instruments is a portable passive infrared sensor that is claimed to use the same technology as that used in state-of-the-art intruder alarms. Its alarm tone automatically sounds when a person or object moves into its line of sight. Infralert can be used to monitor temporarily restricted or hazardous areas, merchandise cases, display windows, doors and windows, stairways, gunracks, swimming pools, etc.



The device is powered for up to a year by a single 9-volt battery. It uses fixed-focus optics that give it a narrow field of view that is less likely to interfere with normal room activities than is possible with wide-field-of-view systems. Its built-in delay circuit gives you time to arm the system and leave the protected area without tripping the alarm.

CIRCLE 16 ON FREE INFORMATION CARD

In-Dash CD Player/Receiver

Panasonic Auto Products' Model CQ-E800 15-step random-access programmable CD player with digital AM/FM-stereo receiver consists of one unit that fits into the dashes of most American-made cars and a support electronics unit that goes under a seat. A special suspension system protects the player's miniaturized laser pickup against vibrations and jolts. Features include a skip key and scan, pause, on-track repeat and automatic loading functions.

The preamplifer has volume, fader, balance, bass and treble controls, plus output terminals for connection to a booster amplifier. The tuner section offers scan and seek functions and instant access to 12 FM and 6 AM stations that the user stores in

memory. An LCD window displays recalled station and frequency (tuner mode) and elapsed time, selection in play and CD selections stored in memory (CD mode).

Electrical noise is handled by Impulse Noise Quieting (INQ) circuitry. An automatic FM Optimizer (FMO) helps improve FM reception in weak signal areas. $699.95.

CIRCLE 17 ON FREE INFORMATION CARD

GPIB Tool Kit

Integrating an IBM PC into a GPIB instrument system has been simplified with Tektronix's new GPIB tool kit. The GPIB Users Resource Utility package, known as GURU, consists interface board with self-test/diagnostics, a shielded GPIB cable, tutorial manual and software support, including a test procedure generator and subroutines library.

GURU's manual provides instructions on how to use the IBM PC and compatibles to control instrumentation via the GPIB and includes programs and a user resource library of applications programs. GURU provides a software tool that allows you to generate a program that executes a prescribed test sequence without having to write code. All you need know are the details of the task to be per-

formed and follow the instructions and answer menu questions, with GURU generating the required routine.

You can call any of the 16 BASIC subroutines that allow you to focus on the problem rather than the bus. These interactive subroutines include instrumentation selection and setup, range and tolerance tests, waveform acquisition and storage, and waveform graphs and statistics. Each subroutine performs a regular check for errors. $600.

CIRCLE 18 ON FREE INFORMATION CARD

Satellite TV Systems Troubleshooter/Tester

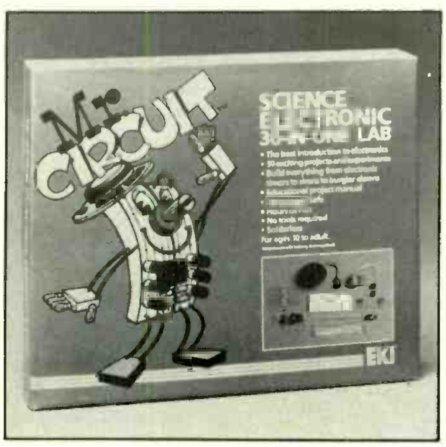
Satellite Test Equipment Co.'s (Scottsdale, AZ) new Model ET-15 satellite troubleshooter and test set is reported to allow a user with minimal technical background to troubleshoot a satellite TV system in 15 minutes or less. The microprocessor-controlled test set produces all signals required at 15 GHz (K band), 4 GHz (C band), and most single and block i-f frequencies.

The ET-15 tests LNAs, LNBs, downconverters, polarotors, TV receivers and monitors, any satellite receiver, cables and splitters. Among its features are a signal-strength meter with a peaking function for setting up antenna dishes and a continuity tester

for checking motor drives and sending devices. It also features an external video input that accepts a camera, VCR or computer signal. $799.

Electronics Education Lab

The Mr. Circuit 30-in-One Lab from Electronic Kits International is the first in a series of learn-by-doing electronics education kits. It allows people who are interested in learning about electronics to have fun while quickly assembling a variety of relatively simple projects. There are 30



different projects in all, ranging from fun devices like and electronic canary to practical devices like an ultrasonic pest repeller. Some projects can even serve as test instruments, like the diode and transistor checkers and an audio generator. Projects are assembled on a solderless breadboarding socket, using reusable supplied components and wires. Everything needed to assemble the projects, except a 9-volt transistor battery, are supplied in the kit.

(Continued on page 96)

Solid-State Audio Circuits

Part 1

By Joseph J. Carr

Audio circuits are among the most interesting of linear circuits with which to experiment. They are excellent as weekend and one-evening projects for electronics hobbyists and experimenters. Part of the reason for their popularity is that they are so useful to so many people; another is that they are generally well-behaved and, thus, can easily be built with low-cost components.

In this first installment of our two-part article, we discuss the basic circuits used in modern audio-amplifying equipment and explore both discrete transistor and integrated-circuit (IC) audio amplifier circuits. The information contained here will lay the groundwork for the more detailed discussions of circuits, built around actual components, that will appear in next month's conclusion.

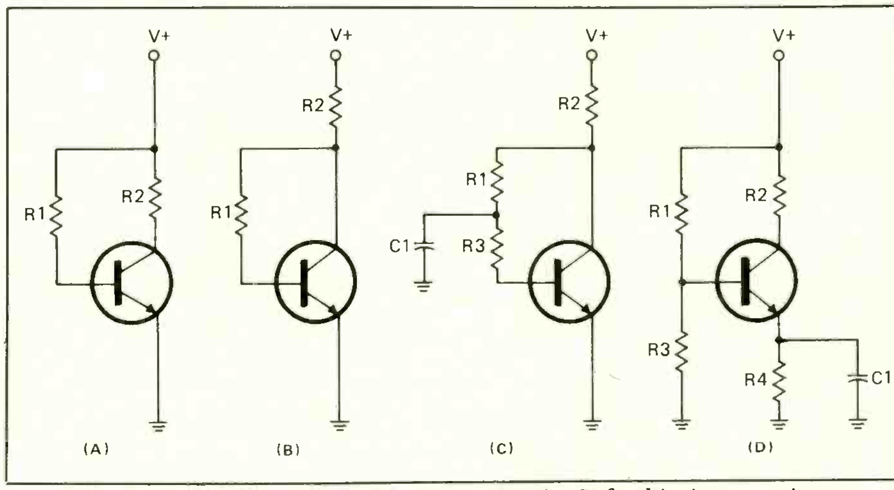


Fig. 1. Several of the most common methods for biasing transistors.

Transistor Biasing

One of the most important factors in understanding solid-state audio circuits is the methods used to achieve proper biasing of transistors. Figure 1 shows several of the most common methods. These circuits, or variations of them, are used in most discrete and IC audio circuits.

Figure 1A shows the simplest—and most practical—biasing scheme. Fixed base-current bias is established by current flow from the emitter-base junction of the transistor through *R1* to the supply voltage. The amount of bias is dependent on the value of *R1* and the supply voltage. The primary disadvantage of this bias arrangement is that it provides no means of automatically limiting collector current. Hence, fixed base-current biasing yields circuits that can be unstable.

Another simple form of self-bias, shown in Fig. 1B, is called collector feedback. Because *R1* is connected to the transistor side of load resistor *R2*, any change in collector current will cause a proportional but opposite change in transistor bias. For example, if collector current increases because of a temperature increase, the voltage at the collector decreases (becomes less positive). In turn, this reduces the current through the emitter-base junction and *R1* circuit. Although this bias system does provide a degree of stabilization, it also introduces deneration caused by feedback of any ac signal voltage developed across the load resistor.

Collector-feedback with ac bypassing is the same as in Fig. 1B, except that an electrolytic capacitor has been added to filter out (bypass) variations.

Combination fixed and self-bias (Fig. 1D) provides both good stabilization and minimum degeneration. Fixed emitter-base bias is developed by the *R1/R3* voltage divider. Usually, the value of *R3* is substantially less than that of *R1*. Resistor *R4* stabilizes the transistor. For example, if emitter-to-collector current increases because of an increase of temperature, the voltage drop across *R3* also increases. This places a more-positive voltage on the emitter,

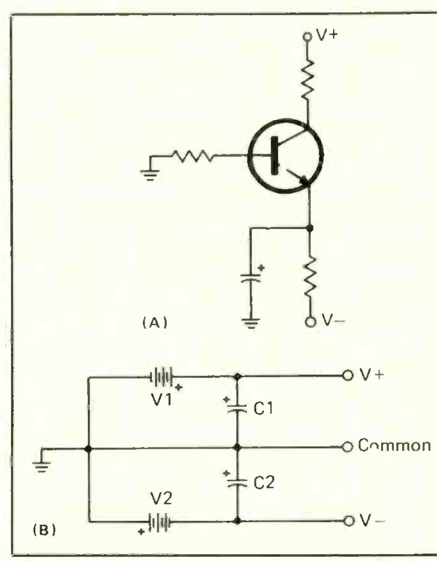


Fig. 2. An amplifier biased for dual-polarity power supply operation (A) and a typical dual-polarity power supply (B).

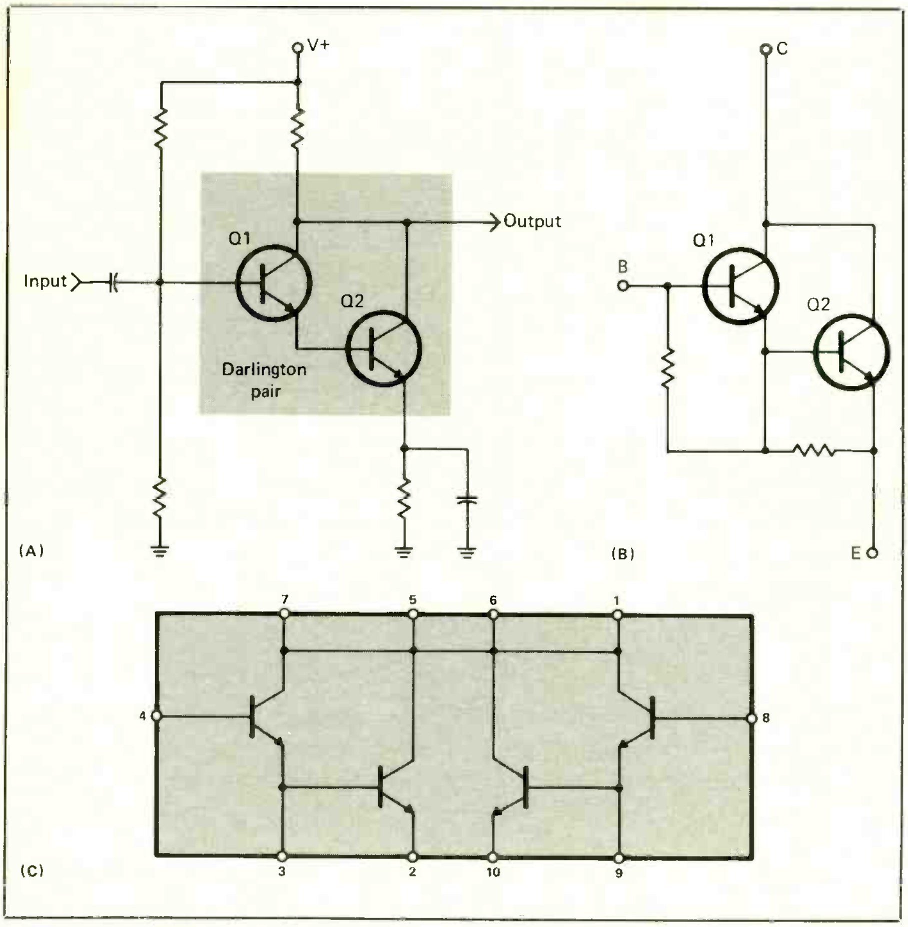


Fig. 3. A Darlington amplifier configuration built around two discrete transistors (A). Though the Darlington arrangement contains two separate transistors, when wired together as shown, the two can be treated as one transistor with single base, emitter and collector leads (B). Matched dual-Darlington transistor pairs are also available in convenient IC package form (C).

which reduces the forward bias on this transistor. The capacitor bypasses ac variations around the emitter resistor to prevent degeneration. The value of *R4* usually is five to ten times less than that of *R3*.

The dual-supply method (Fig. 2A) is a not so universally recognized biasing circuit as some of the others, but is being used more and more in modern circuits. It can be identified by the fact that the ground (or common) is not returned to the positive or negative side of the dc power supply. (The Fig. 2B circuit represents the kind of dc power supply used: two voltages, one positive to ground and the other negative to ground). Instead, in most applications, the ground, usually the chassis or a printed wiring board ground bus, "floats" at the electrical mid-point of the two supplies. In most cases, the two voltages are equal; in others, V− and V+ are different.

Increased output voltage swing is one of the advantages of the dual supply circuit, regardless of whether discrete transistors or integrated circuits are used. Another advantage is improved thermal stability. This can mean a lot in an amplifier that has marginal heat sinking or that is used inside a closed cabinet. A third advantage is that these circuits tend to be less sensitive to hum pick-up caused by power supply ripple.

Another type of circuit that is being used more often in solid-state audio applications is the Darlington amplifier—also called the Darlington pair, or the "super-beta" transistor (when both transistors are inside the same package). An example of this configuration is shown in Fig. 3A. Notice that the collectors of the two transistors are tied together. Also note that the emitter of the input transistor is tied directly to the base of the output transistor. This arrangement produces higher current gain and a much higher range of input impedance than is possible with single bipolar transistors. Beta gain is $H_{fe} = H_{fe(Q1)} \times H_{fe(Q2)}$.

If the transistors are identical, overall beta gain is the square of the beta gain of any one transistor. You can see why this configuration is called "super-beta" by a simple example. Suppose two transistors with a beta of, say, 100 are connected in a Darlington configuration as in Fig. 3A. Overall beta of this combination is 100 × 100, = 10,000.

Although discrete transistors can be connected in the Darlington circuit, several manufacturers offer Darlington-configured transistors in one package, or integrated-circuit Darlington amplifiers. Figure 3A shows the internal circuit of a Darlington transistor. Most often, the device is a power amplifier in which *Q1* is a driver transistor and *Q2* is an output power transistor. One common Darlington pair in hi-fi amplifiers uses a 2N3053 for *Q1* and a 2N3055 for *Q2*.

Figure 3C shows an IC dual-Darlington amplifier. This particular device is the RCA CA3036. There are also operational amplifiers and special-purpose ICs on the market that use a Darlington amplifier as the input circuit.

Audio Power Amplifiers

There are several basic designs for audio power amplifiers. For purposes of discussion let us turn to the Fig. 4 circuit. This basic audio amplifier chain has been used in a lot of equipment over the years. There are three stages shown: preamplifier, driver and power amplifier. The preamplifier builds up the voltage level of the input signal. The driver raises the power level of the amplified signal sufficiently to drive the output power amplifier stage. The output power amplifier, of course, develops the power to drive the loudspeaker.

In Fig. 4B is shown a simple circuit used in many car and home radios, though rarely in high fidelity applications. This single-ended class-A amplifier uses a choke or autotransformer for output impedance matching. It has several disadvantages. For one thing, as a class-A amplifier, the output collector current flows 100 percent of the time, even when there is no input signal. As a result, a lot of heat is generated. In some cases, a 3- to 5-watt fuse resistor ("fusistor") is placed in series with the transistor to protect the circuit if excess heat causes *Q1* to blow. Another disadvantage is that fidelity is not too good unless feedback is provided. Though the fusistor provides a small amount of beneficial degenerative feedback, additional feedback must be provided in most cases.

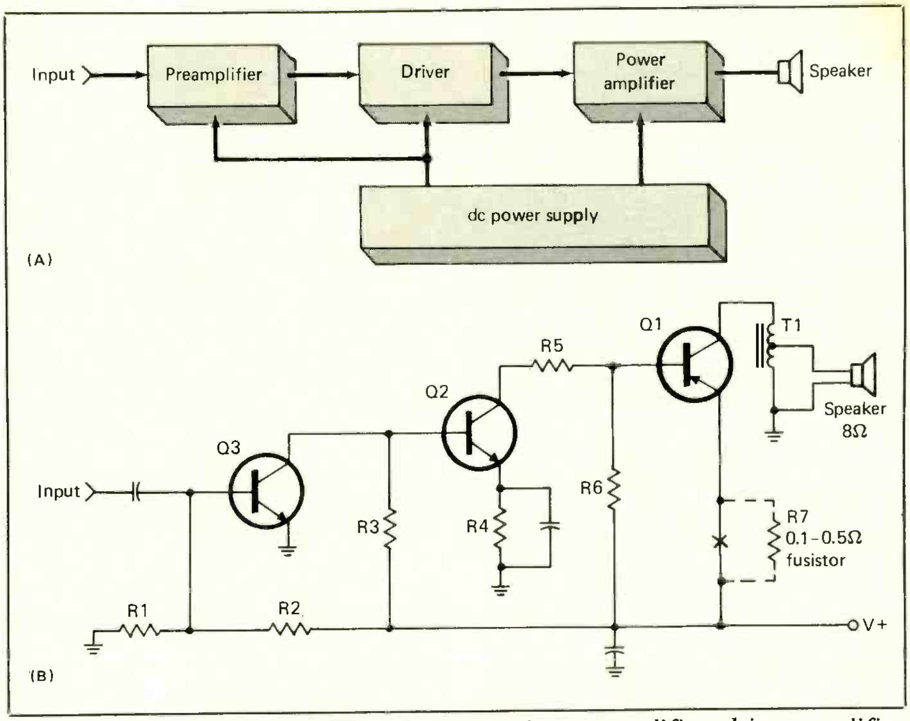


Fig. 4. A typical audio-amplifier chain contains preamplifier, driver amplifier and power amplifier stages, all powered by a common power supply. This arrangement is shown in block diagram form in (A), while (B) shows the schematic equivalent sans power supply.

Two basic kinds of feedback circuits are normally used in audio circuits. One is called the "second collector-to-first emitter" system (Fig. 5A). With correct values of components, this circuit can make a relatively mediocre amplifier sound like a more expensive one. Figure 5B shows the second widely used feedback system, dubbed the "second emitter- to first base" system. This circuit often employs only one resistor to supply feedback signals.

The push-pull circuit is widely preferred over other types for both power handling ability and overall fidelity. Figure 6 shows the standard transistor push-pull circuit that has

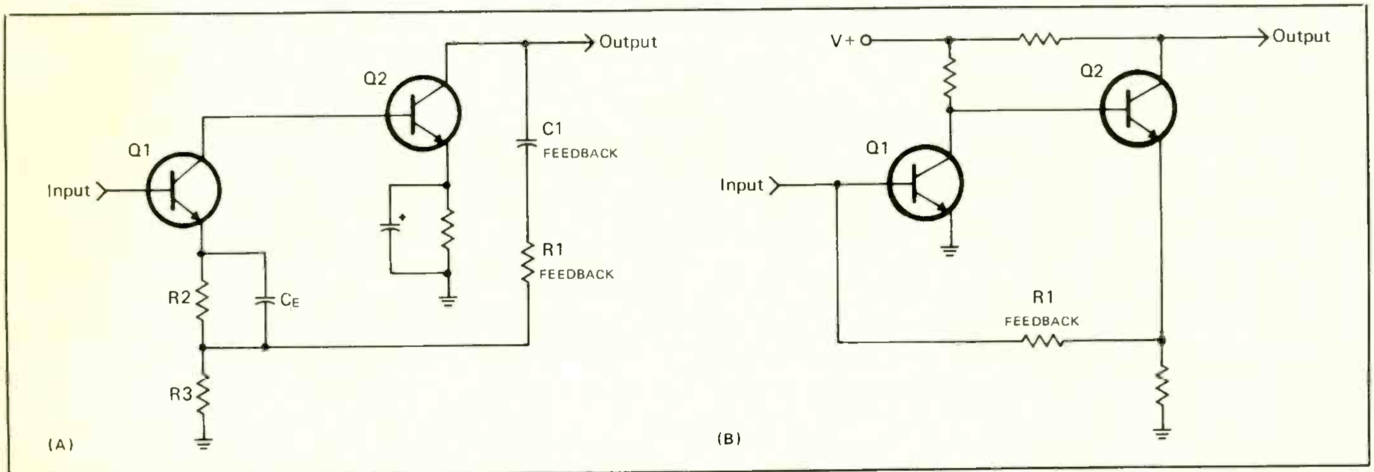


Fig. 5. The two basic kinds of feedback circuits normally used in audio circuits: second collector to first emitter (A) and second emitter to first base (B).

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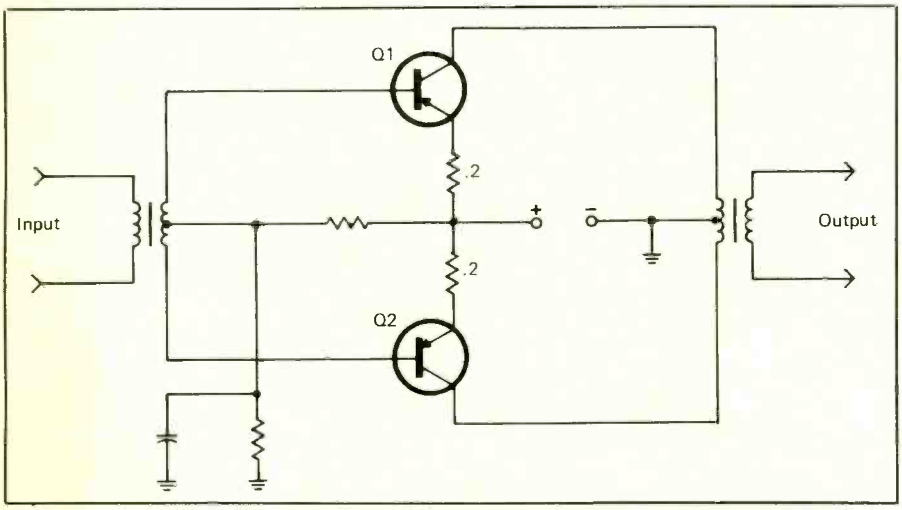


Fig. 6. A typical push-pull amplifier stage with transformer input and output. Note that this arrangement requires a dual-polarity power supply.

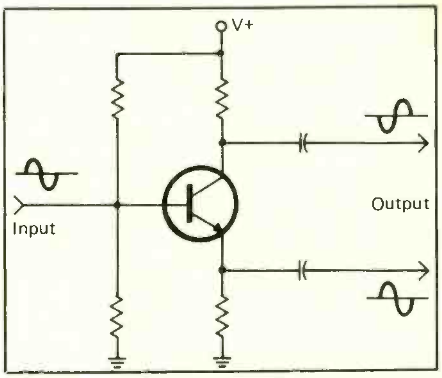


Fig. 8. A transistor phase inverter is one possible replacement for the in terstage (input) transformer needed for the opposite-polarity driving signals for the two halves of the push-pull amplifier circuit.

been used in almost every audio application, from $5 portable radios to relatively high-priced, medium-grade radios and stereos. It is, however, a lot less cost-efficient when compared with other circuits of more recent design.

Another breed of push-pull amplifier is shown in Fig. 7. Often called the "split-secondary, totem-pole" circuit, this one is used in many domestic and (especially) imported radios. The series connection of the output transistors and split-secondary interstage transformer *T1* are the two identifying features of this type of circuit.

One thing that all push-pull amplifiers have in common is the necessity of phase-splitting the input signal to provide two new signals 180 degrees out-of-phase to drive the two halves of the push-pull circuit. In older designs, this was accomplished with either a center-tapped transformer (Fig. 6) or a split-secondary interstage transformer (Fig. 7). In many modern circuits, however, the interstage transformer is replaced by another means to split the input signal.

The transistor phase inverter is one possible replacement for the interstage transformer. These circuits (Fig. 8) have one driving signal taken from the collector, the other from the emitter of the transistor. Another method of providing drive signals of opposite polarity is to use an IC preamplifier that has both inverted and noninverted output terminals. Such ICs provide wideband, push-pull outputs from a common input signal. An example is shown in Fig. 9. This particular circuit is based on the RCA CA3020 IC preamp.

Designers have other methods of accomplishing phase inversion that is often more economical than either of the other methods. These methods are also used in IC and hybrid audio power amplifiers, and are called "complementary-symmetry" and "quasicomplementary" amplifiers. Complementary-symmetry methods, shown in simplified form in Fig. 10, take advantage of the fact that pnp and npn bipolar transistors require signals of opposite polarity to perform the same basic function. Notice that the speaker, minus output transformer, is connected to the midpoint of the two series-connected

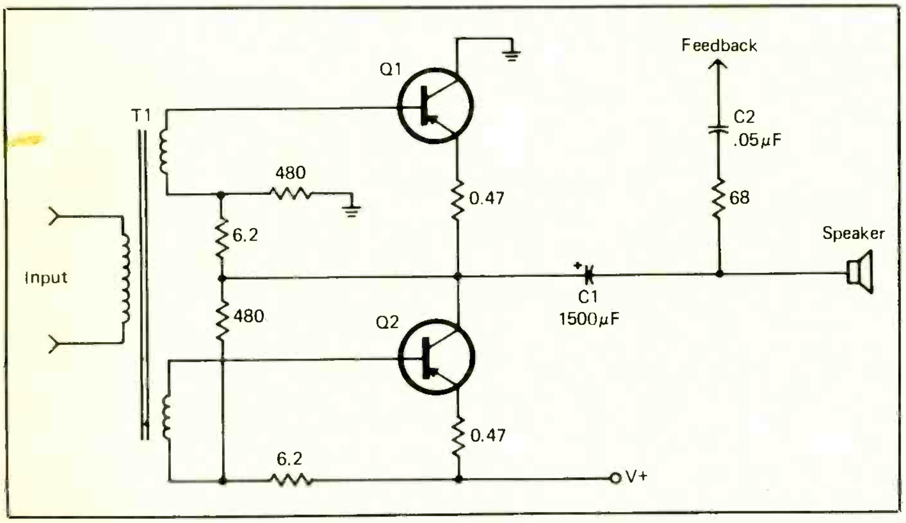


Fig. 7. The split-secondary totem-pole amplifier is similar to the conventional push-pull amplifier, except that it has no output transformer and can operate with a single-polarity power supply.

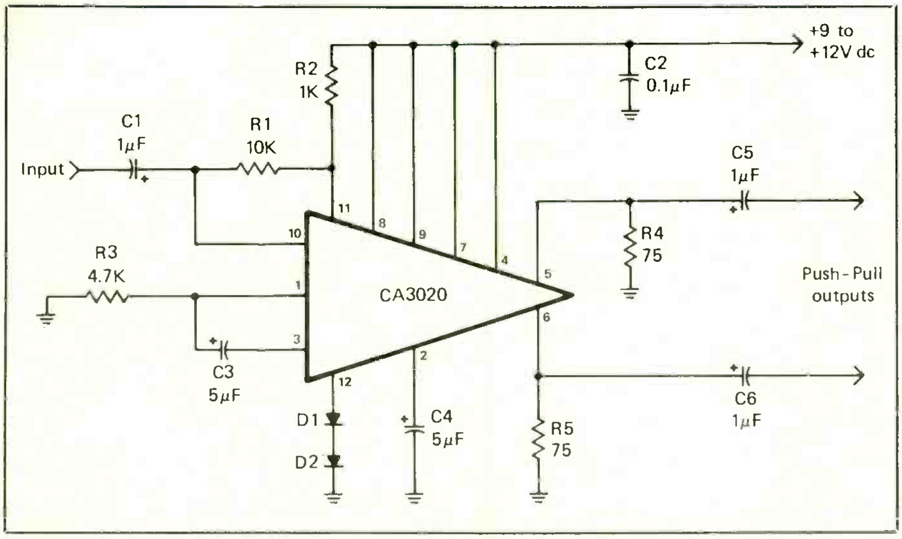


Fig. 9. An IC amplifier that has inverted and noninverted output terminals offers another way of obtaining phase-inverted signals for push-pull operation.

power transistors. Versions of this circuit that use a single asymmetrical dc power supply usually employ a capacitor to block dc from the speaker circuit. (The voltage at point "A" is usually V+/2). Dual-polarity circuits do not require the capacitor.

Complementary-symmetry amplifier circuits have at least one major disadvantage: It is difficult to locate matching pnp and npn transistors. Manufacturer "spec" sheets reveal that there are only a few types that can be paired for complementary service at any given output power level. As the amplifier's power level increases, the number of available types decreases dramatically. The problem becomes even more acute when selecting service replacements for these transistors.

It is relatively easy to find matched pairs of transistors for low- and medium-power complementary circuits. It is even relatively easy to find matched pairs for medium-power (a few watts) applications. But at higher power, the problem is greater. This has led to an interesting modification of the complementary-symmetry circuit, called the quasicomplementary circuit shown in Fig. 11. This circuit uses a "totem-pole" output in which the same type of npn or pnp transistors are in series with each other, and complementary driver stage *Q1/Q2*. It is fairly easy to find the medium-power complementary drivers and matched (identical) output transistors required for this type of circuit.

Coming Next Month

This concludes our primer on the general theory of transistor and IC audio amplifiers. In next month's concluding part of this article, we will discuss the details of audio preamplifier and tone-control circuits built around actual commonly available components. **ME**

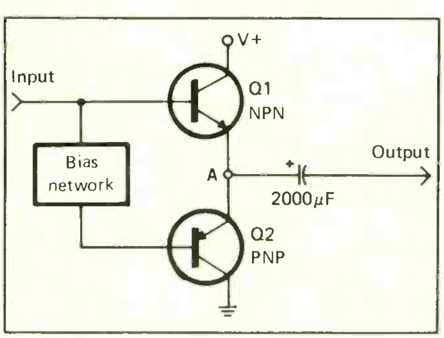


Fig. 10. An economical way of obtaining phase inversion is with the so-called "complementary-symmetry" circuit that uses npn and pnp transistors. Versions of this circuit that use a single asymmetrical power supply usually have a capacitor that prevents dc from getting to the speaker.

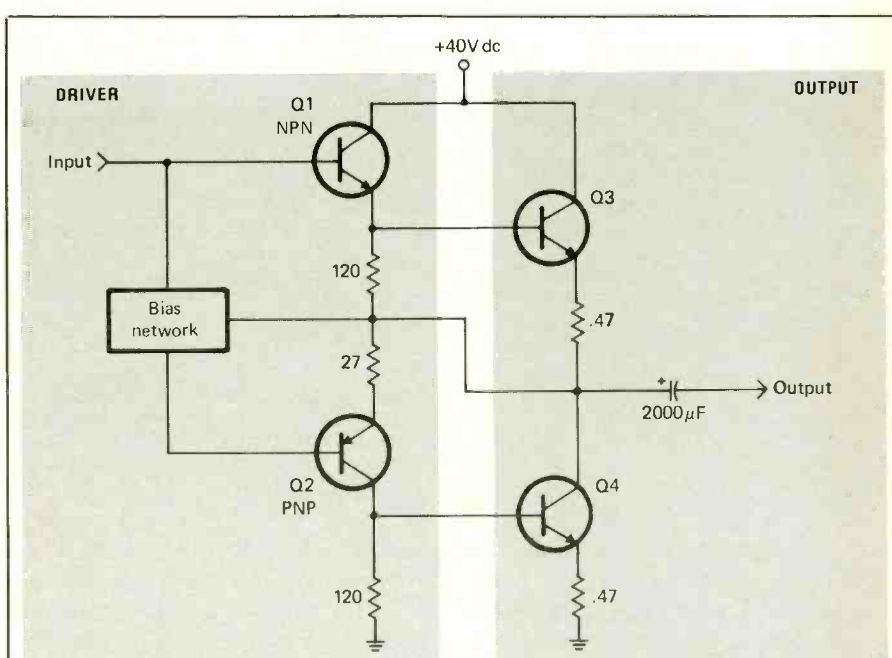


Fig. 11. The "quasicomplementary" circuit uses the same type of npn and pnp transistors in a totem-pole arrangement and a complementary driver stage consisting of Q1 and Q2.

Upgrading a Radio Shack "Bare Bones" Color Computer

How to add 64K RAM, Extended BASIC and 64-column video output to CoCo

By John Richardson

One of the hottest selling holiday-season products last year was Radio Shack's "bare bones" Color Computer II, featuring 16K of memory (RAM) and Standard BASIC. Priced at only $88 they sold like ice pops in July, but many buyers soon discovered that its 16K RAM and "standard" version of BASIC doesn't do very much. Well, here's how to inexpensively upgrade it to run *World Class* word processing and telecommunications software—stuff that puts to shame a lot of the mega-buck software being sold for even "business computers."

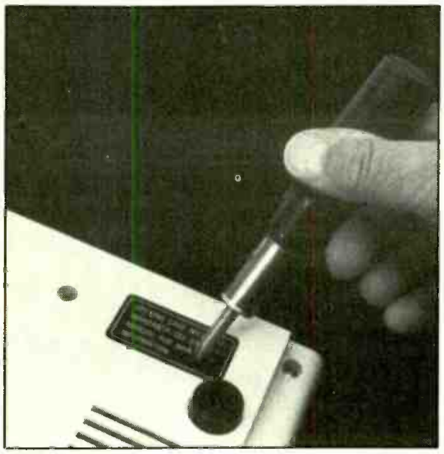
Basically, all it takes is less than $50 and an evening's effort to upgrade the CoCo II to a high-performance computer having both 64K RAM and a video monitor ouptut capable of displaying 64 columns, rather than the CoCo's normal 32 column TV display. With these one-evening retrofits you can then run *MikeyTerm*, a public domain modem program, and *Telewriter-64*, an under-$70 word processor that's easier to use, much easier to learn, and even more powerful than WordStar (it can transmit any printer control codes), and it can directly save its files in ASCII or binary.

Unlike most modern telecommunications software that requires considerable time and effort to learn to use, and which requires frequent reference to the documentation if not used every day, MikeyTerm operates from a single menu. Even more important, it features *dynamic buffer control*, which in plain English means the user can instantly select and save parts of the incoming text because it takes only one key to open/close the receive buffer, which is later dumped to mass storage.

Upgrading the 16K CoCo II is a lot like making over Cinderella from a "Plain Jane" into a princess because most of what's needed is already there. The only extras required for high-performance word processing and telecommunications is a video output for a conventional composite monochrome or color monitor, and sufficient RAM to store many pages of the text—preferably 64KB. Also, if you want to get into sophisticated programming you'll need Extended BASIC—an enhanced version of the BASIC used in the higher priced versions of the CoCo II.

Built For Factory Upgrades

From the introduction of the original CoCo—what enthusiasts call the CoCo I—Radio Shack intended the 16K computer to have its RAM and BASIC upgraded by its own service stations, so sockets and jumpers were built into the motherboard for just about every integrated circuit



One of six screws that must be loosened to open the cabinet is hidden under the label that warns against opening the case. To get at it, push the tip of a Phillips screwdriver through the label.

With the top off, you have access to CoCo's entire interior.

and the RAM address programming. In the upgrades we'll shortly describe, you will simply utilize the sockets that Radio Shack provided for its own use. The only thing Radio Shack would not do was install a composite video output to go along with the TV output, so in later versions of the CoCo they actually made it more difficult—almost *impossible*—to retrofit a conventional video monitor output; but you will easily get around this mine field.

The Monitor Problem

Since the CoCo was designed to use a conventional color TV as a monitor, its output was an rf signal on either TV channel 3 or 4 (user selected). Unfortunately, the bandwidth of a TV set can *cleanly* resolve only 30 to 40 characters per line. Since "standard" business correspondence is usually considered to be 64 characters per line, the aftermarket word processor Telewriter-64 needed a monitor capable of greater than the CoCo's 32 columns. This required a conventional video monitor, which was provided by a $30 aftermarket retrofit video monitor adapter. To do the above, one simply removed the existing *video display generator* (VDG) IC from its socket, plugged in the retrofit video adapter, and then installed the VDG in a socket on the video adapter. It was that easy. But for whatever the reason, Radio Shack eliminated the VDG's socket in later CoCo models, making it necessary for the modifier to either unsolder the 40-pin VDG or solder the video adapter's wires directly to the VDG's pins. Either way, it could result in damage if the person wasn't experienced in miniature assembly.

But regardless of how hard a manufacturer tries to restrict the user to his products, aftermarket vendors will find a way to get around the roadblocks, and that's just what happened in the case of the video drive. One of the original vendors of retrofit video monitor adapters simple equipped their adapter with mini-

To remove the keyboard, lift it straight up and gently flip it back to the rear.

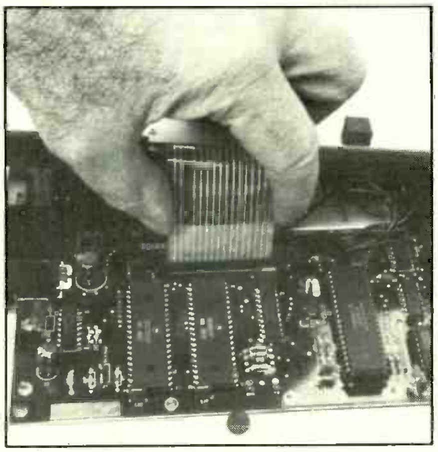
clips that the user hooks over the appropriate VDG terminals (and three motherboard locations). While the retrofit might appear at first glance to be a rat's nest of wires, the mini-clips avoid soldering to the VDG's pins. Although the clips move, they are firmly locked in place and, most important, the thing works—though you won't believe it when you first complete the retrofit. Actually, it is easier and safer to install the new kind of mini-clip video adapter.

Making The Retrofits

The first step in upgrading a 16K CoCo II is to open the case and remove the keyboard so that you can get at the RAM and VDG. Just moving the keyboard out of the way isn't sufficient; it must be removed to avoid possible damage. To open the cabinet you first loosen the six screws on the underside. You will actually see only five screws because the sixth is concealed under the small black label that says the warranty is voided if the cabinet is opened. Simply push a Phillips screwdriver through the label to get at the screw. Note: (The factory knows you have opened the cabinet if the label is broken.) Since the screws are two different lengths, mark which holes get the short screws and which the long ones. Actually, a better way to handle the screws is to simply loosen them and then place a strip of tape over their holes so they won't fall out.

Holding the cabinet together by hand, flip the computer right-side up, then gently lift the top of the cabinet straight up and off. The top comes off very easily: don't pry or bend the edges if it's stuck. If you can't get the top off, the problem is most likely a screw that isn't fully released, or a missed screw.

Next, remove the keyboard, taking care not to damage its plastic connecting cable. Do it this way. Lift the keyboard clear of its mounting posts and flip it backwards, placing



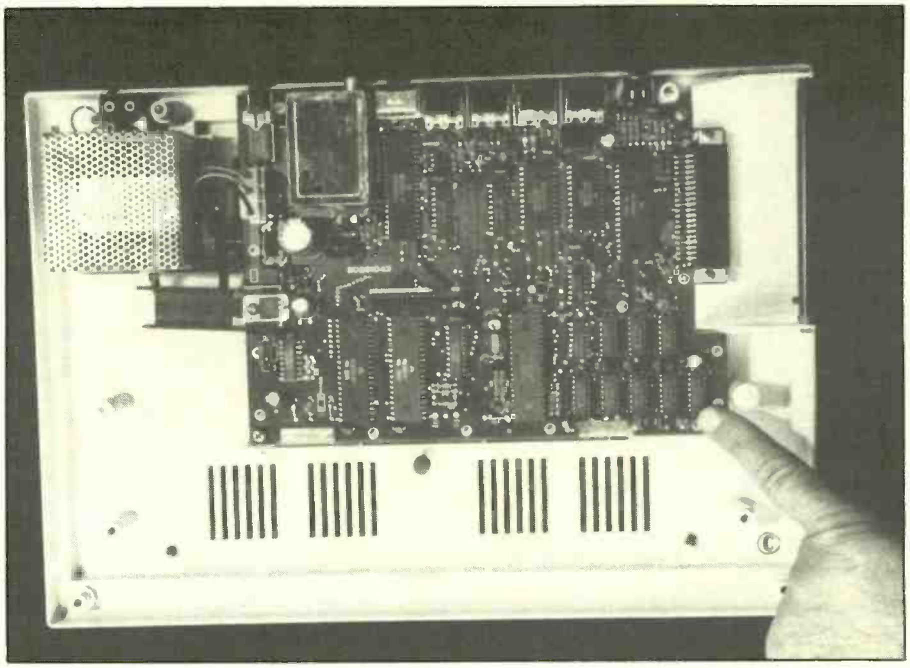
Do not grip the keyboard's ribbon cable as shown to unplug it from the motherboard; it might be damaged. Instead, grip it on both sides between thumb and forefinger and lift straight out.

it gently on the motherboard. You will see that the keyboard connects to the motherboard through a wide plastic strip having silver-color conductors. It will appear that the ribbon is permanently attached to its motherboard connector, but it's not. The small black block on the motherboard that secures the ribbon is really a socket.

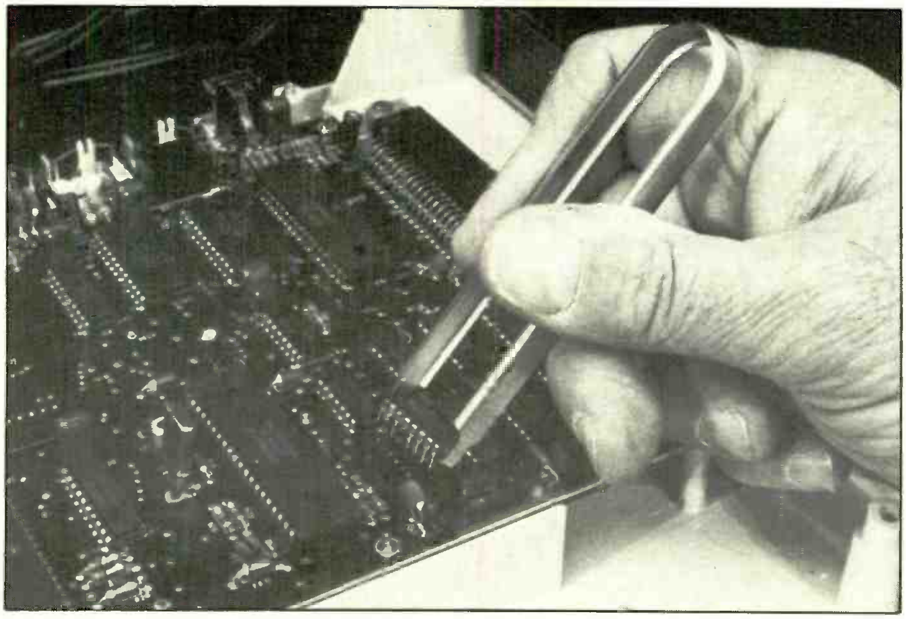
With thumb and forefinger, grasp both sides of the ribbon directly above the motherboard connector and gently rock the ribbon from edge to edge while applying a slight pulling force. The ribbon will work loose and come out of its connecter. Don't rush the job and pull too hard: gentle persuasion will get the ribbon free without damage. (Don't bother to mark the ribbon because it can go back only one way.) When the ribbon is free, lift the keyboard straight out and set it safely aside, making certain you don't lose the small black rubber washers that fit on the posts under the keyboard. You now have access to the entire motherboard.

More Memory

Make the memory upgrade first. There have been several different versions and configurations of the CoCO since its introduction, but whether it has 4K, 16K, 32K or 64K of RAM it uses eight socketed RAM chips to provide the rated memory.



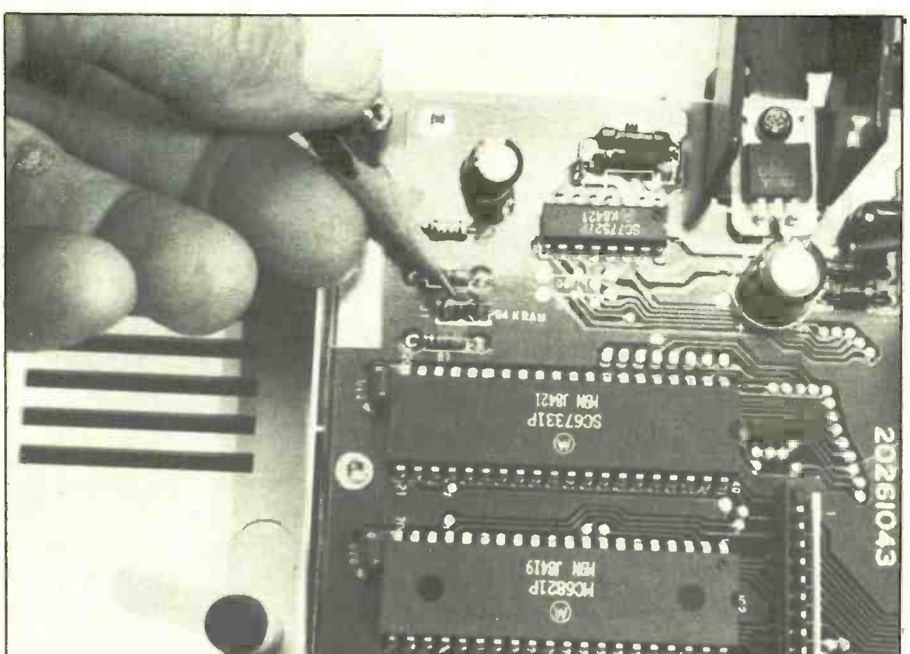
Eight socketed memory ICs are in the lower-right of the motherboard. Remove the factory-installed 16K chips and replace them with 64K chips.



Use an extracting tool to remove the 16K RAM chips.

In earlier models of the CoCo, it was necessary to remove a metal shield and cut some capacitors to upgrade RAM to 64K. Neither is necessary in the new version. There is no shield over the memory chips: you simply replace the existing memory chips with 4164s—the same inexpensive 64K chips used in the IBM PC—and short-circuit two solder mini-pads from the top of the motherboard.

Several variations of the 4164 are sold for the IBM PC, and they might not even be identified as a 4164. The rule is: if the chips are sold as 64K RAMs for the IBM PC or the Color Computer they can be used. Generally available "IBM substitutes" are the 4564N-20 and 4164P, which presently sell for as little as 99 cents apiece. It makes no sense to spend more than $30 for a set of eight "official" 64K CoCo chips.



Program the CoCo to address 64K of RAM by soldering a wire across the two "64K" solder pads located at the upper-left of the motherboard.

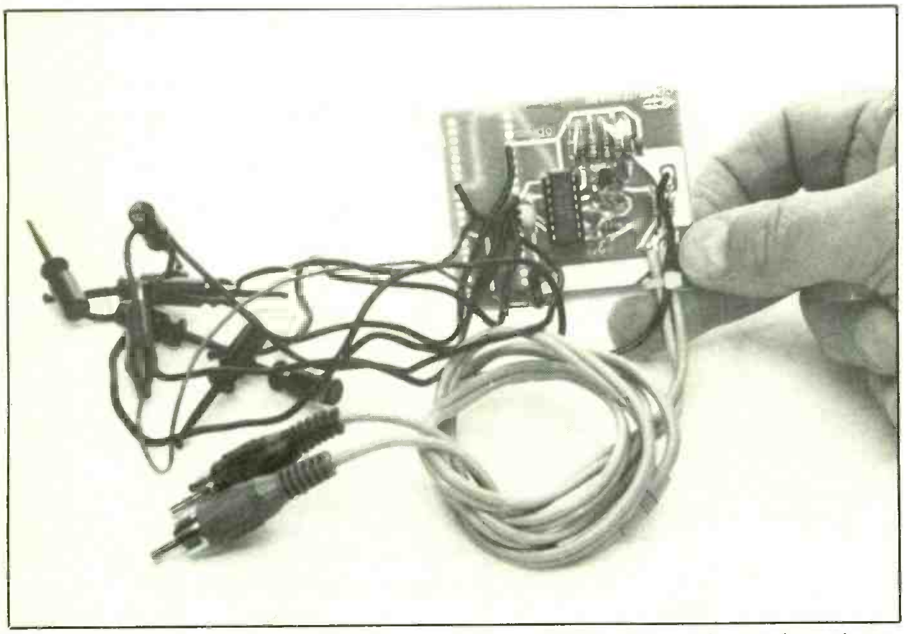
Only A Swap

First step in memory upgrade is to simply swap new chips for the old. Since the ICs are sensitive to static electricity, make certain you are grounded through a ground strap (attached to the metal clip of your watchband) or a grounding bracelet. After you're grounded, remove all eight original 16K memory chips using some kind of extraction device. Don't try to flip the chips out of their sockets using a screwdriver unless you have had experience doing it because a little too much force can damage the socket, and then you're in for a lifetime of intermittent glitches. Make certain the pins of the new ICs are straight—use needlenose pliers if it's necessary to straighten them—and snap the chips into their sockets, making sure the notch at one end of the chip corresponds to the position of the notch of the original IC (they all face the same way) and that no pins fold under as you push the chips home.

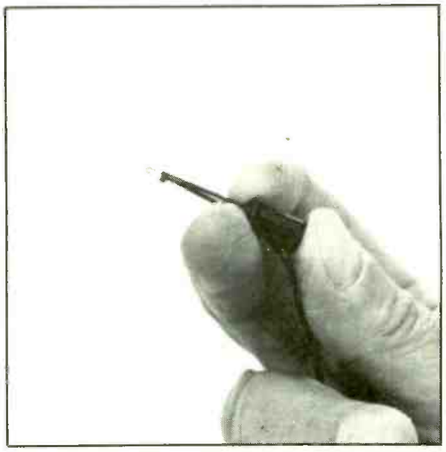
Programming for 64K

After all eight memory ICs are installed, locate the two small solder pads at the upper-left corner of the motherboard labeled "64K RAM." Simply soldering a jumper across the solder pads programs the CoCo for 64K. Install the jumper from the top of the board; don't attempt to remove the motherboard from the cabinet for this operation.

Using a very small pencil soldering iron tip, melt the solder in one hole and slip in the end of a short length of pretinned #20 or #22 solid, bare wire. Form the wire into a small ¼" loop, position the free end over the



Interconnects from the small commercially available video adapter board connect to the CoCo via wires terminated in mini-clips. The two cables terminated in phono plugs are the new video and sound outputs.



The display board's mini-clips provide a secure connection when the spring-loaded "body" is released.

second solder pad, heat the pad and force the pretinned free end of the wire into the hole. That's it!

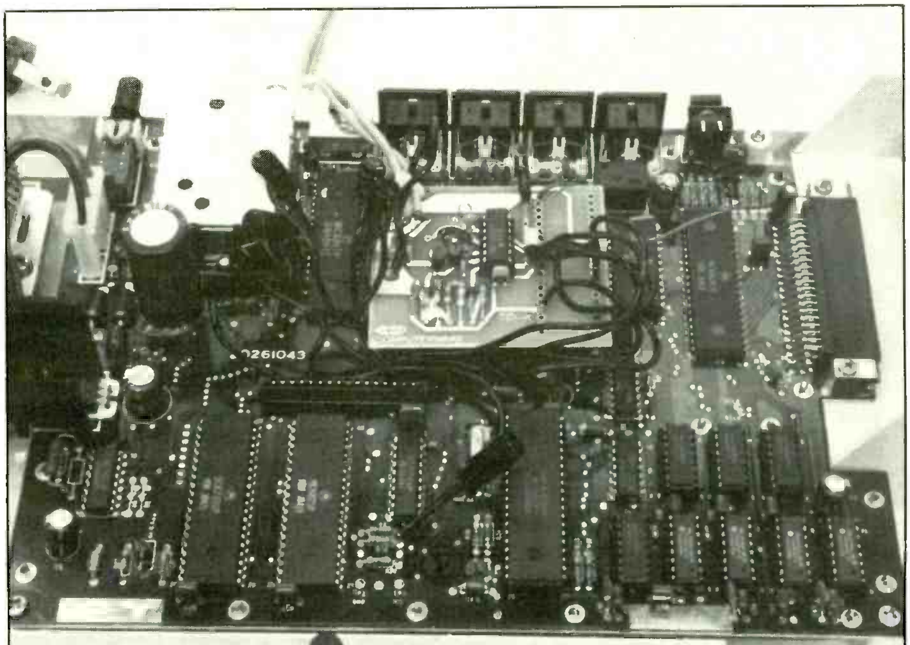
Enhanced Basic

If you think you will want Enhanced BASIC, install the Enhanced BASIC retrofit ROM now—before the video adapter is installed—because it's possible the video adapter will get in the way if you try to do it later. You can purchase the Enhanced BASIC upgrade ROM from Radio Shack or any of several vendors that sell parts for the CoCo. (Since the price is the same, get it the most convenient way.) Simply snap the Enhanced BASIC upgrade ROM into the matching empty socket in the top-right of the motherboard. You can't miss it because it's the only empty socket. Just make certain the notched end of the ROM faces the rear of the motherboard.

Installing The Video Adapter

There are several kinds of video monitor adapters floating around from CoCo aftermarket vendors; for ease of installation we recommend the Universal Video Plus, the one shown in the photographs here. To install the Universal Video Plus adapter simply match its clip leads to the VDG. On the adapter are a set of 40 holes corresponding to the VDG's terminals. Seven holes have clip leads. Just match the seven and connect the remaining clips to the locations specified in the instructions supplied with the adapter.

The adapter is secured to the top of a large IC by a piece of double-



The video adapter mounts on top of an IC with double-sided tape (supplied with kit). Installing the adapter with holes to the right lets you tuck most of excess wire lengths under the board's front edge.

sided tape. It's very sticky and you get just one shot to secure the adapter. To make certain the adapter does not interfere with reinstalling the keyboard, position it so its left edge is adjacent to the VDG, and as far to the rear of the motherboard as possible. In this location the adapter drops down on an IC and sticks in place.

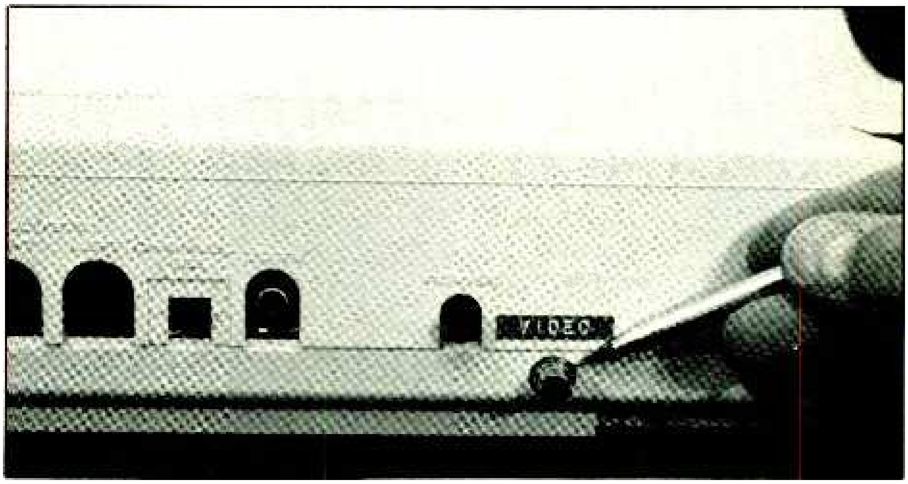
The adapter provides separate audio and video outputs at standard phone connectors. If you have no need for the sound output, you can cut off its shielded cable at the adapter. While you could notch out the cabinet and let the video (and audio) cables simply hang free, the wire is actually too short to reach a monitor's rear input jack. Thus, it will require a female-male extension, which isn't all that easy to locate.

Instead, we suggest you install a standard phono jack (¼ " mounting hole) in the bottom of the cabinet about ¾ "to the right of the power switch (an open area inside the cabinet), cut off the existing video connector, and connect the video output cable to the phono jack using the most direct cable routing (cut off the excess cable). If you also want the audio output, there is room in the same area for a second phono jack.

The video adapter has a small trimmer potentiometer, which is the output level control that must be adjusted after the keyboard is installed.

More Video

The video adapter's output is either color or monochrome, but not both simultaneously. It is supplied set for monochrome. If you want to use a color monitor, cut the small wire jumper on the adapter's printed circuit board. If you want to have the option of color *or* monochrome, cut the jumper and connect each lead to a miniature slide or toggle—*not* momentary action pushbutton—switch. Install the switch on the cabinet wherever you would like to have it.



Instead of bringing the video cable through the cabinet, you can install a phono jack on the CoCo's cabinet to the right of the power switch and connect the cable to this. If you are using the audio option, do the same for its cable. Label jack(s) for easy identification.

Both the video and rf outputs are simultaneously active, meaning you can use both a composite monitor and a TV monitor at the same time; or at the very worst, you can use either without having to connect or disconnect cables. Of course, if you are displaying 60 or 80 charactes on the composite monitor, it will barely be legible on an ordinary TV monitor.

Install the Keyboard

To install the keyboard, rest it on its back toward the rear of the motherboard (the same position it was in when you removed it). Then slide the ribbon straight down into its connector. It will be a tight fit, so don't push too hard or you might bend or damage the plastic. Grab both sides of the ribbon about ½ " back from the end and, if necessary, rock the ribbon from side to side as you gently push down. Once the ribbon slides in it's connected, even if it appears to be just slightly seated. (The ribbon does not go very far into the socket, about ⅛ ", so if it seems to be seated it probably is.)

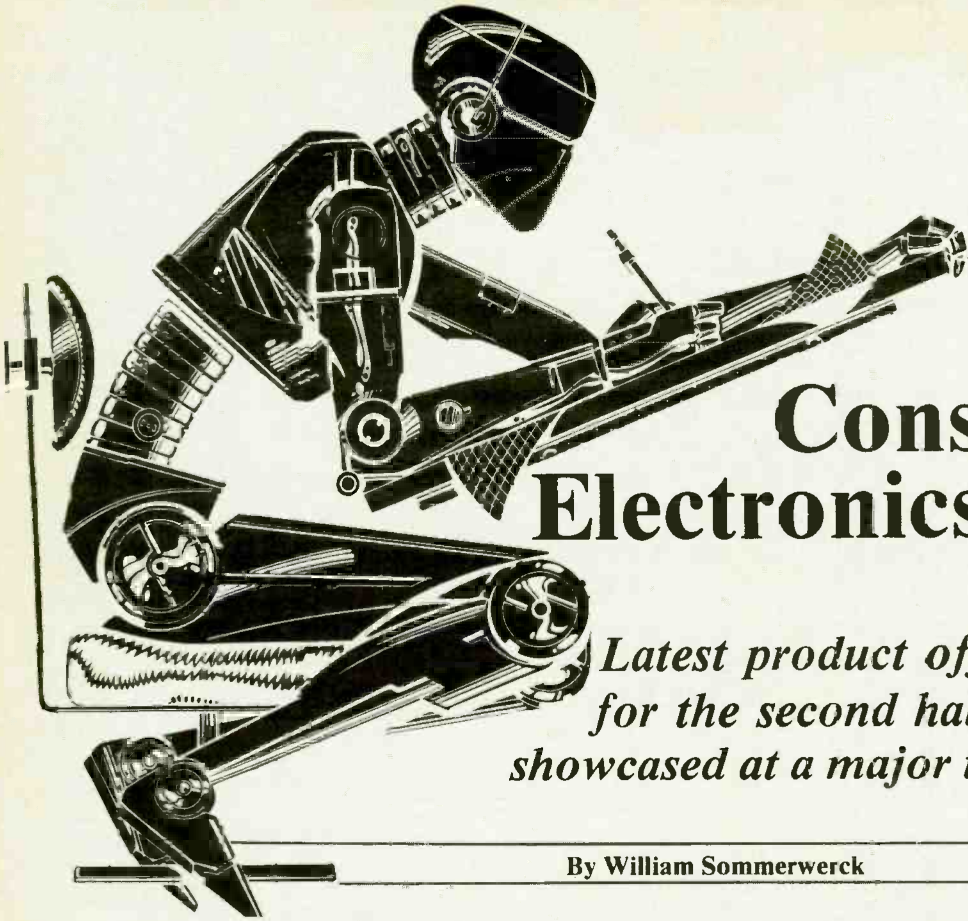
Install the rubber washers back on the posts and flip the keyboard forward onto the posts. Finally, make your checks and adjustments before closing the case.

Checkout

Connect a composite monitor to CoCo's video output and fire up the computer. Adjust the small trimmer potentiometer on the video adapter for a decent screen display. Check that all the keyboard keys work. If not, *turn off the power* and check the seating of the keyboard cable. You might get some strange color box patterns when the computer is first turned on, but if the computer seems to work okay just forget them.

When you're certain all the retrofits are working, adjust the video trimmer for best picture. Write a small BASIC program to fill the screen with characters and then adjust the video trimmer for maximum screen brightness coincident with minimum blooming of the individual characters. Also, fiddle with the monitor's own brightness and contrast controls, interacting them with the adapter's trimmer.

Then reassemble the cabinet when you're satisfied with the video adapter's adjustment. Your new 64K video-output CoCo is now ready to use as a powerful computer. **ME**



Consumer Electronics Showcase

Latest product offerings to dealers for the second half of 1986 are showcased at a major trade show

By William Sommerwerck

Celebrating its 20th year in electronics show biz, the past Summer Consumer Electronics Show was bigger than ever. With more than 1,400 exhibitors spread out over about 725,000 square feet, the whole spectrum of current and coming up consumer electronics products could be seen if one had the time and energy to pursue it fully. Here are some products that were especially interesting because they were innovative, high quality or struck my fancy as I wended my way around the exhibits.

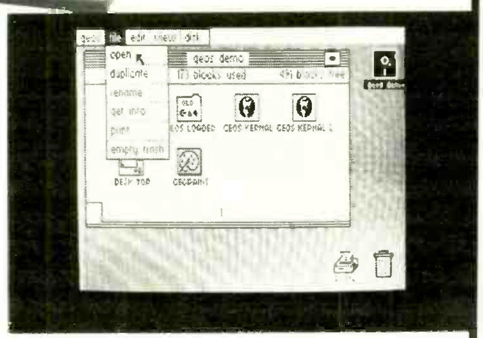
Acoustic Research, after an absence of nearly 15 years, again has a line of electronics, including preamp, tuner, CD player, power amp, integrated amps and receivers, most of which sport single-system remote control. AR is also going after the Bose "RoomMate" market, with its "powered pARtner," a portable speaker/amp with separate woofer and tweeter, and a hefty 15-watt output.

Atari finally released its 7800 video game system and a selection of interesting games. The 7800 system is claimed to have the highest resolution of any home computer or video game, and will also play regular 2600 cartridges. Atari says it'll support the 7800 with more titles. Guess the company believes there's still a spark of life left in this entertainment electronics area.

Casio's new SK-1 keyboard can record any sound, which is then "played back, looped, or changed, using any of 13 different sound envelopes." So what, you say? That's been available on professional synthesizers for several years. Yes, but the SK-1 costs only $130. The company also introduced a $120 scientific pocket portable computer with 65 sci functions and BASIC and Assembly languages.

Cincinnati Microwave claims its new StarCast C-band system minimizes "sparklies," those bursts of microwave noise in a video display. CMC did extensive research to characterize the threshold and peak levels of r-f noise, using this to distinguish the noise from the signal, lopping off the former.

Final Technology finally showed a working version of its Laser Turntable. This is the long-dreamed-of machine that plays conventional LP's with a beam of light; nothing touches the disk. I was one of the few journalists invited to hear the unit, and I can verify that it works. It will not be available for at least another four months . . . at an estimated $2,500.



Commodore introduced a remodeled Commodore 64 computer, the 64C. It features a new hardware/software system that provides graphics-based operation with a "point and click" icon interface for under $250. They say that the new operating system and applications on disk can be purchased separately for $59.95 by current Commodore 64 owners. The new mouse or joystick-controlled machine uses a 6510A CPU that's said to be compatible with the old C-64 computer and can, thus, use older software packages.

Future Communications's "Phasecom" TVRO antennas are flat. Using phased-array principles, they can be mounted on a roof or the side of a house. Prices range from $421 to $1200.

JVC, among others, has responded to the challenge of 8-mm camcorders with an upgrade of VHS camcorders that include 60-minute recording time (twice as much as previously) and HQ video circuits to improve picture quality. The system uses a VHS-C mini-cassette that's played back on home VHS videocassette decks with the use of a special adapter.

Interstate Voice Products displayed its module that attaches to a cellular phone to provide voice operation without having to touch the phone or take your eyes off the road.

Kodak has entered the premium battery market with its SupraLife alkaline and UltraLife lithium cells. The latter appears to be the first consumer 9-volt lithium battery, said to last more than 200% as long in use as alkaline types do.

Scisys's "Leonardo" chess computer has an "open system architecture." This permits future upgrade of memory or CPU without having to discard the basic machine. There is also an interface for connection to other computers.

Mastervoice's "Butler in a Box" recognizes vocal commands and answers in a human-sounding synthesized voice. It controls lights and appliances (via BSR X-10 protocol), answers the phone, and communicates with (or is controlled by) a computer through an RS-232C port. It can query an intruder, and if it doesn't recognize the voice, turn on lights and sound the alarm. This barely scratches the surface; you need a demonstration to appreciate this brilliant piece of design.

Sega's "MasterSystem" video game appears to incorporate the same graphics chips used in its current arcade games. Software comes in two forms: the Sega Card (which resembles an electrified credit card, and can hold up to 32K), and the Mega Cartridge (with four times that capacity). I was more impressed with Sega's hardware and game selections than with Nintendo's Entertainment System introduced last year.

Seiko's LVD-302 LCD pocket color TV has a screen that measures only 2" diagonally. But with 74,000 picture elements, it produced the least coarse display of any I've seen. The LC elements now change state quickly, with virtually no streaking of moving objects. The color picture displayed was clean and highly saturated.

Polaroid (in cooperation with Toshiba) has a freezeframe recorder that permits any single video frame to be recorded on their new Spectra film, or most 35-mm color negative or transparency films. Special circuits double the number of scanning lines for a more pleasing picture.

Sony has a water-tight casing for its popular 8-mm "HandyCam." The portable video recorder even includes a waterproof microphone!

Toshiba's DX-7 is the first VCR with a digital frame store. Any selected frame can be converted from analog to digital and held in 144K of RAM. This permits stable, noiseless slow motion and freezeframe. The deluxe VHS deck includes the usual high-end features, such as Hi-Fi sound and HQ video. The company also demonstrated a digital noninterlaced TV monitor that provides 525 lines in 1/60th second.

Video Interface Technology's Video Vitalizer is a sophisticated digital pattern and effects generator. Up to 120 effects are possible, depending on how many ROMs you're willing to buy. There isn't enough room to list all the features, let alone explain them. Prices run from $549 to $1031, depending on the number of effects and accessories.

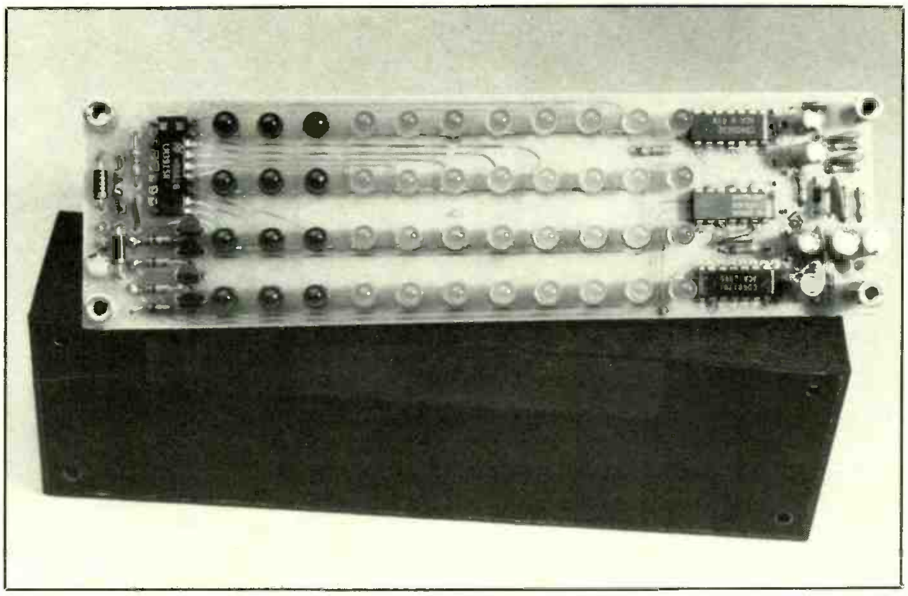
Yamaha's new DSP-1 Digital Sound Field Processor is said to be able to recreate the acoustic "personality" of many music environments. Forty eight preset acoustic environments are stored digitally to give a user a choice of listening to music in an intimate jazz club or a 1,000-seat auditorium, according to the company. Dolby Surround sound field is included in the new unit, which is the popular sound imaging technique used in many movie theatres.

CIRCLE 27 ON FREE INFORMATION CARD

Two-Band Stereo LED Power Meter

Lets you visually monitor your car stereo system's high- and low-frequency output power

By Ross Ortman



Many modern car-stereo amplifiers are so powerful that they can put your normally rugged speakers in jeopardy of burning up. A stereo power meter like the dual-band one described here provides an excellent means for guarding against this type of hazard.

The Two-Band Stereo Power Meter offers an unusual bargraph-like display. Unlike most power meters that provide a single display for each channel, this project has two per channel. Input signals are split into high- and low-frequency groups that are separately monitored for each channel. This allows you to keep an eye out for dangers to your woofers and mid-range drivers/tweeters separately, making displayed data much more meaningful.

All power information is displayed in four attractive horizontal "bargraphs" made up of discrete LEDs. The LEDs are of different colors, with green at the low-power end, yellow in the medium-power middle range and red in the high-power "danger" end. Consequently, not only is the Power Meter a practical device, it is also a very attractive high-tech addition to your vehicle.

About the Circuit

As shown in the block diagram in Fig. 1, the Power Meter consists of three main sections. The first is the input filter, which separates the left and right outputs from an amplifier into high- and low-frequency groups, with a crossover frequency of about 3 kHz.

Second in the chain is the multiplexing circuit. This circuit's oscillator, operating at about 380 Hz, is used to clock a 4017 decade counter/divider that supplies 10 decoded outputs, four of which are used to sequentially pass the filter outputs to the display driver and turn on its corresponding row of light-emitting diodes. A 4066 quad bilateral switch selects the filter output dictated by the counter/divider.

Outputs from the bilateral switches are sent to the display circuit, which is the third section. This circuit consists of four rows of LEDs, an LM3915 bar/dot driver and switching transistors that selectively supply power to individual rows of LEDs. The LEDs display the amplitude of the signal delivered to the Power Meter, as filtered and switched by the preceding sections, in a bargraph-like display format.

Now that you have an idea of system architecture, refer to the schematic diagram in Fig. 2. Power for the circuit is supplied by the electrical system of the vehicle in which the project is used. It is protected against transients and incorrect power connection by *D1*, *D2*, *C1* and *C13*.

Inputs to the project are ac coupled through *C2* and *C3*. This allows the Power Meter to be used with floating ground and high-power car stereo systems that usually have a dc component in their outputs. Separ-

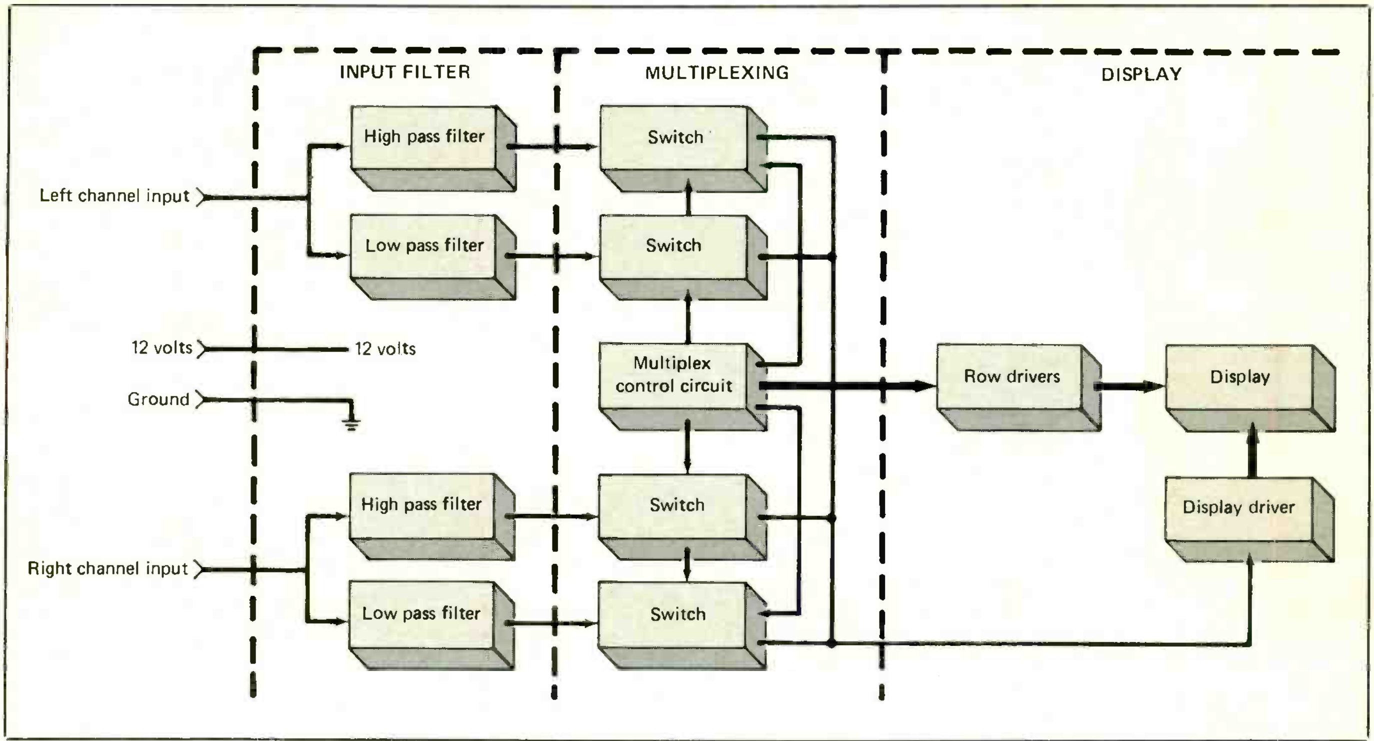


Fig. 1. Stereo Power Meter consists of an input filter, a multiplexer and a decoder/driver/display system.

ate low- and high-pass filters are provided for each channel: *C4/R3* for the high- and *R1/C6/R5* for the low-pass filters in the left channel and *C5/R4* for the high- and *R2/C7/R6* for the low-pass filters in the right channel.

Once the inputs are filtered, *D3* through *D6* rectify them and store their relative amplitudes in *C8* through *C11*. Individual level adjustments for each channel are provided by *R7* through *R10*. At the wiper of each of these controls is a calibrated dc voltage that is relative to the level of the power present at the inputs of each channel.

Since the input power is separated into two separate frequency bands, the amount of high- and low-frequency power in the left channel are the dc voltages at *R7* and *R9*, respectively. In the right channel, the appropriate controls are *R8* and *R9*, respectively.

Sections A and B of *IC2*, along with *R11* and *C12* make up a 380-Hz oscillator. Decade counter/divider *IC3* provides a sequential set of four pulses that are used to control the multiplexing. The multiplexing circuit is used to scan the four filtered voltage levels and display their amplitudes on their respective rows of LEDs. It does this by selecting each filter output in sequence and turning on the transistors for each respective row of LEDs. Using this scheme, only one row of LEDs is on at any given instant in time. However, because of the high-speed scan rate, all rows appear to be on simultaneously.

There are separate power-level bargraph driver/display circuits for the high- and low-frequency bands for each channel. These are *Q1* with *LED2* through *LED11* and *Q3* with *LED24* through *LED33* arrangements, respectively, for the left channel. The right-channel arrangements are *Q2* with *LED13* through *LED22* and *Q4* with *LED35* through *LED44*. Not part of the actual power-measuring section of the project are *LED1*, *LED12*, *LED23* and *LED34*, which serve as power indicators that come on whenever dc power is applied to the circuit from the vehicle's electrical system, even if no input signal is present.

Quad bilateral switch *IC1* passes each filter's output to the input of bargraph display driver *IC4*. This IC then turns on from one to ten LEDs of the selected row. The number of LEDs that come on indicate the relative input power level.

Construction

You can build the Power Meter using any wiring technique that suits you. However, printed-circuit wiring is recommended to provide stability and safety in the harsh automotive environment. No matter where you decide to mount the Power Meter—in an overhead console or under the dashboard—make sure to house it in some type of enclosure to protect the circuit from accidental shorting to any exposed metal in the vehicle. An enclosure also provides a more readable and attractive display.

A double-sided printed-circuit

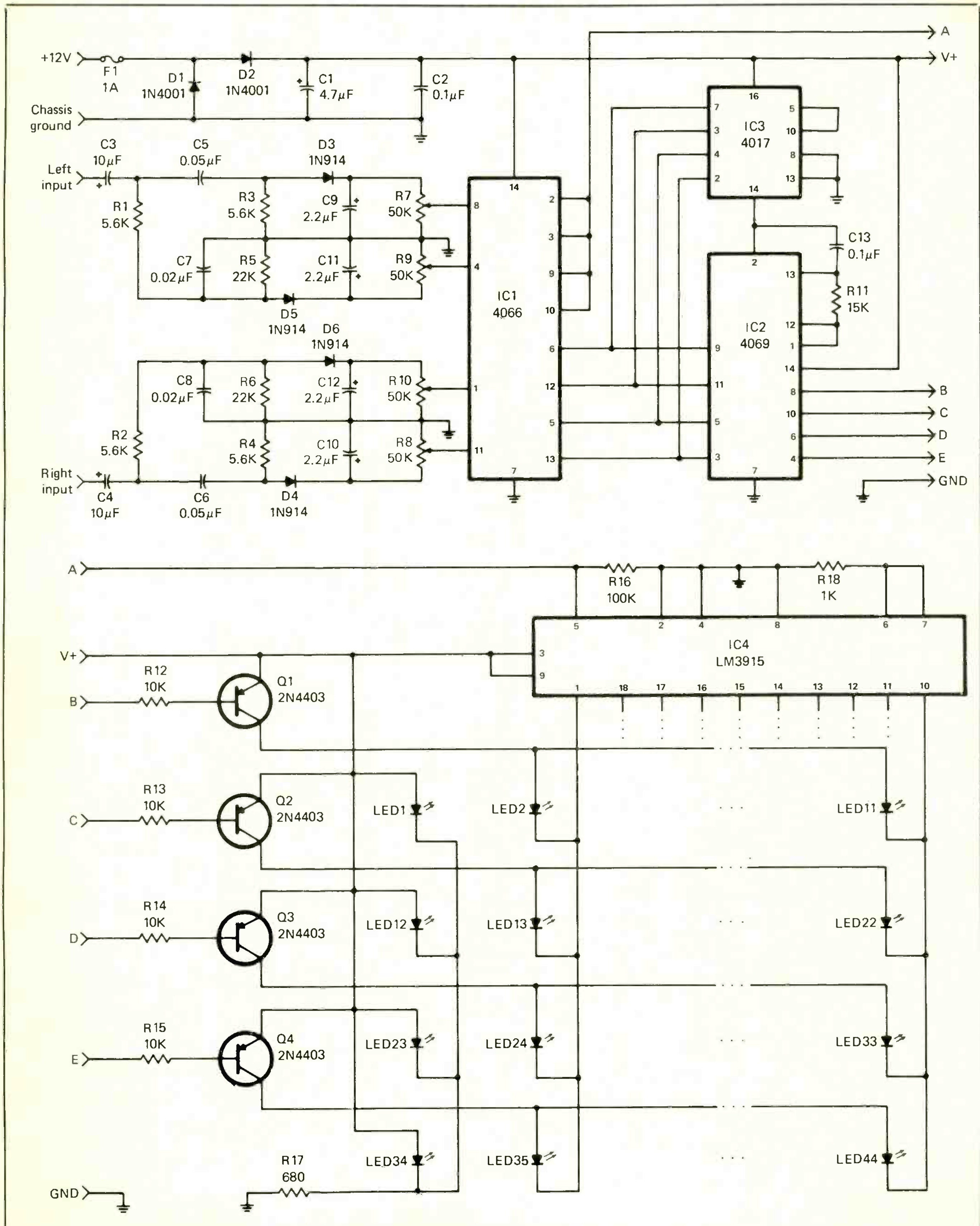

+12V
F1
1A
D1
1N4001
D2
1N4001
C1
4.7μF
C2
0.1μF
Chassis
ground
C3
10μF
C5
0.05μF
D3
1N914
Left
input
R1
5.6K
R3
5.6K
C9
2.2μF
R7
50K
C7
0.02μF
R5
22K
C11
2.2μF
R9
50K
D5
1N914
D6
1N914
C8
0.02μF
R6
22K
C12
2.2μF
R10
50K
R2
5.6K
R4
5.6K
C10
2.2μF
R8
50K
Right
input
C4
10μF
C6
0.05μF
D4
1N914
IC1
4066
IC3
4017
IC2
4069
C13
0.1μF
R11
15K
A
V+
B
C
D
E
GND
R16
100K
R18
1K
IC4
LM3915
R12
10K
Q1
2N4403
R13
10K
Q2
2N4403
R14
10K
Q3
2N4403
R15
10K
Q4
2N4403
LED1
LED2
LED11
LED12
LED13
LED22
LED23
LED24
LED33
LED34
LED35
LED44
R17
680

Fig. 2. Separate high- and low-frequency "bar" displays consist of 10 LEDs in each channel bar, plus one LED in each bar that comes on when dc power is applied. Only four LEDs are shown for each channel.

PARTS LIST

Semiconductors
D1,D2—1N4001 rectifier diode
D3 thru D6—1N4148 signal diode
IC1—4066 quad bilateral switch
IC2—4069 hex inverter
IC3—4017 decade counter/divider
IC4—LM3915 bar/dot driver
LED1 thru LED44—0.2" light-emitting diode (20 green; 12 yellow; 12 red—see text)
Q1 thru Q4—2N4403 transistor

Capacitors
C1—4.7-µF, 16-volt electrolytic
C2,C13—0.1-µF disc
C3,C4—10-µF, 35-volt electrolytic
C5,C6—0.05-µF disc
C7,C8—0.02-µF disc
C9 thru C12—2.2-µF, 25-volt electrolytic

Resistors (¼-watt, 5% tolerance)
R1 thru R4—5,600 ohms
R5,R6—22,000 ohms
R11—15,000 ohms
R12 thru R15—10,000 ohms
R16—100,000 ohms
R17—680 ohms
R18—1,000 ohms
R7 thru R10—50,000-ohm vertical-mount trimmer potentiometer

Miscellaneous
F1—1-ampere fast-blow fuse
Printed-circuit board; suitable enclosure (see text); power cable with in-line fuse holder; two-conductor zip cord; ½" spacers (4); machine hardware; hookup wire; solder, etc.

Note: A double-sided pc board with plated-through holes is available for $17.95 plus $1.50 P&H from: Dakota Digital, R.R. 1, Box 83, Canisota, SD 57012.

board was used for wiring the Power Meter's circuit in the prototype shown in the lead photo. You can fabricate this board, using the Fig. 3 actual-size etching-and-drilling artwork. Alternatively, you can purchase a ready-to-wire pc board with plated-through holes from the source given in the Note at the end of the Parts List.

Bear in mind that with a homemade double-sided board, all component leads and pins that contact the foil pattern on top and bottom must be soldered to the pads on *both* sides of the board. This means that if you wish to use sockets for the ICs, some of whose pins contact pads on both the top and bottom, you will have to use all-metal Molex Soldercons instead of the usual sockets. If you use the plated-through commercial board, however, you can use standard IC sockets. Capillary action will assure that all junctions on top and bottom of the board will be securely soldered if you solder on only the bottom of the board.

Referring to Fig. 4, begin wiring the board by installing and soldering into place the resistors. Follow with the diodes, making sure to properly orient them. Then proceed to the transistors. Bend the center base leads of the transistors slightly toward the flat of the case. Holding the board in the orientation shown in Fig. 4, install each transistor with the flat facing the top of the board. The bent-forward base lead in each case plugs into the offset hole in the solder-pad pattern. Adjust the height of the transistors to about ¼" from the surface of the board and solder the leads to the pads. Use heat judiciously to avoid damaging the transistors.

Now install and solder into place the capacitors, making sure that the polarized electrolytics are properly oriented. You have the option of installing the ICs directly on the board, with their pins soldered to the foil patterns (on both sides if your board is homemade) or via sockets or Soldercons.

The most difficult step in assembly is installation of the LEDs because of the repetitive nature of the operation and the fact that all LEDs in each row and column must be carefully aligned and of uniform height to provide a balanced display. Keep firmly in mind that the cathodes in all cases go into the holes nearer the bottom edge when the board is oriented as shown in Fig. 4. There are two ways to identify the cathode lead: the lead near the slight flat in the case lip and the widened lead near the bottom of the case.

A good way to assure uniform LED height is to push the LED leads down until the widened portion of the cathode leads just touch the top of the board. Solder only the cathode leads of all 44 LEDs to the pads. Each horizontal "bar" in the display consists of green, yellow and red LEDs. The first five LEDs in each bar (e.g. *LED1* through *LED5* in the topmost bar) are green, the next three are yelow and the final three are red.

If you prepare an alignment template for the LED matrix, a lot of time can be saved in positioning the LEDs to make a symmetrical display. The template is made from heavy cardboard stock like Bainbridge board or thin but rigid plastic like ⅛"-thick Plexiglass cut to 5" long by 2" wide. Cut out and paste the actual-size template shown in Fig. 5 to the cardboard or plastic template blank. If you prefer not to cut up the page, place the blank behind Fig. 5, centering it in the outline, and pierce with a pin or needle at the center of each circle. Then remove the blank.

Drill an ¹¹⁄₆₄" or ³⁄₁₆" hole through the center of each hole outline (or through each marked point). You should have a total of 44 holes arranged in a symmetrically balanced matrix. Place the template over the LEDs. Adjust the positioning of the LEDs so that their domes fit into all 44 holes. With the LEDs in place, position the template so that it is parallel with the top edge of the board. Check to make sure that all LEDs are at a uniform height. If any are not, reflow the solder and adjust as necessary. Then solder the cathode leads

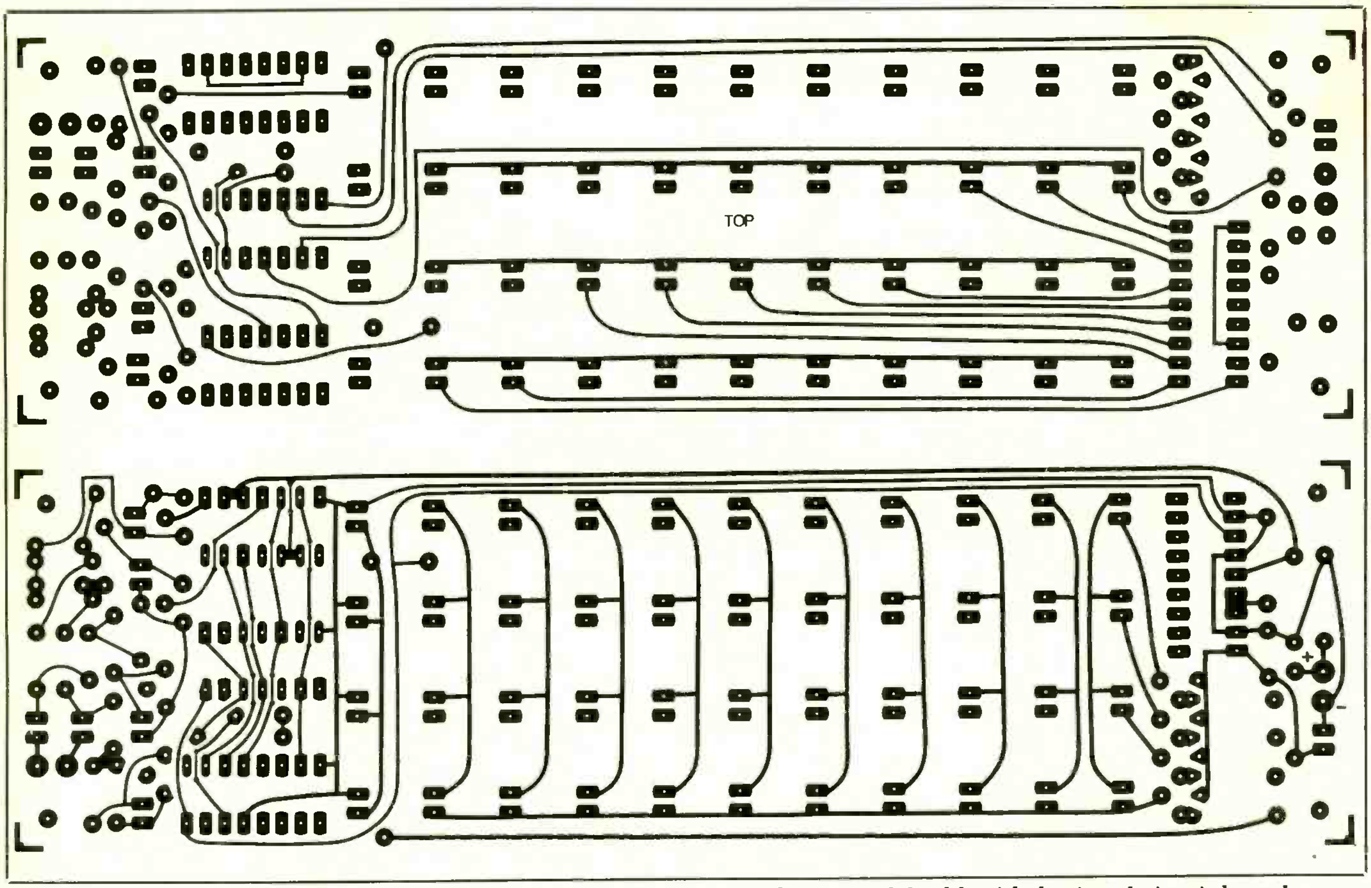


Fig. 3. Actual-size etching-and-drilling guides for top and bottom of double-sided printed-circuit board.

of first the top row of LEDs to the solder pads. Repeat for the second, third and fourth rows. Use heat sparingly to prevent damaging the LEDs.

Remove the template and discard it if you have no further need for it. If you plan to make more Power Meters, store the template away for later use.

You can, of course, arrange the LEDs without the aid of a template. In this case, you will have to perform the entire operation by eye. Needless to say, this can be a very time-consuming operation.

Referring back to Fig. 4, install the *R7* through *R10* trimmer controls on

(Continued on page 90)

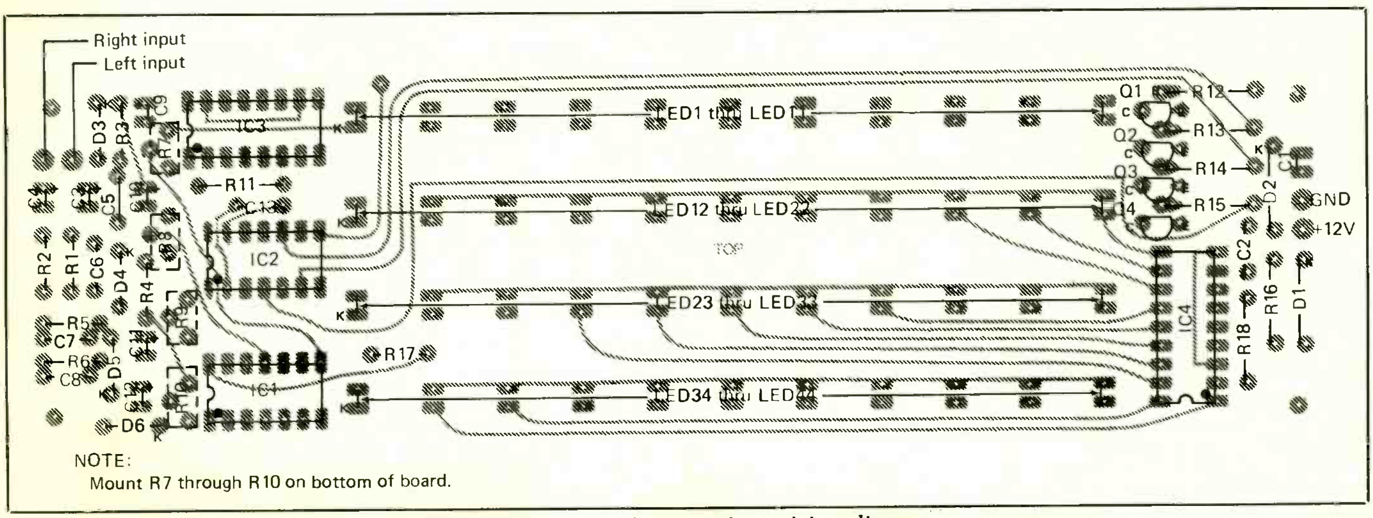
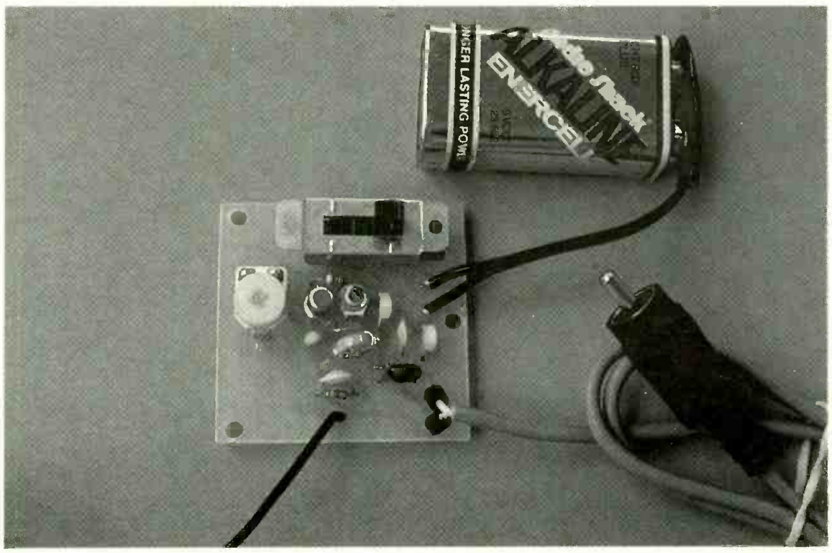


Fig. 4. Placement/orientation wiring diagram.

An Experimenter's Aviation-Band Receiver

Low-cost project lets you tune in on airport and airborne radio activity

By Dan Becker



If you live within 20 miles of a busy airport, you have an opportunity to tune in on some exciting radio activity. With the Experimenter's Aviation Band Receiver to be described, you can listen to aircraft and tower communications in the 118-to-135.95-MHz band assigned to aviation activities, including the 121.5-MHz world-wide emergency channel.

Channels are divided into increments of 50 kHz each, with each assigned to a different type of service. Some channels are used by air traffic controllers who continuously give course and altitude instructions to pilots aloft. Other channels are used while an airplane is on the ground. These service channels carry maintenance, fuel status, weather (including wind speed and direction and temperature aloft) and personal requests by pilots enroute. Much of what you can hear is routine, but in times of emergency, you can get first-hand information before the news media report it.

About the Circuit

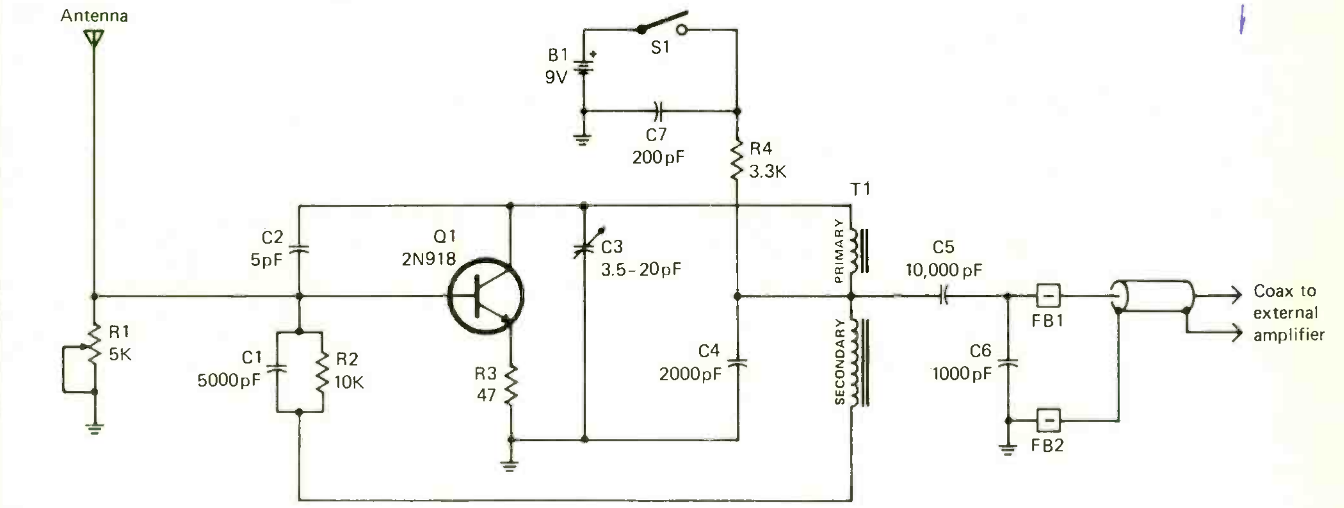
Shown in Fig. 1 is the complete schematic diagram of the Experimenter's Aviation Band Receiver. It is built around a single transistor, identified as *Q1*, which operates as both and r-f amplifier and a detector. The output of this transistor is coupled to an external audio amplifier via a coaxial (shielded) audio cable. Almost any epitaxial transistor rated for vhf service will work in this circuit.

Because aviation communication is via amplitude-modulated (AM) signals, the value of the dc collector current of *Q1* can be made to vary in direct proportion to these signals. This requires an input signal amplitude of greater than 10 millivolts. In addition, any variation in the dc collector current must be extracted and amplified.

Two functions are performed by the Aviation Band Receiver. One is its operation as a Hartley oscillator in which the approximately 120-MHz operating signal frequency is governed by *T1*, *C2* and *C3*. This greatly amplifies the microvolt-level signals that appear at the antenna and feeds them back to the base of *Q1* with an amplitude greater than the 10-mV minimum level needed by the circuit for proper operation.

In the second function, any variation in the dc collector current will appear as a variation in the emitter-collector voltage, measured at the collector side of *R4*. It is here that the audio information is extracted and sent off to the audio amplifier.

Capacitors *C1*, *C4*, *C6* and *C7* by-



PARTS LIST

Semiconductors
Q1—2N918 npn transistor
Capacitors
C1—5,000-pF ceramic disc
C2—5-pF, high-Q ceramic disc
C3—3.5-to-20-pF trimmer
C4,C7—2,000-pF ceramic disc
C5—10,000-pF Mylar
C6—1,000-pF disc
Resistors (⅛-watt, 5% tolerance)
R2—10,000 ohms
R3—47 ohms
R4—3,300 ohms
R1—5,000-ohm trimmer potentiometer

Miscellaneous
B1—9-volt battery
FB1, FB2—Vhf ferrite bead
S1—Spst slide or toggle switch
T1—Hand-wound transformer
Printed-circuit board; suitable enclosure; T-25-0 powdered-iron toroid core and 30-gauge enameled wire for T1; 1-meter length of hookup wire for antenna; connector for B1; coaxial audio cable; machine hardware; hookup wire; solder; etc.

Note: A kit of all parts including pc board, all components and audio cable (but not enclosure) is available for $8.95 plus $1.00 S&H from: Dan Becker, 101 Highland Dr., Chapel Hill, NC 27514.

Fig. 1. Complete schematic diagram of Experimenter's Aviation Band Receiver.

pass radio frequencies. Potentiometer *R1* and resistors *R2*, *R3* and *R4* establish a quiescent dc collector current of approximately 1 mA. In addition, regenerative control *R1* permits the gain to be adjusted to establish oscillation and *C3* permits fine tuning of the operating frequency. Ferrite beads *FB1* and *FB2* in series with the audio output help isolate the audio cable from r-f signals. The antenna is made from a 1-meter or shorter length of hookup wire.

Power for the circuit is supplied by ordinary 9-volt battery *B1*. It is applied to the circuit via spst switch *S1*.

Construction

The very simple circuit of the Experimenter's Aviation Bank Receiver is readily assembled on a 2″ × 2″ piece of perforated board, using appropriate soldering hardware. Alternatively, you can fabricate a printed-circuit board using the actual-size etching-and-drilling guide shown in Fig. 2. A third alternative is to assemble the circuit on a ready-to-wire pc board supplied in the kit of parts from the source given in the Note following the Parts List.

If you elect pc construction, wire the board exactly as shown in the components-placement and orientation diagram given in Fig. 3. (You can also use Fig. 3 as a rough guide to component layout if you use perfboard construction.) When wiring the board, be sure to keep all lead lengths as short as possible.

All components for this project, except *T1*, are readily available from parts suppliers ready for installation. The only component you are not likely to find is the transformer, which you must wind yourself. This is not difficult. All you need are a powdered-iron toroid core (see Parts List) and some 30-gauge enameled wire. Begin by winding four turns of the wire onto the core to make the primary. Without cutting the wire, form a 2″ loop and continue winding eight more turns to make the secondary winding. Wind all turns in the same direction.

When all turns have been wound

on the toroid core, cut the loop and the ends of the wire so that there are four equal-length leads. Carefully scrape away the enamel from all four leads for a distance of about ½". Then lightly tin with solder the exposed metal of each lead. Inspect the solder. If there are any gaps or the solder has blobbed instead of evenly coating the leads, you missed some of the enamel while scraping. Rescrape any lead that appears to be suspicious and retin.

Install and solder into place first *S1* and then the transformer as shown in Fig. 3. Then install the resistors and capacitors. When you install transistor *Q1*, adjust its height above the board's surface to 3⁄16". Then wire the battery connector to the appropriate pads. Keep the battery connector's leads to just a few inches in length and arrange them as far away from the rest of the circuit as possible.

If your coaxial audio cable has phono plugs at both ends, snip off one from either end. Then remove 1" of outer insulation from the cut end. Be careful to avoid cutting through the shield conductors as you do this. Depending on whether the shield is braided or spirally wound, separate the fine conductors so that they can be twisted into a tight bundle. Then strip ¼" of insulation from the inner conductor. Very lightly tin with solder the inner conductor and tightly twisted shield wires. Exercise care soldering to avoid melting the insulation and causing a short circuit.

Slip a ferrite bead over the cable's shield wires and the inner conductor. Then install and solder into place the two conductors in the appropriate holes in the board.

Prepare a suitably sized metal enclosure to accommodate the circuit board by drilling three mounting holes for 6-32 machine hardware. Use the board itself as a template for determining where to drill the holes. Then cut a slot for *S1*'s toggle, drill access holes for *R1* and *C3*, and drill small holes through which the antenna lead and audio cable are to exit the box. Make sure the hole for the antenna wire is exactly in line with the antenna hole on the pc board. Line the antenna and audio cable holes with rubber grommets to protect the wire and cable from chafing and shorting out against the metal box.

Mount the board in place with spacers and 6-32 machine hardware. You can mount *B1* either with a standard metal battery clip fastened to the box with machine hardware or with double-sided foam tape to any wall where it will not interfere with the circuit board.

Adjustment and Use

Set trimmer control *R1* to about three-quarters of its travel clockwise and trimmer capacitor *C3* to approximately minimum capacitance. Place the circuit board on a table near an audio amplifier and plug the Aviation Band Receiver's audio cable into the amplifier's auxiliary (AUX) or microphone (MIC) input jack. Position the project's antenna up and away from the circuit board. Use a thumb tack to hold it against a wall.

Plug a 9-volt transistor battery into the battery connector and turn on the project and the amplifier. Set the amplifier's volume control about half-way up and the tone controls for minimum treble to reduce the hiss from the oscillator.

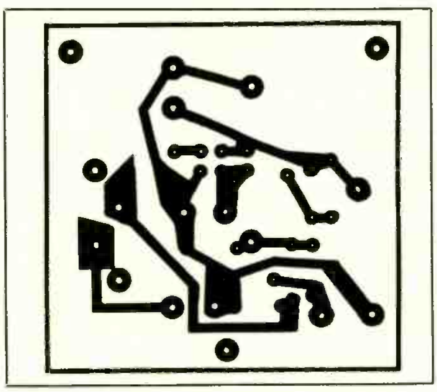


Fig. 2. Actual-size etching-and-drilling guide for receiver's printed-circuit board.

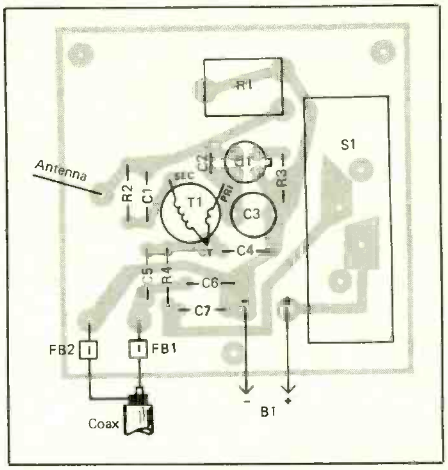


Fig. 3. Components-placement/orientation diagram.

Adjust the setting of *R1* until you hear a distinct hissing sound coming from the amplifier's speaker(s). This hiss indicates that the circuit is oscillating. In addition, you can vary the settings of both *R1* and *C3* to tune in different segments of the Aviation Band.

In closing

If you are an avid listener, you will likely want to keep your Experimenter's Aviation Band Receiver on at all times. Therefore, you might consider building a dedicated audio amplifier and separate ac-operated power supply to use instead of the battery for continuous monitoring. You can find projects for these options in past issues of *Modern Electronics*. You can also use an amplifier module with its own battery power supply and speaker for portable operation. In this case, you will undoubtedly want to equip your receiver with a transfer jack that will switch back in th *B1* battery supply when ac power is removed when operating in the portable mode. Happy listening. ME

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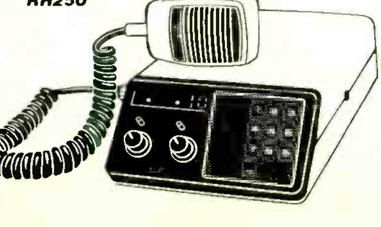

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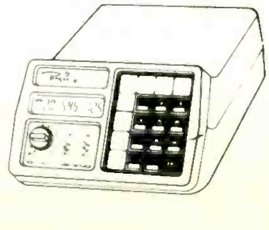

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Using the Operational Transconductance Amplifier

Discover the advantages of working with this often-disregarded member of the op-amp family

By C.R. Fischer

Hundreds of uses for the common operational amplifier have been paraded through pages of books and magazine articles during the past 20 years. Strangely, though, several other devices in the op-amp family have been virtually ignored during the same period. One of the lesser-known close cousins of the op amp is the operational conductance amplifier, or OTA. This nifty little device has attributes that are difficult to duplicate by other means.

Among the OTA's functions is a unique biasing input that allows the device to be used as a voltage- or current-controlled resistor or switch. This feature makes it invaluable for varying parameters in such analog circuits as waveform generators, amplitude and frequency modulators, electronic musial instruments, etc. While the operational transconductance amplifier resembles a typical operational amplifier at first glance, there are some essential differences that cannot be ignored if you expect it to operate properly. In this article, we will cover these differences, show you some basic circuits to get you started experimenting, and talk about some of the OTAs currently on the market.

Defining the OTA

For purposes of comparison, Fig. 1 shows the pinouts of the ordinary 741 op amp and the CA3080 operational transconductance amplifier. The two devices appear to be identical at first glance, but if you look closely, you will notice that the CA3080 has an amplifier bias input at pin 5. This input provides a means for varying the conductance (reciprocal of resistance) of the CA3080 OTA by varying the current flowing into this pin. With no current, there is no output whatsoever, while an input current of about 1.5 mA produces maximum gain.

Pin 5 is 0.7 volt above the negative supply potential, and input current must be limited to less than 2 mA to avoid damaging the IC. Note also that the CA3080 requires a dual-polarity power supply that delivers no more than +18 and −18 volts. To remain on the safe side, you should limit power supply potential to +15 and −15 volts.

Two other idiosyncracies of the OTA are the input and output structures. The inputs are capable of handling only very-low-level signals, ranging from 10 to 40 mV in the case of the CA3080. Applying a higher-level input causes severe distortion in the output signal, though some new-

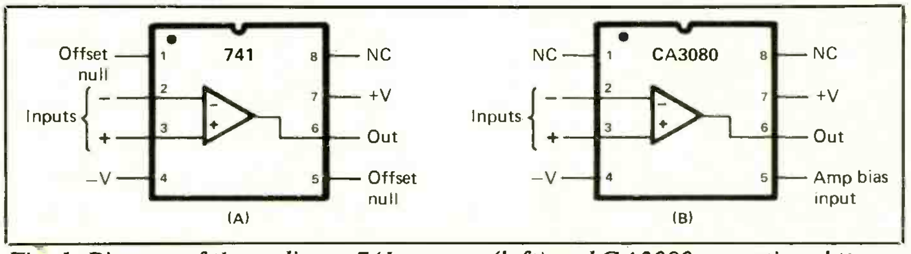
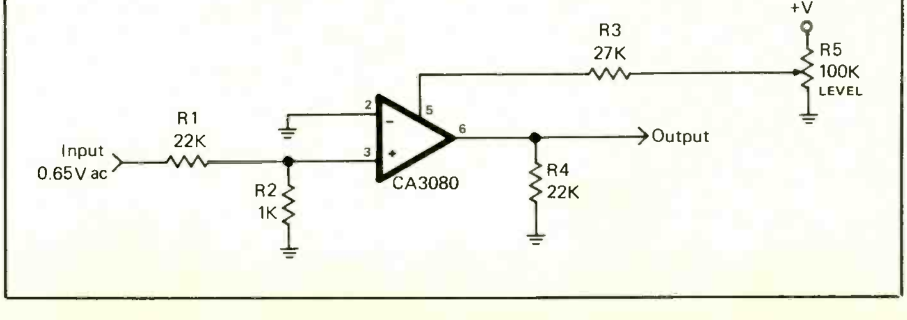


Fig. 1. Pinouts of the ordinary 741 op amp (left) and CA3080 operational transconductance amplifier (right). Though both appear to be identical, note that the 741 has offset null, while the CA3080 has a bias input.

Fig. 2. A simple single-chip voltage controlled amplifier, or vca.



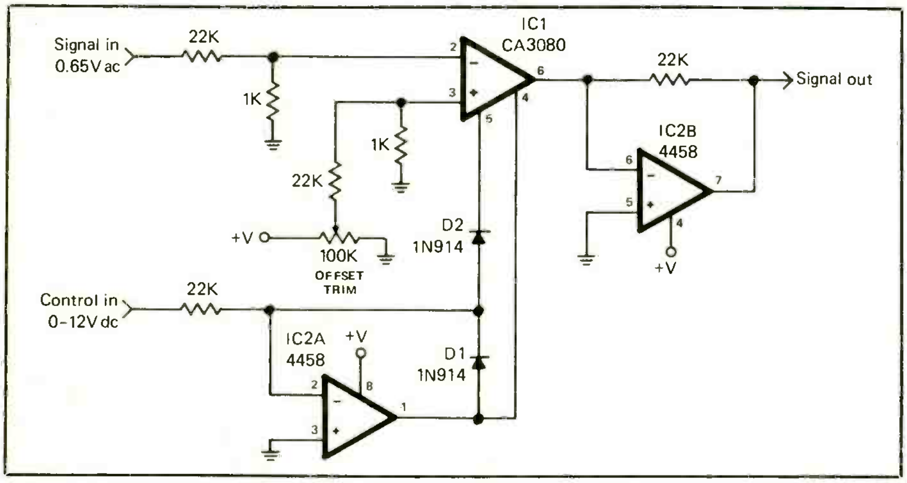


Fig. 3. Improved voltage-controlled amplifier uses ordinary operational amplifiers as a voltage-controlled circuit source and an output buffer.

er chips have been designed to safely handle higher-level inputs.

Another way the OTA differs from conventional op amps is that it has a current output with an impedance in the tens of megohms. If this is a disadvantage in a given application, you can simply follow the OTA with an ordinary op amp, which then serves as an output buffer.

A load resistor to ground can convert the output current back to a voltage. Since the value of this resistance controls the voltage gain, the OTA gives control of this parameter with a single component.

In essence, there are three ways to control the output level of the OTA. You can vary the input signal voltage level, the load resistance, and the control current. In most cases, the first two would be fixed and only the control current would be varied.

OTA Applications

A very simple voltage-controlled amplifier, or vca, is shown in Fig. 2. The *R1/R2* input attenuator has been set for a 0.6-volt ac input signal. Current to the bias output of the OTA is limited by *R3, R4* is the output load, and *R5* provides a variable control voltage. With the value shown for *R5*, the circuit's gain range is from 0 to 1 (unity).

If an envelope generator is used with the Fig. 2 circuit, this vca can be used to reproduce the attack and decay feature of a musical instrument. In fact, this type of circuit will work in any application where resistance must be changed and manual control is impractical or impossible. Remote controls, amplitude modulators and computer control of analog circuits (use a D/A converter) are a few representative examples.

Though the Fig. 2 circuit can be used as is, performance can be improved by using the circuit shown in Fig. 3 (adapted from a similar vca in Walter Jung's *IC Op Amp Cookbook*). Directly driving the *IC1* CA3080 OTA is the *IC2A* voltage-controlled current source. This design eliminates the need for a current-limiting resistor and references the control voltage to ground instead of to −14.3 volts.

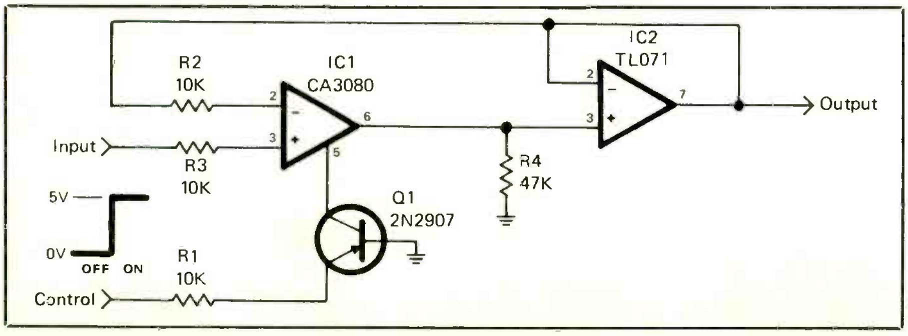
Serving as a buffer for *IC1, IC2B* gives the improved vca a reasonably low output impedance whose output level is set by R_f. The OFFSET TRIM control in the CA3080's input circuit is used to null any undesired offset voltage that can cause an audible "pop" when the control voltage is rapidly changed. In some cases, control may not be necessary if pin 2 is grounded.

A vca is usually modulated with a changing voltage, but there is no reason why it cannot be gated so that it functions as an analog switch. This opens a whole new range of applications that allow you to remotely turn on and off signals. Chips like the 4016 and 4066 are inexpensive and easy to find. However, since they are limited to a 15-volt signal range and require a switching signal that equals the supply voltage in amplitude, you might find it more convenient to use an OTA instead of these devices.

Figure 4 shows an OTA configured as an analog switch. Transistor *Q1* switches the input on and off with a low-level signal. In selecting *R1*, scale its value at a rate of 2,000 ohms per volt on the control line. With the correct value, you can control the switch with 5-volt TTL or higher-voltage CMOS logic.

Figure 5 shows a very common use for the analog switch. This sample/hold circuit "samples" a voltage at

Fig. 4. Using an operational transconductance amplifier as an analog switch to gate high-level signals from digital logic.



its input when triggered and continues to "hold" that level until another command is issued. When the control line goes high, the *IC1* OTA acts as a closed switch and charges *C1* until the input and output voltages are equal. With the line low, the "switch" opens so that the voltage is stored in *C1*. To prevent leakage currents from introducing errors, use a low input bias operational amplifier like the CA3140 or LM351 for *IC2* and polyester or polystyrene capacitor for *C1*.

There are quite a few uses for the sample/hold circuit in electronics. For example, it can be used to create a random music box, as shown in Fig. 6. Here *IC3* is a simple voltage-controlled oscillator (vco) that acts as a tone source and serves as an input for the Fig. 5 sample/hold circuit. Trigger generator *IC4* can be varied from 0.5 Hz to beyond 10 kHz. The sample/hold circuit picks voltages off the triangle-wave output of *IC3* and feeds them back to the vco to give the familiar Hollywood "computer language" sound used in motion pictures and TV shows. You are likely to find this neat little toy quickly appropriated by your children, however.

You may have noticed that the circuits in Figs. 4 and 5 lack the input attenuators that were necessary in the vca circuits. This is possible because here the 10-to-40-mV level applies the difference between the − and + inputs. Since one of the vca's inputs in Figs. 2 and 3 was grounded, the other input had to be near ground potential. In a switching circuit, however, when the switch is open, no signal can get through. Also, distortion is meaningless. When the switch is closed, the output buffer sends the input signal back to the remaining input. With both inputs at the same level, distortion is not a problem.

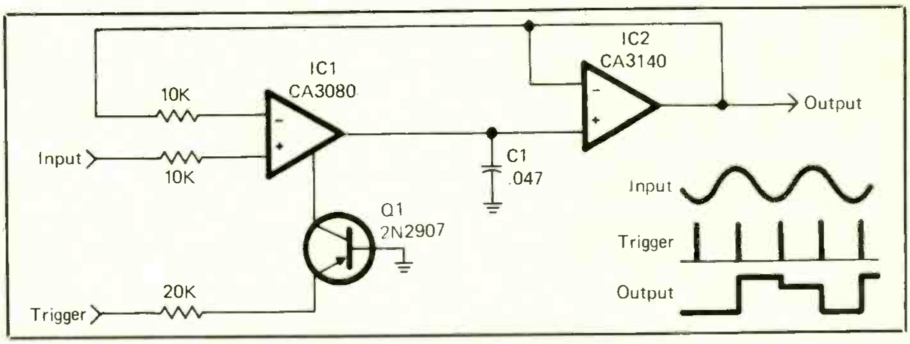


Fig. 5. A typical OTA sample/hold circuit.

Some Available OTAs

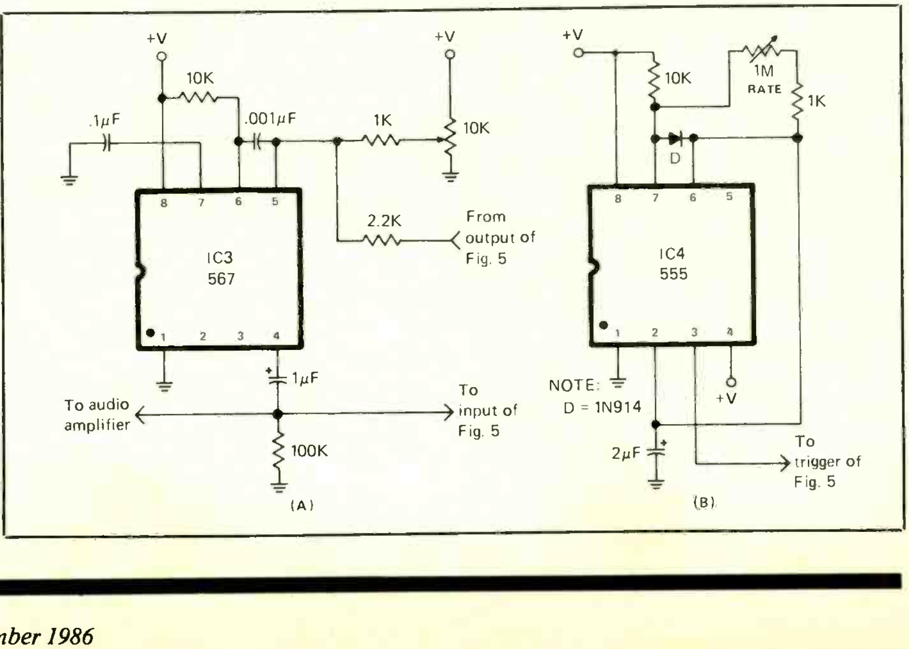
In this article, we showed representative circuits built around RCA's CA3080 because this OTA is readily available and inexpensive to purchase. It costs about $1.00 from mail-order suppliers. RCA (Solid State Div., P.O. Box 3200, Sommerville, NJ 08876) has been marketing the CA3080 since 1971. It is still used in new designs today. It may suffer from a severely limited input level that compromises its signal-to-noise ratio, but the CA3080 is still useful where this is not an important consideration. Note, too, that RCA also manufactures the CA3280, a dual version of the CA3080.

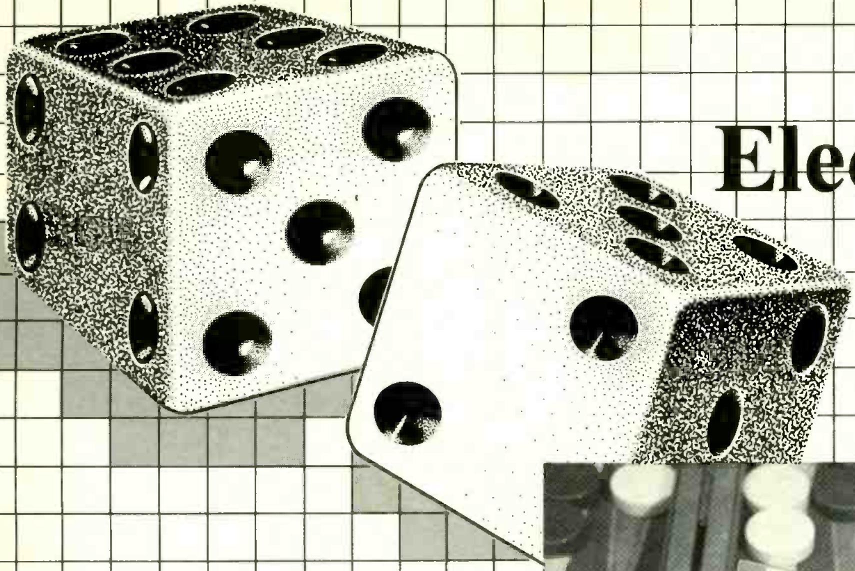
National Semiconductor's (2900 Semiconductor Dr., Santa Clara, CA 95051) very interesting and versatile LM13600 dual OTA has several features not found elsewhere. Among these are linearizing diodes that reduce signal distortion and an internal buffer for each OTA. Because the buffers are not internally wired, you can substitute an external buffer if desired. National's applications booklet for the LM13600 has a variety of circuits for the experimenter, including a stereo volume control, voltage-controlled filters (vcfs), and a two-chip sine-wave vco with a range of 5 Hz to 50 kHz, the last at less than 1% distortion.

Since audio signal processing and electronic music make up a significant portion of the OTA market, it should come as no surprise that manufacturers have designed ICs especially for audio applications. While these devices are much more expensive than the CA3080, their im-

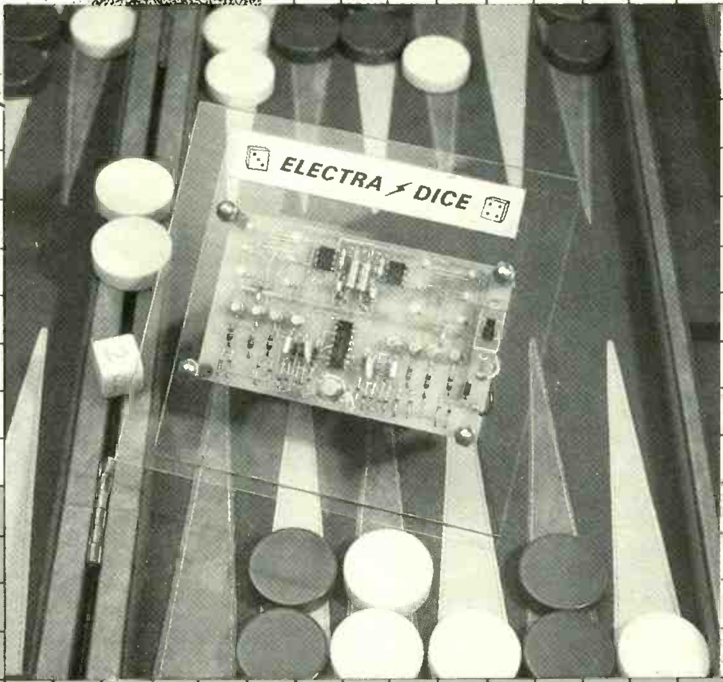
(Continued on page 83)

Fig. 6. Adding these two IC circuits and a few other parts to the sample/hold circuit in Fig. 5 produces an entertaining random music machine.





Electronic Dice



Visible circuit with LEDs makes playing board games more fun than with traditional cubes and assures players of true "rolls"

By Bill Owen

Almost everyone likes playing board games in which the action turns on the roll of dice. The old way of playing such games with actual dice cubes may not be unexciting, but "Electra Dice" described here can make the playing more fascinating as players press a button and watch light-emitting diodes flicker until they stop rolling to present the numbers of the roll.

The fascination goes beyond just flickering of some LEDs. Unlike most projects that are hidden inside utility boxes, you sandwich Electra Dice between two layers of clear Plexiglass so that players can view the circuitry as well as the "roll" of the electronic dice. Moreover, having the numbers generated electronically gives one a sense of confidence in the trueness of a roll.

The projects costs only about five times what you would pay for ordinary dice cubes. And it is convenient to use because it runs on a standard 9-volt battery.

About the Circuit

Shown in Fig. 1 is the overall schematic diagram of Electra Dice. It consists of two identical halves that form the two "dice." Each die consists of seven LEDs that randomly

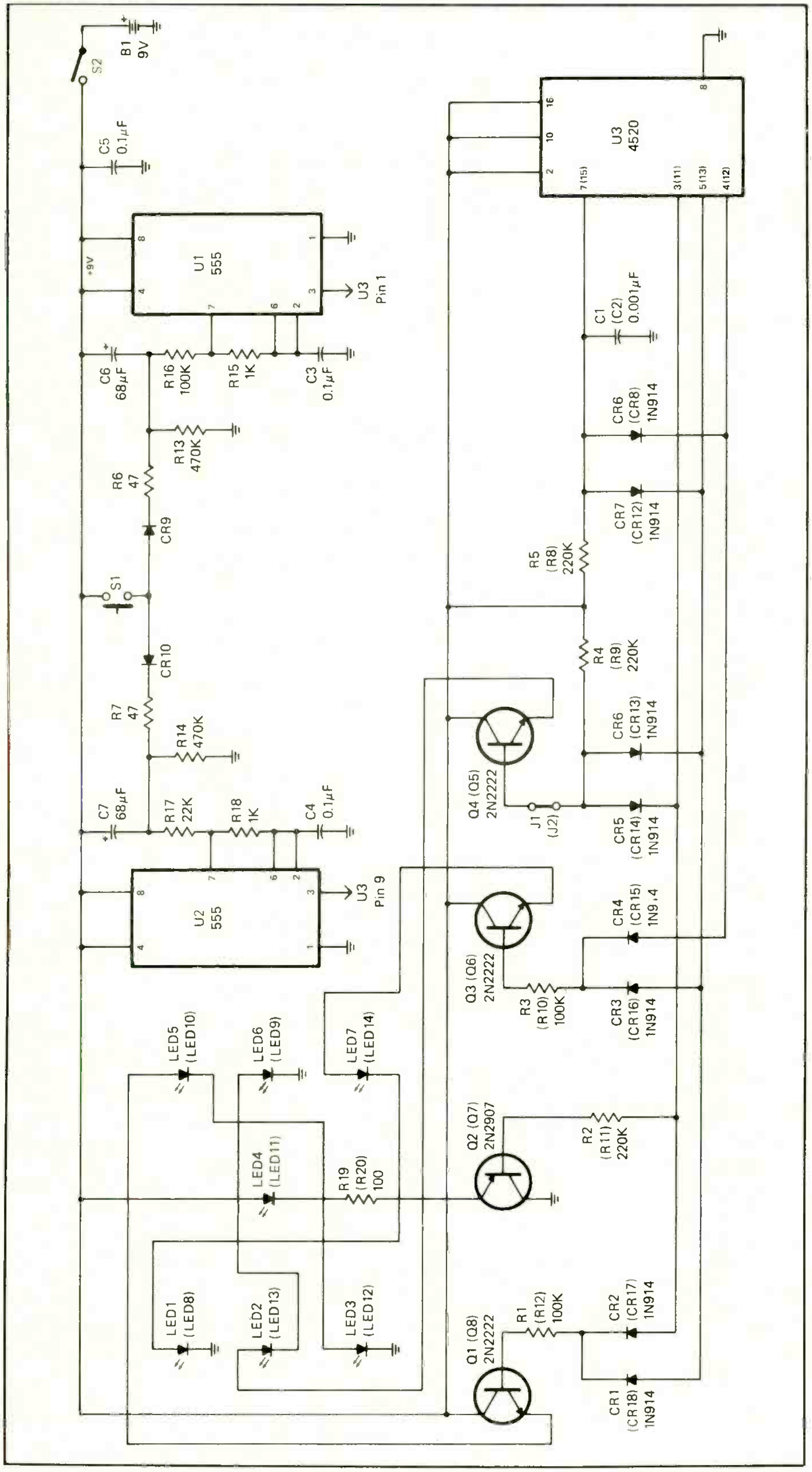


Fig. 1. Though project has two dice display circuits, only one die's driver/LED system is shown. Remaining circuitry is mirror-image of LED1-LED7/Q1-Q4 circuitry. Completing circuitry is indicated by numbers in parentheses.

PARTS LIST

Semiconductors

CR1 thru CR18—1N914 switching diode
LED1 thru LED14—3-mm red light-emitting diode
Q1,Q3,Q4,Q5,Q6,Q8—2N2222 npn transistor
Q2,Q7—2N2907 pnp transistor
U1,U2—555 timer
U3—4520 dual decade counter

Capacitors

C1,C2—0.001-µF disc
C3,C4,C5—0.1-µF disc
C6,C7—68-µF, 16-volt tantalum

Resistors (¼-watt, 5% tolerance)

R1,R3,R10,R12,R16—100,000 ohms
R2,R4,R5,R8,R9,R11,R17—220,000 ohms
R6,R7—47 ohms
R13,R14—470,000 ohms
R15,R18—1,000 ohms
R19,R20—100 ohms

Miscellaneous

B1—9-volt transistor battery
SW1—Spst pushbutton switch
SW2—Spst slide switch
Printed-circuit board; ⅛"-thick Plexiglass panels (2); 4-40 × 2¼" machine hardware; IC sockets or Molex Soldercons (optional—see text); battery clip for B1; double-sided foam tape; hookup wire; solder; etc.

Note: The following items are available from NRG Electronics, P.O. Box 24138, Ft. Lauderdale, FL 33307: Pc board and all electronic components for $14.95; drilled Plexiglass panels with hardware and label for $4.95. Add $2.00 S&H per order. Florida residents, please add 5% sales tax.

light to form the usual 1 through 6 dots that appear on conventional dice. Though traditional dice cubes have a maximum of six dots on the highest number face, the Electra Dice has seven LEDs. This gives the same effect that you would have if you were playing with conventional dice when you roll a 1, 3 or 5. It makes the display appear balanced, with the odd dot in the center, rather than off to one side.

After closing power switch *SW2*, the action begins when ROLL push-

Die count	Q1 (LED3, 5)	Q2 (LED4)	Q3 (LED1, 7)	Q4 (LED2, 6)
1	Off	On	Off	Off
2	On	Off	Off	Off
3	Off	On	On	Off
4	On	Off	On	Off
5	On	On	On	Off
6	On	Off	On	On
1	Off	On	Off	Off

Fig. 2. Conditions for each driver transistor for specific die counts.

4250 Counter Output Logic

Counter output C	B	A	Pulse No.
0	0	0	
0	0	1	1
0	1	0	2
0	1	1	3
1	0	0	4
1	0	1	5
Reset			6

button switch *SW1* is momentarily pressed and released. Separate 555 timer ICs *U1* and *U2* then begin counting down. During the countdown periods, which are different for the two timer circuits, counter *U3* continuously rolls the LED "dice." When the two timer stages reach the end of their countdown cycles, the dice stop rolling and the LED dice displays "freeze." At this point, the left and right dies will separately display a number between the usual 1 and 6.

Light-emitting diodes *LED1* through *LED7* make up the left die. *LED8* through *LED14* the right die. Because the project consists of mirror-image circuitry, only the portion for the left die is shown in Fig. 1. The portions that make up the right die are indicated by the numbers in parentheses.

During a roll, the LEDs are continuously and repeatedly sequenced from 1 through 6. Examining the six different die counts in Fig. 2 makes it clear that only four different combinations of LEDs are required. Therefore, *LED1/LED7, LED2/LED6* and *LED3/LED5* are connected in series pairs so that both LEDs in each pair light simultaneously when the circuitry decodes their specific sequences. Transistors *Q1* through *Q4* electronically switch on and off the LED pairs. (This same action occurs in the second half of the circuit, with *Q5* through *Q8* controlling *LED8* through *LED14*.)

Figure 2 shows the manner in which these four driver transistors can be switched on to derive the six die counts. Note that *Q2*, a pnp transistor, is different from the other three driver transistors in that a high at its base input turns off and a low turns on the transistor. The other transistors are all npn devices.

Unfortunately, there does not exist a ready-made electronic circuit or IC that will produce the high and low inputs to the transistors to properly sequence them. However, a standard digital counter IC's outputs can be used either directly or in combination to do the job.

Shown in the Counter Output Logic Table are the highs and lows present at the outputs of the 4520 counter IC (*U3* in the project) as pulses are fed into the clock input. In this circuit, a pulse is a transition from high to low and back to high. The 4520 is a dual binary counter. Its four outputs are capable of counting from zero to 15 (for a total count of 16). Because the 4520 is a dual binary counter, it is a natural as the sequencing device for a project in which two dies are required, as is the case with the Electra Dice because all we need is the one integrated circuit.

To display the six die counts with seven LEDs, the four transistors must receive six unique input combinations. To achieve this, the counter is rigged to reset back to zero after the sixth pulse is counted. Only three counter outputs are required to provide the six unique inputs required. These are the A, B and C outputs from the 4520, which are added together using diodes or connected directly, as in the case of *Q2*, to the bases of the driver transistors.

Digital circuit design is usually the result of logical expressions written to satisfy specific requirements. The designer works from the desired outputs—such as the die patterns in Electra Dice—back to the available outputs from the counter IC. Transistors and diodes permit logical expressions to be carried out electronically. A logical expression can be formulated for each desired result. Because the seven LEDs can be controlled by four transistors, a logical expression is needed for each transistor in terms of the A, B and C counter outputs. The expressions with their electronic equivalents are shown in Fig. 3.

Using a pnp transistor for *Q2* satisfies the requirement for a low at output A of counter *U3* for *LED4* to light when a 1, 3 or 5 is rolled. The OR expression as in "A OR B" finds its electronic equivalent in two diodes that connect together at the base, allowing a transistor to turn on

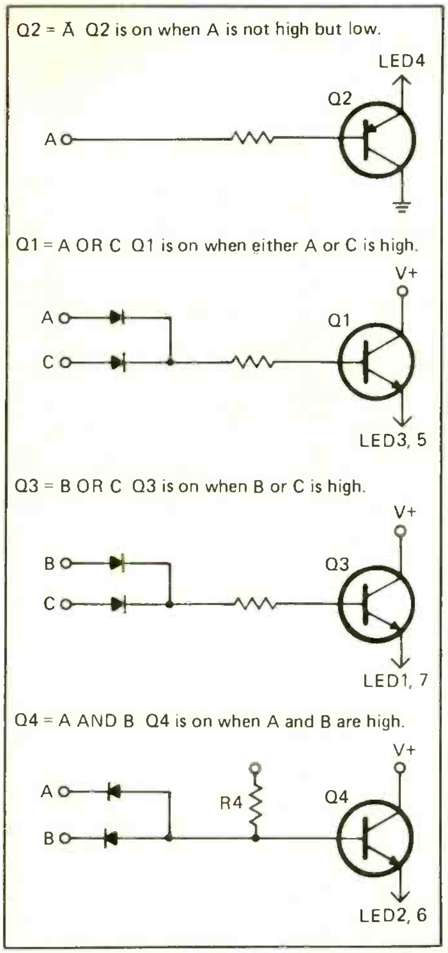


Fig. 3. The logic expressions and electronic equivalents for each driver transistor.

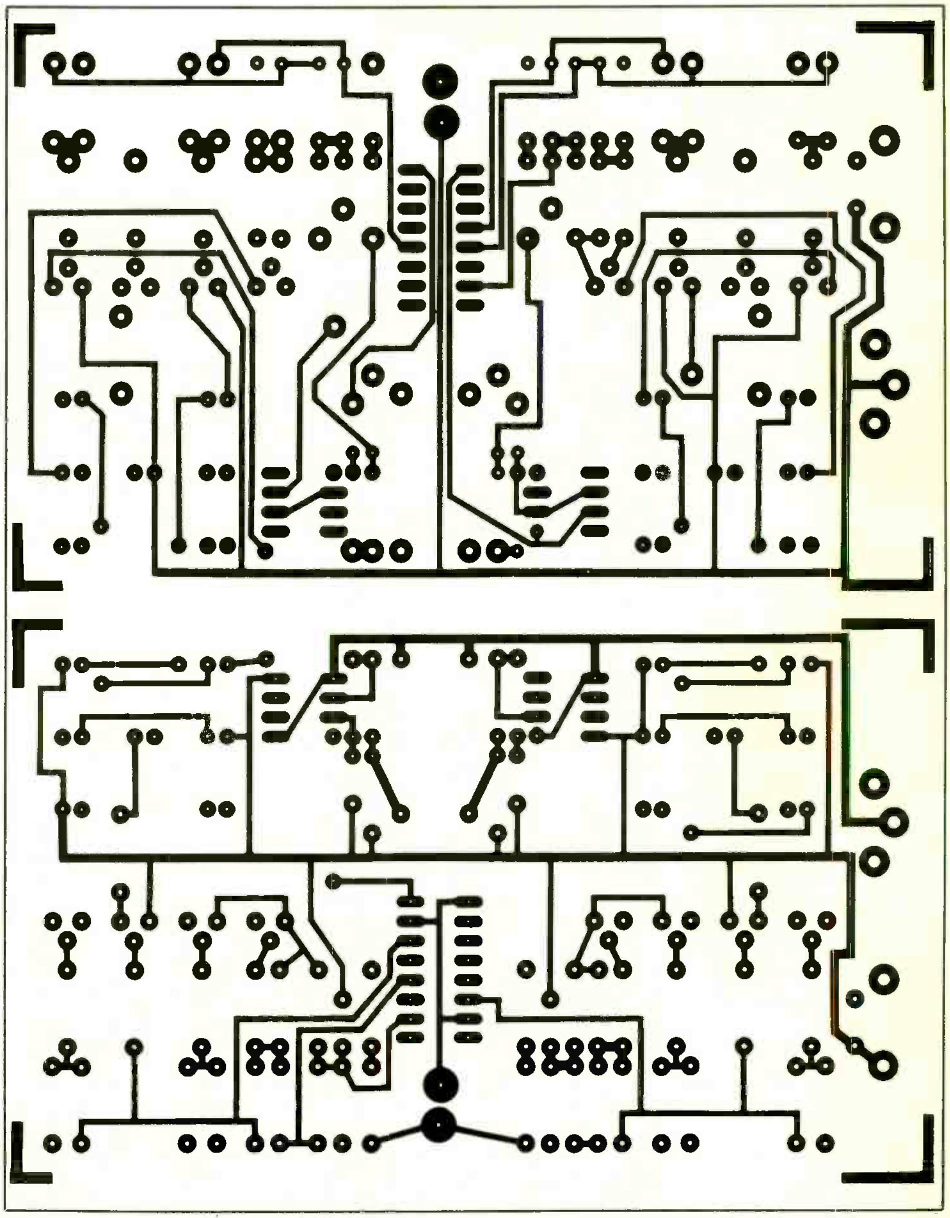


Fig. 4. Actual-size etching-and-drilling guides for both sides of printed-circuit board.

from either input. The AND expression follows from the fact that *Q4* will be turned on by *R4* only if A AND C are high simultaneously.

As mentioned above, *U3* must be reset after the sixth pulse. Otherwise, it would count right on up to 16 and cause problems with counts coming out of turn. The sixth pulse causes the B and C outputs to both go high. This condition is detected and used to reset the counter. If either the B or the C output is low, the reset input is also low. However, when both B and C are high, the counter automatically resets to zero.

Construction

There is nothing particularly critical with regard to circuit layout. For convenience, though, printed-circuit board construction is recommended. You can fabricate this double-sided pc board, using the actual-size etching-and-drilling guides in Fig. 4. If you do, make sure that both guides are properly registered on the pc blank during exposure. When installing components on a home-made double-sided pc board, solder all leads that contact the top and bottom traces on *both* sides of the board. Additionally, it is necessary to solder short lengths of solid hook-up wire or component lealds in the holes that bridge conductors on both sides of the board.

If you prefer not to etch and drill your own board, you can purchase a kit of parts that contains a ready-to-wire pc board from the source given in the Note at the end of the Parts List. The board in this kit has plated-through holes that eliminate the need for having to solder on both sides.

Referring to Fig. 5, begin wiring

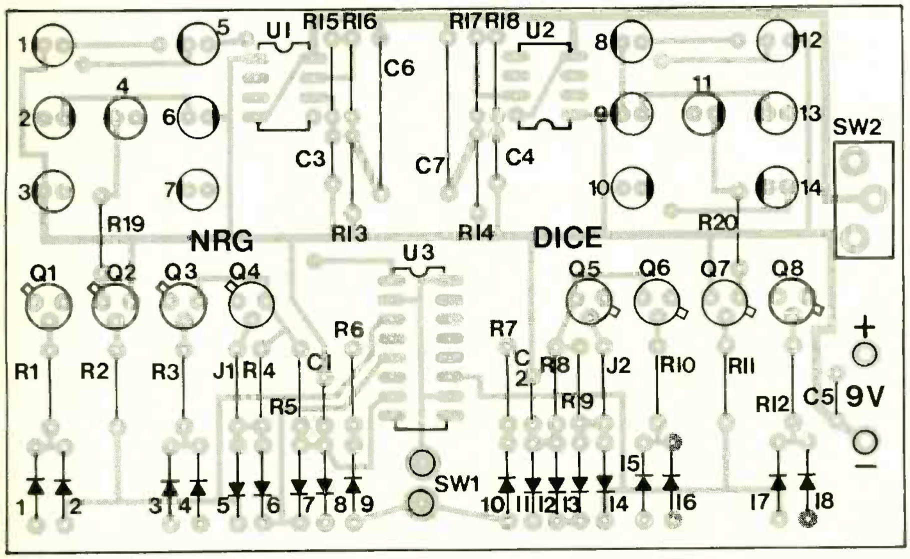


Fig. 5. Components placement/orientation diagram for pc board.

the board by installing and soldering into place the diodes at the locations indicated by numbers only along the bottom of the board when held in the orientation shown. Make sure you properly orient these and all other polarized and indexed components—tantalum capacitors, LEDs, transistors and ICs—before soldering their leads or pins to the board's copper pads.

After installing the diodes, proceed with the resistors, insulated jumper wires (in the locations indicated by J1 and J2) and capacitors. Next, install the ICs. You can install these directly on the board or via optional sockets that make it easier to troubleshoot the circuit and replace a defective IC if this should become necessary. Use sockets only if the plated-through board is used. You can not use sockets with a homemade board because they do not provide access to solder the pins to the required pads on the top of the board. Instead, use Molex Soldercons that do give soldering access.

Practice safe handling procedures for the 4520 CMOS decade counter IC. One way to ensure against damaging this IC with static electricity is to make sure that your hand is the only thing that touches it once it is removed from its protective carrier and that you hold the board in your other hand as you plug it into the holes in the board, the socket or the Molex Soldercons.

Install the transistors, making sure their emitter, base and collector leads plug into the appropriate holes and that they stand approximately ¼ " above the surface of the board. Install the 2N2907 transistors in the *Q2* and *Q7* locations and the 2N2222 transistors in all other locations. Note that the tabs pointing to the transistors' emitters point upward and slightly to the left for *Q1* through *Q4* and downward and slightly to the right for *Q5* through *Q8* as shown in Fig. 5.

Now install the LEDs in the locations indicated by numbers only in the upper-left and upper-right. Make sure that the cathode leads plug into the holes indicated by the flats in the case outlines. Let the LEDs stand a uniform ¾ " above the surface of the board. You might want to slip ¾ " lengths of small-diameter plastic tubing over each anode lead before plugging the LEDs into the board. The tubing serves two purposes—one is to give a uniform height, the other to provide insulation to prevent the LED leads from shorting to each other.

Bear in mind that light-emitting diodes are heat sensitive and are easily damaged by excessive soldering heat. Therefore, it is a good idea to use small heat sinks or the jaws of longnose pliers to absorb the heat as you solder each lead to its copper pad on the board. When all LEDs have been soldered into place, arrange them in symmetrical patterns.

Solder the leads of the battery clip to the labeled 9V pads on the right side of the board. The red clip lead goes to the hole labeled with the + sign, the black lead to the hole labeled with the − sign.

Prepare two 2 " lengths of hookup wire by stripping ¼ " of insulation from both ends. If you use stranded wire, tightly twist together all fine strands of wire at each end and sparingly tin with solder. Solder one end of each wire to the pads labeled *SW1*. Then install slide switch *SW2* directly on the board.

Cut two sheets of ⅛"-thick Plexiglass to 6" × 5¾ ". Drill four ⅛" holes through both sheets for mounting the circuit-board assembly centered in the area. Drill a fifth hole for pushbutton switch *SW1* in the top panel. Place a ½ " × ¾ " strip of double-sided foam tape exactly in the center of the bottom panel for mounting the 9-volt battery.

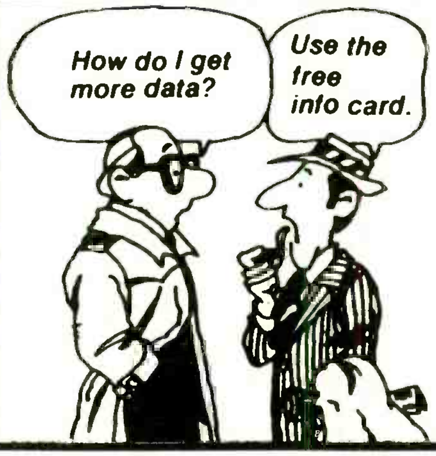
Mount *SW1* in its hole in the top panel. Solder the free ends of the two hookup wires to the lugs of *SW1*. Then use 1 " spacers and 4-40 × ¾ " machine hardware to sandwich together the circuit board and Plexiglass panels. When you are finished, there should be eight spacers, two at each corner, separating the circuit board from each Plexiglass panel.

Press the battery into the foam tape and clip the connector onto its terminals. Reach under the top Plexiglass panel and flip *SW2* to on. The LEDs should immediately begin flashing and eventually stop at a roll pattern. Press and release ROLL switch *SW1*; the LEDs should again flash until they stop at a roll pattern. Press and release *SW1* several more times to assure that the circuit is operating properly. If everything appears to be okay, Electra Dice is ready to be put into service.

If the project is not working properly, turn off the power and remove the clip from the battery. Before suspecting a bad component, carefully check all connections to determine if you missed soldering one. Also check for cold-soldered joints, resoldering any that are suspicious. If this does not clear up the problem, carefully check the polarization and orientation of all diodes, transistors, LEDs, ICs and the two tantalum capacitors.

Whenever Electra Dice is not being used for playing games, always turn off its power. Though the circuit itself does not draw much current, the LEDs do. Note, too, that mounting power switch *SW2* directly on the board instead of on the top panel makes it almost impossible for *SW2* to be toggled on by accident.

To play with Electra Dice, all you do is turn on the power and press and release the ROLL switch. Then sit back and watch the flickering of the LEDs gradually come to a halt.



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Piezoelectric Buzzers

By Forrest M. Mims III

Piezoelectric sound sources have been available for more than 20 years. In the mid-1960's, Mallory introduced the Sonalert™, a piezoelectric sound source installed in a plastic housing with a built-in driver circuit. Today numerous kinds of self-contained piezoelectric buzzers, as they are often called, are readily available from many sources. Radio Shack's catalog, for example, describes piezoelectric buzzers that produce continuous, pulsing, dual, and chime sounds.

Consumer and industrial applications for piezoelectric buzzers abound. They are used in wrist and pendant watches, alarm clocks, calculators, microwave ovens, telephones, smoke alarms, geiger counters, automobiles, and in many other consumer appliances and industrial equipment. Because piezoelectric buzzers and elements are inexpensive, easy to use, and highly reliable, they are particularly popular with experimenters.

Piezoelectric Buzzer Design

Piezoelectricity literally means pressure electricity. It is the phenomenon wherein a voltage is produced when pressure is applied to certain crystals. Conversely, piezoelectric crystals change their shape in response to an applied voltage. Crystals of quartz, tourmaline, and Rochelle salt exhibit piezoelectric properties. Though its piezoelectric effect is weak, quartz is the most important of these crystals. It is used to make highly reliable and reproducible mechanical oscillators whose frequency varies only slightly with changes in temperature. Such crystals provide frequency standards and highly stable oscillators for digital clocks and watches, television receivers, radio transmitters, and so forth.

Rochelle salt crystals have long been used to make high-impedance crystal earphones and microphones. Development of high-intensity piezoelectric buzzers and related devices awaited the development of a family of manmade ferroelectric ceramics having excellent piezoelectric properties. Among the best developed of these is zirconate titanate.

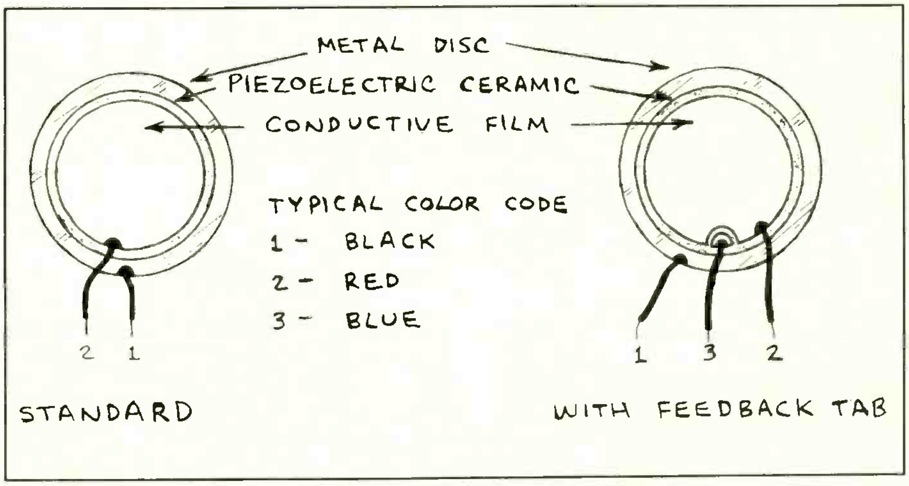


Fig. 1. Details of typical piezoelectric buzzer elements.

Figure 1 shows two typical piezoelectric sound generator elements. Most such elements have a diameter ranging from 25 to 40 mm and a preferred or resonant frequency of from 2 kHz to 7 kHz. The elements are formed by bonding a disc of piezoelectric ceramic to a larger disc of flexible metal. Electrical contact to the disc is provided through the metal disc and a conductive film applied to the opposite side of the ceramic disc. When a voltage is applied across the two electrical contacts, the diameter of the ceramic disc expands. This motion is transformed into a movement perpendicular to the plane of the disc by the spring-like action of the metal disc. The direction of motion of the disc is dependent on the polarity of the applied signal.

Note that one of the discs in Fig. 1 is equipped with a third terminal called the feedback tab. This tab is a separated portion of the metalized coating on the surface of the ceramic material. When an oscillating signal is applied across the other two terminals, a voltage appears at this tab that can be used to stabilize the frequency of the oscillator circuit. More about this later.

A circular disc will tend to vibrate at a preferred frequency called the mechanically-resonant frequency. A dramatic illustration of the resonance of a piezoelectric buzzer element can be arranged by connecting the element to a variable frequency signal generator, either a commercial unit or one of the circuits that follows. The element is then placed with its metal side up on a soft surface (a few layers of tissue paper works well), and some light, dry powder such as sugar or an artificial sweetener is then poured on the center of the metal disc. A signal is then applied, and its frequency is swept across the audio spectrum.

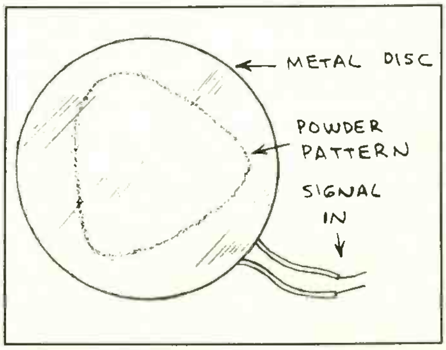


Fig. 2. Nodal pattern of an oscillating piezoelectric buzzer element.

The powder may vibrate slightly when the signal is applied. At a particular frequency, the powder will become considerably more agitated. Much of the powder will vibrate off the surface of the disc, leaving behind a nearly circular pattern outlining the disc's nodal region, the position of minimum vibration. Figure 2 shows a typical powder pattern that results when a resonant signal is applied to a real disc.

Knowing the nodal pattern of a piezoelectric element is important, for mechanical attachment to the disc can be made in the nodal region without impairing the sound producing abilities of the disc. Figure 3 shows the nodal mount configuration along with other methods of mounting a piezoelectric disc. Though the mounting method can greatly affect both the mechanical resonance of the disc and its sound amplitude, the mounting procedure need not be so precise as suggested by Fig. 3. For instance, a disc can be cemented to a rigid surface with a flexible sealant such as silicone adhesive. If the surface to which the disc is cemented is itself acoustically resonant, the sound level may be further amplified. This effect occurs when piezoelectric discs are cemented to the inside of musical greeting cards since the paper from which the cards are made adds to the resonant area of the disc along.

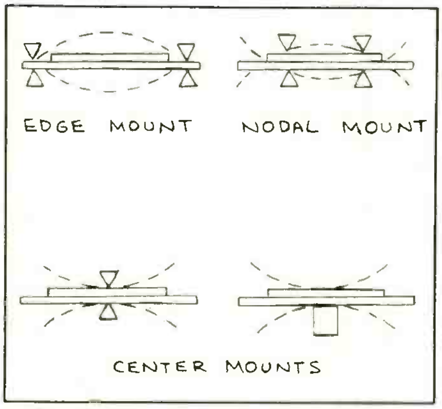


Fig. 3. Mounting arrangements for piezoelectric buzzer elements.

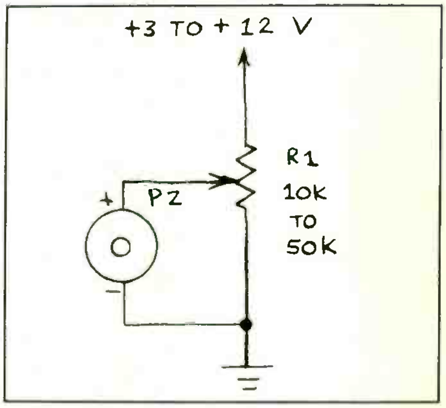


Fig. 4. Controlling the volume of a piezoelectric buzzer.

Operating Precautions

Recall that the operation of piezoelectric devices is reversible. A dramatic demonstration of this can be made by connecting a neon glow lamp to the terminals of a piezoelectric sound generator element. When the element is struck by a hard object, the resulting piezoelectric voltage will be high enough to flash the lamp. Several hundred volts or more can be produced in this manner. Therefore, to protect the driver circuitry, it may be necessary to connect a blocking diode across a piezoelectric element that might be subjected to mechanical shock or vibration.

It is important to avoid connecting a dc source across a piezoelectric buzzer element. Apparently this may depolarize the ceramic material, thereby greatly reducing or even eliminating its piezoelectric properties.

Finally, when experimenting with piezoelectric buzzers, remember that these devices can produce exceptionally loud, shrill sounds. Sound pressure levels in excess of 100 dB are easily possible. Sound levels this high can be very uncomfortable and can produce long-lasting headaches. Therefore, it is important to use ear protectors when working with piezoelectric buzzers at close range. I used COM-FIT™ multi-purpose earplugs (North Consumer Products, P.O. Box 7500, Cerritos, CA 90701) while experimenting with the circuits described below. These earplugs have an attenuation of around 35 to 40 dB over the frequency range at which most piezoelectric buzzers operate (2 to 4 kHz). Before I purchased these earplugs, I stuffed wads of cotton or facial tissue in my ears. While this helped, the professional earplugs work much better.

If other people are present in or near the area in which you plan to experiment with a piezoelectric buzzer, you can muffle the sound of the buzzer somewhat by placing some modeling clay over the sound output aperture. Of course this method will not work if you are experimenting with piezoelectric elements and do-it-yourself driver circuits such as those described below.

Buzzer Drivers

A piezoelectric buzzer consists of a self-contained piezoelectric disc element and a miniaturized oscillator-driver circuit. Many different kinds of buzzers are available, most of which can be operated by connection to a suitable power supply. Figure 4 shows how to vary the volume of a piezoelectric buzzer by means of a series-connected potentiometer. Considering the very loud sound emitted by many such buzzers, this simple arrangement can become very handy.

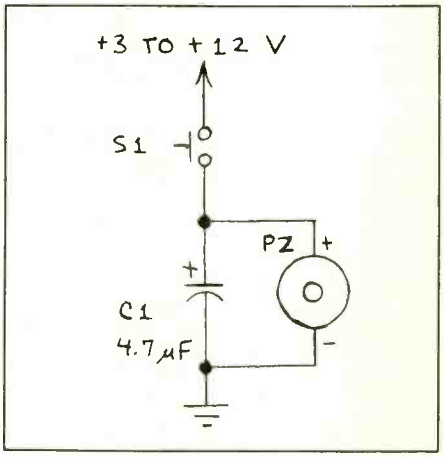


Fig. 5. Achieving a bell-like sound from a piezoelectric buzzer.

Piezoelectric buzzers that produce chime and bell-like sounds are available from Radio Shack and other sources. Alternatively, you can simulate such sounds by connecting a capacitor across a buzzer as shown in Fig. 5. When pushbutton *S1* is briefly pressed, the buzzer emits a tone and *C1* is instantly charged to the supply voltage. When *S1* is released, *C1* continues to power the buzzer for a brief time. During this interval, the volume of the tone from the buzzer drops markedly, thereby simulating the sound of a bell or chime. The resultant effect can be modified by trying different capacitor values.

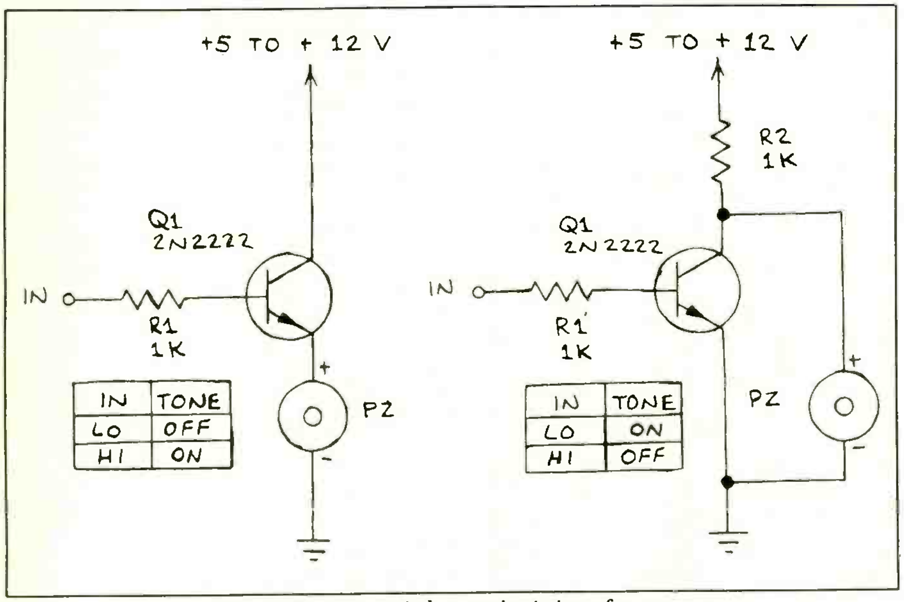


Fig. 6. *Piezoelectric buzzer logic interfaces.*

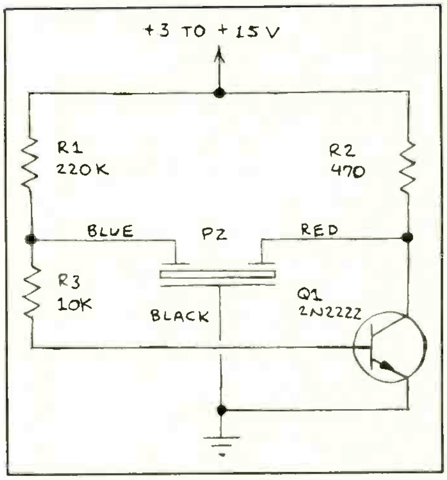


Fig. 7. Single-transistor piezoelectric buzzer element driver.

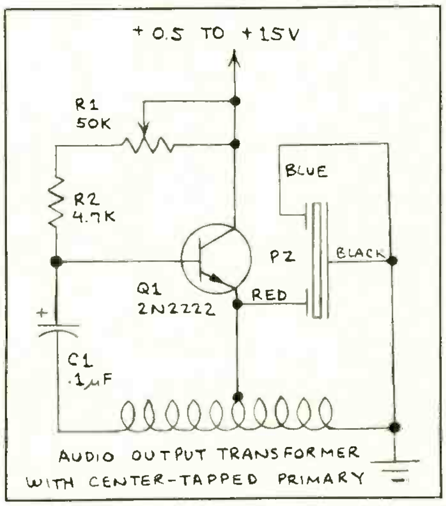


Fig. 8. Hartley oscillator piezoelectric buzzer element driver.

Piezoelectric buzzers can be easily actuated by logic circuits. Figure 6 shows two simple interfaces. One circuit preserves the logical status of the input signal; the other inverts the logical status of the input. Many different npn switching transistors can be used for *Q1*. Resistor *R1* can range in value from 1k to 10k or more. Supply voltage should not exceed the maximum allowable for the piezoelectric buzzer.

Element Drivers

Piezoelectric buzzer elements are considerably smaller than factory-assembled buzzers that include driver circuits. For this reason it's often advantageous to use unmounted buzzer elements when space is at a premium. Fortunately, buzzer element driver circuits can be very simple, particularly since the elements can also function as capacitors and feedback elements.

Fixed-Frequency Driver

Figure 7 shows a single-transistor oscillator designed to drive a three-terminal buzzer element at a fixed frequency. The element I used in a test version of this circuit, a No. PKM11-6A from muRata Corporation of America (1148 Franklin Rd., SE, Marietta, GA 30067), operated at a frequency of 6772 Hz. A similar element is also available from Radio Shack (Catalog No. 273-064). Since oscillation frequency of this circuit is controlled by the dimensions of the element's feedback tab, the circuit is remarkably stable. For instance, adding or subtracting 100k to or from *R1* changed only the shape of the circuit's waveform, without affecting its frequency. Moreover, the frequency of oscillation is relatively independent of the supply voltage.

Variable-Frequency Drivers

Variable-frequency piezoelectric element drivers may or may not use a three-element piezo device with a feedback tab. In either case, though the element emits sound across the audio spectrum, it will produce the loudest sound when driven at its acoustically resonant frequency.

Figure 8 shows a single-transistor buzzer element driver designed for variable-frequency operation. The circuit is a modified Hartley oscillator, a single-stage amplifier with positive feedback provided by a center-tapped inductor. Though he inductor can be made by wrapping magnet wire around an air or ferrite core, an easier solution is to employ the primary side of a center-tapped audio-output transformer such as Radio Shack's Catalog No. 273-1380. This inexpensive transformer has 1,000-ohm center-tapped primary and 8-ohm secondary windings.

Oscillation frequency of the circuit in Fig. 8 can be altered by means of *R1* (*C1* also controls the frequency). The most unique aspect of the circuit is the fact it can be powered by a 0.5-volt supply. Therefore, a single high-efficiency silicon solar cell will power the circuit. Of

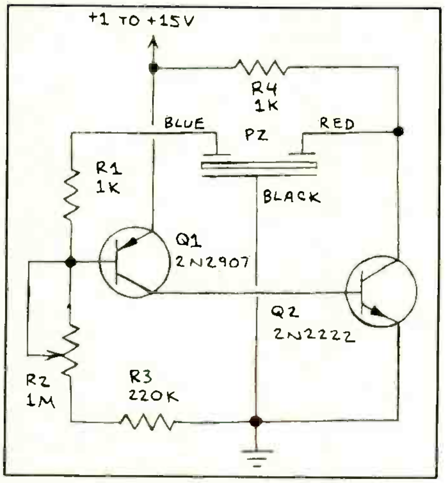


Fig. 9. Adjustable-frequency piezoelectric buzzer element driver.

course, sound level will not be as high as at higher supply voltages. Both *Q1* and the buzzer element require more than 0.5 volt for proper operation, which is supplied by the autotransformer action of *T1*. When current through the transformer is interrupted during each cycle of oscillation, a voltgage is generated in the transformer's winding by the collapsing magnetic field. This voltage supplies the boost necessary to operate the circuit.

Figure 9 shows a simple two-transistor driver in which a buzzer element does double duty as a capacitor. Oscillation frequency of the circuit is controlled by *R2*. As long as polarity is preserved, many different transistors can be substituted for *Q1* and *Q2*. Note that this circuit will operate, albeit at a reduced sound level, when the supply voltage is as little as 1 volt.

Figure 10 shows a simple variable-frequency unijunction transistor driver. As in the Fig. 9 circuit, the Fig. 10 circuit's buzzer element does double duty as a timing capacitor. In operation, the buzzer element's terminals are charged through *R1*, which controls oscillation frequency, and *R2*. When the charge on the element reaches the switching threshold, the UJT switches on and discharges the voltage on the element through *R4*. The alternating charge/discharge cycle causes the buzzer element to emit an audible tone.

Figure 11 shows a single-chip CMOS variable-frequency buzzer element driver adapted from one published in a Gulton Industries' application note. Notice how the three pairs of gates in the 4049 are connected in parallel to permit higher drive current. Though the frequency of this circuit can be altered by means of *R2*, because of the feedback tab connection, the circuit will lock onto the buzzer element's resonant frequency when that point is reached in *R2*'s adjustment. For example, the breadboard version of the circuit I built operated over a range from about 200 Hz to 7 kHz. When *R2* was adjusted, the frequency changed in abrupt steps rather than gradually. When the resonant frequency of the buzzer element was reached (about 7 kHz in the test circuit), the circuit no longer responded to changes in *R2*'s value. Instead, it oscillated at the buzzer element's natural resonant frequency.

Figure 12 shows a simple variable-frequency driver designed around a 555 timer chip. This circuit doesn't use the feedback tab of the buzzer element (in the event one is included). Therefore, the frequency of oscillation is continuously variable by means of *R1*. By increasing the value of *C1* to 0.47 μF, the circuit will produce a metronome-like pock . . . pock . . . pock sequence.

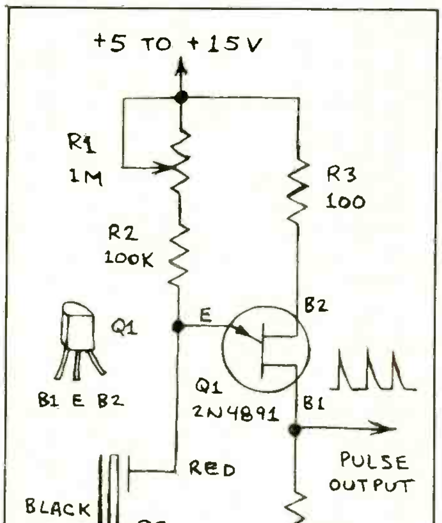


Fig. 10. Unijunction transistor piezoelectric buzzer element driver.

Experimenting with Piezoelectric Buzzers

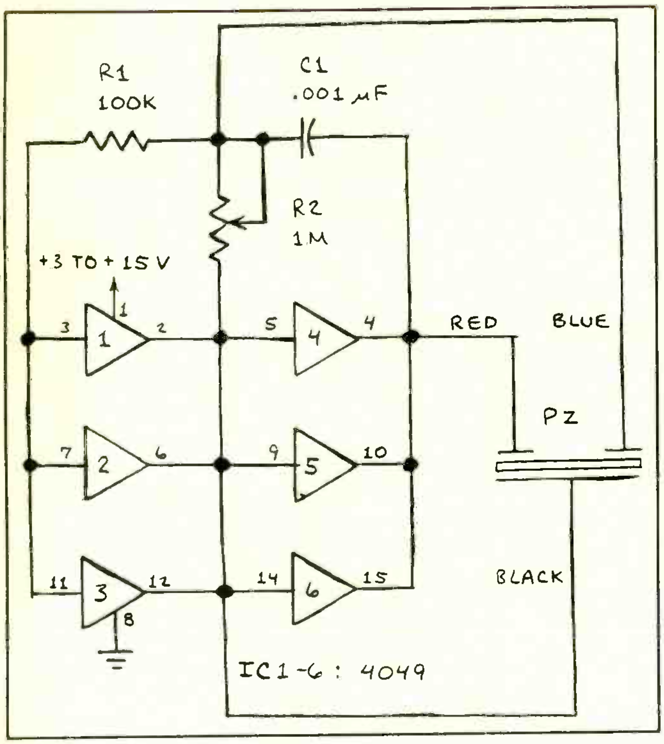
Though piezoelectric buzzers are intended for use as miniature speakers and warning devices, they can also be used to perform a number of interesting experiments. Figure 13 shows how to demonstrate the ability of a three-terminal buzzer element to function as an audio-frequency filter. A signal generator inputs a variable-frequency waveform to the red lead of a buzzer element. An osciiloscope connected to the blue feedback lead will display the signal that propagates through the piezoelectric ceramic.

I used a No. PKM11-6AO element in the arrangement shown in Fig. 13. This element has a resonance peak at about 7 kHz. The arrangement in Fig. 13 indicated peaks at 2.3, 7.0, 18, 27 and 45 kHz.

Keep in mind that there is no electronic connection between the signal generator and the scope. The signal applied to the buzzer element generates an acoustical pressure wave that travels through the ceramic to the feedback electrode where an output voltage then appears. This is the principle behind ceramic filters, surface-acoustic wave devices and piezoelectric transformers and isolators.

If you don't have access to a signal generator and scope, you can demonstrate these principles with the help of the driver circuit in Fig. 12. Simply connect the anode lead of a LED to the buzzer element's feedback tab. Connect the cathode lead of the LED to ground. When power is applied to the circuit, the voltage appearing at the feedback tab will be adequate to forward bias the LED and cause it to glow dimly. For best results, use a high-efficiency red LED and try different oscillation frequencies.

Piezoelectric buzzers can be used in many experiments that demonstrate the principles of sound. For example, place a



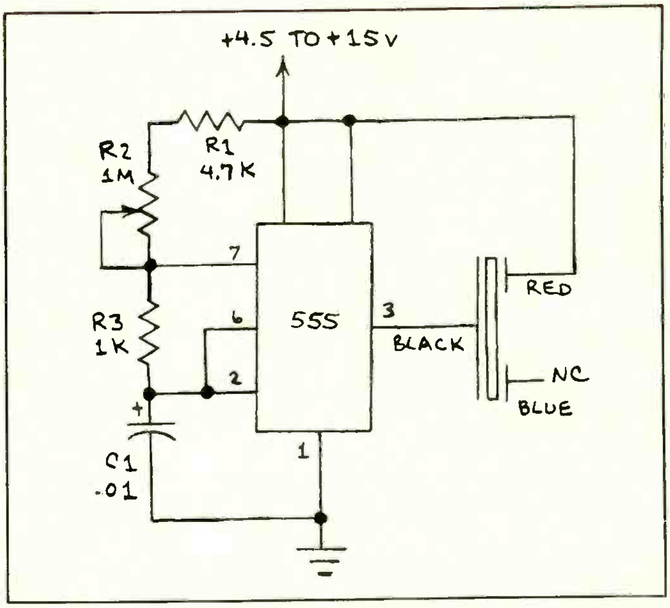


Fig. 12. Piezoelectric buzzer element driver built around 555 timer.

Fig. 11. Hex-inverter piezoelectric buzzer element driver.

buzzer somewhere in a room and then walk through different portions of the room. You will notice that the sound of the buzzer will be dramatically different in various parts of the room. Merely moving your head an inch or so may make a major difference in the volume of the sound level. This phenomenon occurs because of stable standing waves set up by the fixed-frequency tone from the buzzer. Highly localized areas of constructive and destructive interference cause the sharp variations in sound level. This experiment works best in small rooms with little or no sound-absorbing matter such as curtains, carpets and upholstered furniture.

The preceding experiment can be made much more interesting if you have access to a sound level meter. I used a Realistic sound level meter from Radio Shack to measure the sound pressure level from a fixed-frequency buzzer placed in a corner of my office. You can also use the simple (and uncalibrated) do-it-yourself sound-level meter described in the October 1985 installment of this column. The fluctuations in the sound level sometimes exceeded 20 dB when the meter was moved a small fraction of an inch. With the help of the calibrated meter, it was easy to detect sound being reflected from flat surfaces like filing cabinets and a wall.

Still another experiment I have tried is to launch a piezoelectric buzzer in a model rocket. The buzzer was activated just prior to launch and its sound recorded with a small recorder. The recording was later connected to a frequency meter and the frequency of the tone measured at intervals. The frequency of a sound source is shifted with respect to an observer if there is relative motion between the two. This is the well known Doppler shift. Knowing the shift in frequency, it was then possible to calculate the velocity of the rocket. Indeed, a teenage member of the rocket club I then sponsored did just that for a science fair project. Incidentally, a piezoelectric buzzer forms a handy tracking beacon for a model rocket that parachutes into tall grass.

Finally, it seems prudent to again remind you that the sound from piezoelectric buzzers can sometimes be excrutiatingly uncomfortable. Persons working with operating buzzers may be exposed to potentially harmful levels in excess of 100 dB. Therefore, it is very important to wear ear protectors when working with these miniature but potent sound sources. I did just that while preparing this column and am happy to report my head is clear. Some previous unprotected sessions with piezoelectric buzzers gave me headaches and left me feeling dizzy. **ME**

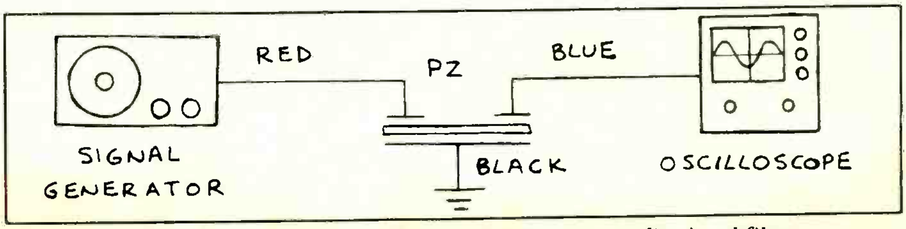


Fig. 13. Using a piezoelectric buzzer element as an audio signal filter.

Using Double-Layer Capacitors; Computer Power Interface, Underground Radio Technology

By Don Lancaster

How Big is a one-Farad capacitor? Would you believe less than a cubic inch? Conventional wisdom and poorly done cartoons notwithstanding, a new capacitor technology is now available that crams incredible capacitance values into very small volumes. As Fig. 1 shows, these are called double-layer capacitors. They are both reasonably priced and available from distributor stock. For instance, a 1.0-Farad, 5-volt *NEC #* FZ0H105Z is available from *Mouser Electronics* for $4.59 each (part 551-1.0Z05).

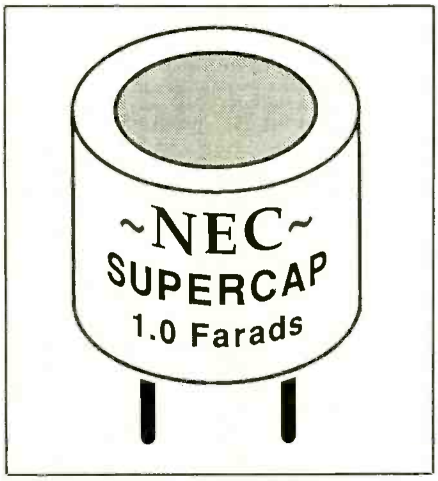


Fig. 1. A 1.0-Farad capacitor!

Being a brand new and "hacker friendly" part, there's lots of exciting new possibilities here. But there are also some definite use limits and restrictions.

One major use for double-layer capacitors is as power backup for CMOS memory chips. The capacitor can fake memory nonvolatility during a short power outage. Unlike most batteries, these devices can be cycled indefinitely, have at least a 10-year life, can easily be soldered in place, are not polarized, usually cannot leak or explode, and readily indicate their charge.

Back to the basics. A traditional capacitor consists of two conductors separated by an insulator. When a current is routed through a capacitor, a charge will build up and will be stored. The amount of the charge depends on the current and how long the current is applied.

The charge also depends on the surface area of the conductors, the spacing between conductors, and a property of the insulator material known as the dielectric constant.

Capacitors have many electronic uses, ranging from storing dc in power supplies; coupling/bypassing ac signals; resonating coils for frequency selection; and for integrating precision waveforms.

The storage size of a capacitor is measured in Farads. A 1-Farad charge will supply a current of 1 ampere for 1 second. Most capacitors have traditionally been much smaller than this, and are measured in microfarads (μF) or picofarads (pF) instead of Farads.

For instance, if you hold two fingernails one fingernail apart, you will have created the equivalent of a 1-pF capacitor. Among other difficulties, there are not nearly enough people in the world to build a 1-F capacitor by this method.

Some ways to get more capacitance are to increase the plate area, to decrease the spacing between the plates, and to raise the dielectric constant. All of these techniques have been used in combination to create the various capacitor families available today.

For example, ceramic capacitors use special insulators with a dielectric constant of 8000 or more. Electrolytic capacitors build up an extremely thin insulating oxide film. They also increase the conductor surface area by etching. Sometimes a double etch is used where big pits are first added to the original surface, and when this is done, small pits are added to the big pits.

But the double-layer capacitor goes far beyond what traditional capacitors are able to do. It uses a fundamentally different principle, first discovered by Helmholtz over a century ago. It turns out that if you have a boundary between a solid and a liquid, a double layer of charge builds up at the surface between the two. To build a useful double-layer capacitor, you use a solid plate, a liquid electrolyte and a second solid plate. To prevent the two solid plates from touching, you place a porous, insulating separator between the two. The separator allows ions in the electrolyte to move back and forth as charge is accumulated, but prevents any direct short-circuit between plates.

The solid plates used for today's double-layer capacitors are made from activated charcoal which has an incredible surface area, since it is made up of countless tiny particles. A gram of activiated charcoal may have a surface area equal to one-quarter of a football field! And therein lies the secret to extreme capacitance values in a very small package.

In exchange for the extreme capacity in a very small space, there are some definite tradeoffs. The breakdown voltage of the electrolyte used in today's double-layer capacitors is only 1.2 volts. To get a useful +5-volt dc working voltage, six capacitors are placed in series inside the package.

Instead of directly building a 1-F capacitor, there are really 36 farads of capacitance in the package, since six series connected capacitors each yield a 1-F series equivalent capacitance.

So, you *must* be careful to never exceed the recommended working voltage of a double-layer capacitor.

In addition, these are not precision components, since activated charcoal itself is not a very precise material. Tolerances are in the −20% to +80% range. Also, charge is inherently an "undense" way of storing energy, compared to chemical conversions. Large single-layer capacitors are simply not in the same energy storage league as batteries, and I don't thing you will ever see the day when you start a lawnmower with a double-layer capacitor.

So, while double-layer capacitors are incredibly better than regular capacitors for storing bunches of charge in a small volume, they are not nearly as good as a battery when mucho dense energy storage is required.

Finally, charcoal is not a very good conductor, and conductive elastomers are also used in the construction that are only moderately conductive. Thus, a double-layer capacitor is *not* a low-impedance device and can *not* be rapidly charged or discharged.

One interesting side effect here is that the inherently limited charge and discharge rates of a double-layer capacitor give automatic short-circuit protection. Some batteries, especially Ni-Cds, instead tend to get downright violent when you short them.

Several manufacturing options are available that trade off maximum possible charge and discharge currents against cost and size. The smallest and cheapest versions are intended for long-time, low-current memory backup uses.

Let me know what interesting uses you can come up with for this exciting, yet imperfect, new hacker component.

OK. How did you do it?

If there's one thing I can't resist, it's a good hack, especially if it lies well beyond the far side of "disgustingly elegant." Check the capacitor lettering in Fig. 1. Note that we not only have isometric lettering, but the lettering is also correctly wrapped around a cylinder! This was quickly and easily "drawn" with the stock and standard Apple Writer word processor, as were *all* parts of *all* figures in this column. Oh, yes, I did add a short little custom text routing of my own that I'll be happy to share with you. The same routine also lets you set text in a helix or an inwardly closing spiral.

Write or call for you free copy.

How can I Control AC Power With a Personal Computer?

There are two problems involved in controlling high-power ac loads with a personal computer or microprocessor parallel port. The first is that the weak port signals must somehow be *amplified* to make them "strong enough" to control a high power load. The second hassle is that there is a very deadly shock hazard involved with ac power control, which means that some sort of *safety isolation* is an absolute must.

While you could use a relay driver IC and a relay, the usual way to handle 110-volt ac high-power interface today is to connect a phototriac optoisolator to a triac power control device. Figure 2 shows details.

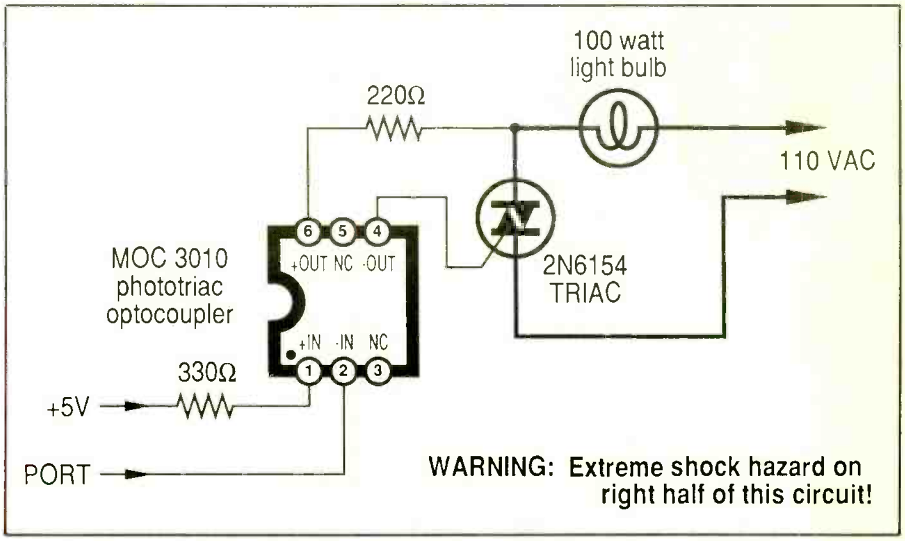


Fig. 2. A 110-volt ac power control interface for a personal computer.

The triac optoisolator consists of a light-emitting diode that drives a photosensitive ac power control device called a phototriac. When the LED lights, the phototriac turns and activates the main high-power triac to switch the load.

Because only a light beam connects the input to the output, you get total safety isolation. The "amplification" you need comes from both the internal phototriac and the main power triac.

There are some important details you have to be aware of when you use this circuit. First and foremost, note that there is a deadly shock hazard anywhere to the right of the triac optoisolator; so use extreme caution when working on *any* circuit of this type.

The power triac will switch on or off most any ac load, such as lamps, motors, heaters, or whatever. A minimum load must always be provided for proper operation, say 7 watts or so. The maximum load depends on the triac and the size of the heat sink you use.

One classic handbook for triac power control is the *SCR Manual* from *General Electric*. My issue is sort of dated, so it may have a new name and a new price by now. Cost should be around $5.

You also *must* use a phototriac optoisolator, rated at least 200 volts for 110-volt ac operation, or 400 volts for 220-volt ac operation. Note that the other types of optocouplers will instantly self-destruct if you try to use them for ac power control. The *Motorola* MOC 3010 is often a good choice and costs slightly over a dollar.

I have also shown the inputs to this circuit connected "backwards" from some other circuits you may have seen. There is a very important reason for this. Most parallel ports on microprocessor systems are much better at sinking current to ground than they are at sourcing current from a positive voltage.

With this circuit, the output port either sinks current to ground, activiating the phototriac optoisolator and powering the load, or doing nothing and not delivering power to the load. Connected "backwards," the optoisolator is much better matched to the parallel computer port and will work much more reliably.

One little gotcha with this "backwards" connection: Your port will now be active low, so a zero at the port will *activate* the load. Your software must, of course, recognize this fact, and write zeros to the port locations when you want to power the load.

Note that a machine-language command of EOR #$FF will automatically convert all of the ones in a word to zeros and vice versa. From BASIC, an XX =

(255 − XX) will also convert all ones in a word to zeros or vice versa. Details vary with the application, of course.

Typical cost of one channel of power control should be under $3, unless you are using a very large triac.

More info on microcomputer power interface appears in my *Micro Cookbook*, Volume II (SAMS #21829).

Is There an Easier Way?

Well, if you want to pay a little more, you can cut the parts count to one. Figure 3 shows how to use a Crydom D2W202F solid-state relay by *International Rectifier* and do all of your power control with a single part. *Newark Electronics* sells them for $7.95 in singles as stock #81F4904.

The circuit is still the same as before, since the resistors, triac and optocoupler are all inside the package. Also as before, the + input goes to the microcomputer's +5-volt supply line, and the − pin goes to the port output. A zero turns on the load, a one turns it off.

The device is good for 2 amperes and might be pushed a little further with some sort of clip-on heat sink. Around 220 watts of light bulbs, or possibly a quarter-horsepower motor can be controlled. Note that a severe shock hazard exists on the power side of this circuit.

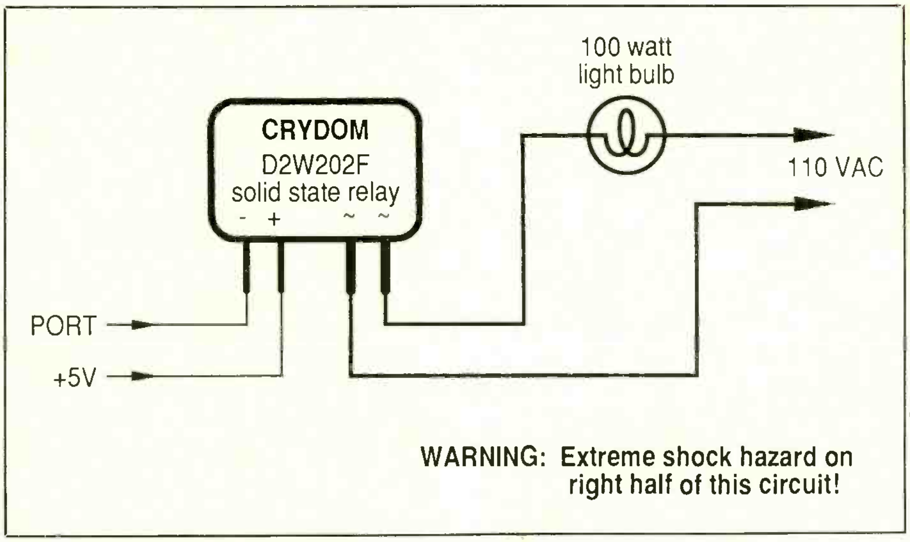


Fig. 3. A simpler but more costly power interface option.

What About Proportional Control?

If you have a proportional control interface, you not only can turn on/off motors, heaters, and lamps, but you can control their brightness, temperature, or speed as well.

It turns out that the Fig. 2 and 3 circuits can also be used for proportional control, but the software gets more complicated. And you have to be aware of exactly what you are up to.

First, the load you use *must* respond to voltage in a proportional manner. Incandescent lamps will, but fluorescent lamps will not. Most heaters or soldering irons will respond proportionally and present no problems.

Universal type motors (those with brushes) will alter speed with changing voltage, but the more common ac induction motor can destroy itself if you try voltage control. Even when you control the speed of a universal motor by varying its voltage, you may get very limited torque. There are fancier techniques involving feedback that can be used to get around this problem.

So, your initial experiments at proportional power control are best done with incandescent lamps, heaters, etc.

The trick to proportional power control is to deliver a turn-on pulse that is precisely delayed from each ac-line half cycle. Figure 4 shows details.

If turn-on occurs very early in each ac half-cycle, nearly all the power will appear across the load. If turn-on takes place in mid-cycle, around half of the power gets to the load. Shoud the turn-on occur very late in the cycle, only a small amount of power gets to the load. Finally, with no turn-on pulse at all, the load gets no power and stays off.

Your computer must somehow sense the beginning of each half line cycle. This can be done with a line-derived interrupt signal or by routing something similar to an input port. The software inside the computer or microcontroller then will

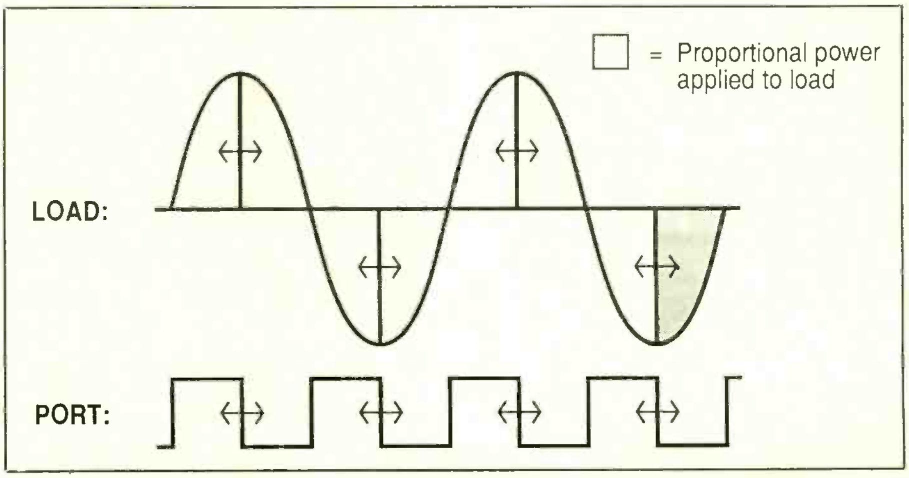


Fig. 4. Proportional power control requires precise timing.

automatically convert a speed, brightness, or temperature value to the proper turn-on delay.

The timing is such that machine-language code *must* be used, particularly if you are controlling more than a few loads with the same computer. The precision and linearity of your outputs can be greatly improved by using some sort of feedback. This, of course, ups your system complexity.

You should be able to use a computer the size of an Apple IIe to control something like 32 theater lights to 32 brightness levels. This would make a very interesting programming project.

A totally different way to handle proportional control is with those *BSR* power modules sold by *Radio Shack* and others. These are fairly easy to interface to most computers, besides offering remote-control options.

Is There any more Information on Underground Radio Technology?

I've found another most interesting publication on underground technology. This beauty covers such things as underground radio communications and position measurement, ultrasonic and laser rangefinding, self-climbing ladders and even automatic spare-lamp switchers. All hands-on and real-world with full schematics, parts lists, the whole bit. It's called *Speleonics* and is published quarterly (four times a year).

Included in each issue are a dozen how-to articles and a subscriber list of others interested in similar underground tools, concepts, and techniques. Price is — better sit down for this one — a dollar per issue or $4 per year!

Should you want information on caving and speleology in general, you can instead contact the *National Speleological Society* and they can put you in touch with individual local cavers and an NSS grotto or two in your area. **ME**

NAMES AND NUMBERS

General Electric
Electronics Park Bldg. 7
Syracuse, NY 13221
(800) 626-2001

Motorola Semiconductor
Box 20912
Phoenix, AZ 85036
(602) 244-6900

Newark Electronics
228 East Lake Street
Chicago, IL 60640
(312) 941-7200

International Rectifier
1521 E. Grand Avenue
El Segundo, CA 90245
(213) 322-4987

Mouser Electronics
Box 9003
Lakeside, CA 92040
(619) 449-2222

Howard W. SAMS
4300 West 62 Street
Indianapolis, IN 46206
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Natl. Speleological Society
Cave Avenue
Huntsville, AL 35810
(205) 852-1300

NEC Electronics
401 Ellis Street
Mountain View, CA 94043
(415) 960-6000

Speleonics
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(812) 335-7305

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Thatcher, AZ 85552
(602) 428-4073

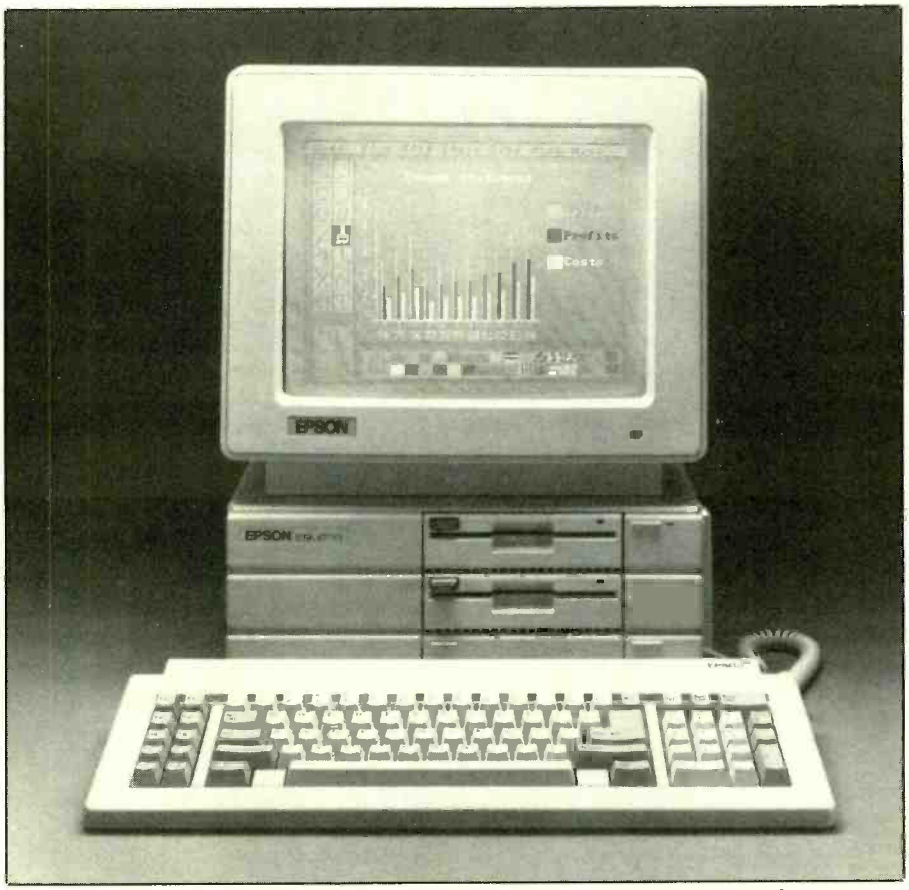
First Impressions: Epson and AMQ Compatibles, Personal Publisher

By Eric Grevstad

I don't think I've reviewed a plain, unabashed PC clone since the NCR PC4 in 1984, back when IBM compatibility was still uncommon and the reviewer's toolkit consisted of 1-2-3 and Flight Simulator. Nowadays that acid-test twosome doesn't scare anyone. You can buy PC-compatible BIOS (basic input/output system) chips on any street corner in New York—well, maybe not in the low-tech neighborhoods on the West Side, but you know what I mean—and the industry's moved on to 80286 processors, microfloppy drives, and Enhanced Graphics Adapters.

But it's good to get back to basics, to see the old 8088 CPU percolating along at its old 4.77-MHz clock rate. This month's micros are from two companies (a global titan and a near unknown) in two categories (desktop and transportable), but they have one thing in common. Each costs a third as much as the IBM and Compaq machines I would have compared them to in 1984.

On the other hand, the old clock can seem kind of slow for today's newest applications. Did someone say "desktop publishing"? Read on, and let's get on with the reviews . . . .



Epson's Equity I: compact, compatible, nothing to write home about.

Epson's Compact Cube

Setting aside the mail-order specials, there are three brand-name entries in the low-cost desktop race: the Tandy 1000 (U.S.), Leading Edge D (Korea), and Epson's Equity I (Japan). The Epson is the most conventional clone of the three. It's the only one that makes novices buy and install a video board—but has some appealing features. For one thing, it's only $995 with 256K and one disk drive ($1,295 with two drives, $1,895 with one floppy and a 20-megabyte hard disk).

The Equity system unit is a trim 15 inches square by six inches high; there are too many ugly lines and cosmetic plastic latches for my taste, but at least it doesn't hog your desk. Its space efficiency is even more impressive when you pop the top: the motherboard fits under the drives, with nothing but blank metal beneath the three full-length expansion slots (they're on a small platform plugged into a motherboard bus, in an example of the Epson's modular architecture).

You'll have only two slots free after installing a video card, but a piggyback RAM card ($169) lets you upgrade to 512K without using one. (Going to 640K requires a slot, but at least parallel and serial ports are standard.) Epson's monochrome text card ($129) looks homely even by text-card standards, bristling with capacitors by way of meeting radio interference rules and producing faintly wobbly characters on the 12-inch green monitor ($149), but the Equity accepted all my non-Epson boards: my Quadboard to reach 640K, my Tecmar graphics adapter for video games, and my All Sales Final Mail-Order Mostly Hercules-Compatible Graphics Card, which lit constellations of pixels behind Microsoft Word just as it does in my Tandy 1200.

There are several convenient touches, from a power socket for your monitor to DIP switches mounted up front instead of under the hood—little doors conceal the switches, reset button, power switch, and keyboard connector. The keyboard is first-class, once PC owners adapt to its AT-style layout (giant shift, Ctrl, and Enter keys, but the backslash where backspace should be and no separate Enter key for the keypad).

While the Epson ran all the software I tried, it's worth checking out the supplied GW-BASIC and MS-DOS 2.11 disks. Beginners will appreciate several menu routines that make tricky FORMAT or MODE syntax or Epson printer setup as easy as pressing the arrow and

Enter keys; experts will like Executive Systems' XTREE, a helpful directory sorter for running programs or flagging groups of files for DOS operations.

Once you add memory, a monitor, and a video card, the Equity I isn't the cheapest compatible around; once you've grappled off its top cover and sprung loose its flimsy back panel, you'll think it's not the sturdiest, either. It works well, but I'd say the Tandy 1000 offers superior economy and the Leading Edge better standard equipment.

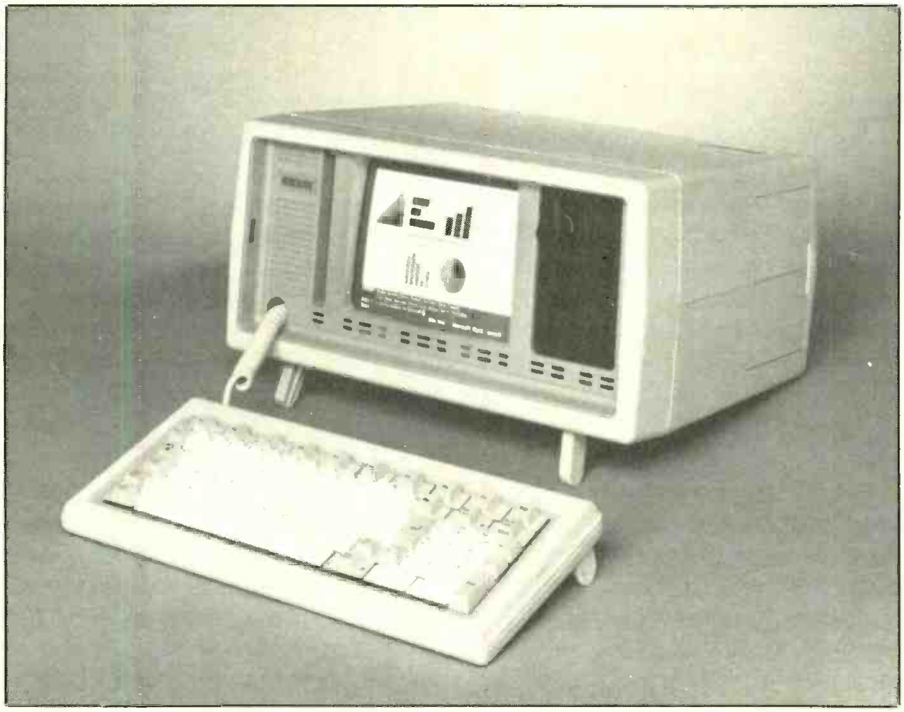
Watch Out, Compaq

Compaq could get away with high prices when both IBM compatibility and suitcase transportability were scarce, but they'd better stop congratulating themselves on making the Fortune 500 and have a sale. The papers are full of stories about business buyers' new willingness to try bargain brands, and AMQ Computer Corp. is gunning for Compaq with a "Made in U.S.A." flag in one hand and a one-year warranty in the other.

The AMQ line is built around an 8088-based luggable with 9-inch monochrome display, parallel and serial ports, a keyboard that latches (with some twiddling) onto the system to form the bottom of the suitcase, and sliding doors to conceal the cooling fan and power switch.

That's nothing you won't find in the original 1983 Compaq, but check the extras—a cubbyhole to stash the power cord, an RGB port for an external monitor, and 704K on the motherboard (Lotus 1-2-3 Release 1A can use the extra 64K, though I don't know what else can). Then check the size—15 by 18 by 8.5 inches, like the new Compaq Portable II instead of the bulkier Compaq Portable. Then check the price—$1,395 with two 360K floppy disks, $1,995 with a 10 MB hard disk, $2,195 with 20 MB.

The 24-pound, two-disk AMQ I tested was noticeably easier to haul around than a standard Compaq, ran all the software I gave it, and even carried four or five disks in its little slot beside the screen. There were minor complaints: I didn't mind the function keys horizontally above the regular keys, but wished AMQ hadn't left the backslash between the shift and Z keys (the Alt key was a trifle sticky, too).



AMQ goes head to head with Compaq.

The keyboard was balky about retreating into its lair when I packed up. The standard text/graphics display isn't too sharp (AMQ promises Hercules-compatible monochrome graphics as a factory-installed option). It's a bad choice for first-time buyers—no DOS is supplied, and the manual is dreadful.

Still, the affordable AMQ impressed me enough to outshine the top-of-the-line AT 286: the same machine, with one of its four expansion slots taken by a 20 MB hard-disk controller and another (really two) stuffed with Phoenix Computer Products' Pfaster286 board. This mighty kludge packs an 8-MHz 80286 chip, two megabytes of RAM (for a 2.7-MB system total), and its own AT-compatible BIOS. Like the turbo boards I tested last February (p. 84), it gives you, in effect, two computers controlled by a keyboard toggle—type PFAST to activate the 80286, PSLOW to return to the PC side.

At $3,995, the AT 286 definitely undercuts Compaq's 80286 Portable II, and its colossal memory allows great gimmicks like a one-megabyte RAM drive with caching to cut down on disk access. But for all its speed it didn't strike me as a fully integrated AT compatible (there's a lot of rigamarole with different startup batch files for each processor; Word 3.0 wouldn't run on the 80286, the the Norton Utilities rated the slow side at 0.8 times PC performance).

Besides I doubt that many people need both hotel-room computing and blazing performance. Given a traveling job and enough cash to buy an 80286 Compaq, I'd buy an AMQ—but I'd buy one of the 8088 models, and use the money left over to buy a desktop AT clone for the office.

Creeping Into Journalism

Desktop publishing may be the current catch phrase, but it's not the next VisiCalc. For many users, it can actually decrease productivity—you'll spend hours lining up columns and rotating graphics,

Names and Addresses

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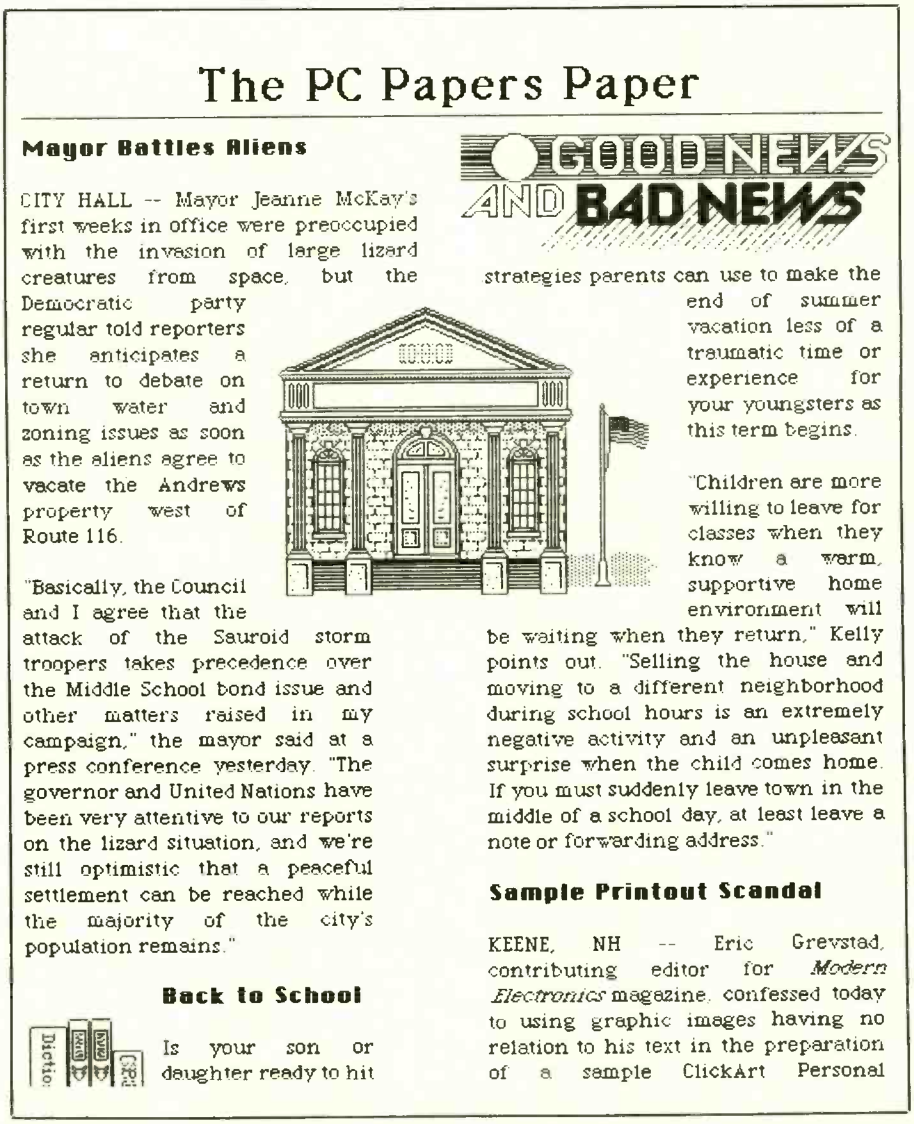
T/Maker Graphics
2115 Landings Dr.
Mountain View, CA 94043
415-962-0195

when a quick, simple memo might suffice. But if you truly need to put out announcements or newsletters, there's now a reasonably priced package for the PC that's a fine illustration of the concept's pros and cons. T/Maker's ClickArt Personal Publisher ($185) mixes text and clip art so nicely you'll play with it for days. It's also such a strain on the 8088—despite requiring 512K and preferably a hard disk—that you'll miss your deadline while waiting for word wrap.

Personal Publisher can't handle a long document or annual report, but for one- or two-page productions it's a terrific implementation of Macintosh concepts (including working without a mouse better than any other Mac imitation I've seen.) Each page is composed of layered "transparencies" for text and graphics, respectively, each with a cut-and-paste clipboard; you'll have to save your text to disk while loading and picking clip art, but MacPaint-style icons make choosing, moving, and erasing art and drawing lines and boxes easy.

Text comes in one to three columns and a number of familiar Macintosh fonts, though type size choices are limited. Putting ingredients together, with "PictureWrap" to arrange text around graphics and zoom-out previews to offset the IBM color card's quarter-page screen display (the sharper Hercules card shows half a page), is remarkable "Gee, it really works" fun.


The PC Papers Paper

Mayor Battles Aliens

CITY HALL -- Mayor Jeanne McKay's first weeks in office were preoccupied with the invasion of large lizard creatures from space, but the Democratic party regular told reporters she anticipates a return to debate on town water and zoning issues as soon as the aliens agree to vacate the Andrews property west of Route 116.

"Basically, the Council and I agree that the attack of the Sauroid storm troopers takes precedence over the Middle School bond issue and other matters raised in my campaign," the mayor said at a press conference yesterday. "The governor and United Nations have been very attentive to our reports on the lizard situation, and we're still optimistic that a peaceful settlement can be reached while the majority of the city's population remains."

Back to School

Is your son or daughter ready to hit

strategies parents can use to make the end of summer vacation less of a traumatic time or experience for your youngsters as this term begins.

"Children are more willing to leave for classes when they know a warm, supportive home environment will be waiting when they return," Kelly points out. "Selling the house and moving to a different neighborhood during school hours is an extremely negative activity and an unpleasant surprise when the child comes home. If you must suddenly leave town in the middle of a school day, at least leave a note or forwarding address."

Sample Printout Scandal

KEENE, NH -- Eric Grevstad, contributing editor for *Modern Electronics* magazine, confessed today to using graphic images having no relation to his text in the preparation of a sample ClickArt Personal

It's not the New York Times, *but ClickArt Personal Publisher brings newsletter layout to the dot-matrix owner.*

It also makes Microsoft's sluggish Windows look like a rocket ship. On 8088 systems, Personal Publisher's word processor can take half a minute to close up a line of text after deleting a few words; changing type size or column layout, you'll stare at the "please wait" wristwatch icon for so long it should be a sundial. After giving the print command, go see a movie; printing a "final-quality" page on an Epson LQ-1000 took half an hour. (The product was late coming to market and the laser driver options, $150 each for HP's LaserJet and Apple's LaserWriter, didn't come in time for review; there'll also be various font and picture disks for $49.95.)

Personal Publisher needs a bit more development and an AT or faster machine before it challenges Mac publishing products, but it has gorgeous potential for the future. Usually I argue that the 8088 is just fine, but I may join the crowd awaiting the 80386 after all. **ME**

COMPUTING POWER

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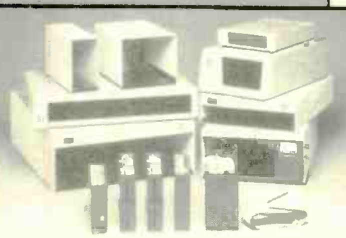
The XT-clone system pictured above is our Super System VII XT clone. It contains a turbo processor, a 20mb hard disk formatted RLL to 31mb, 640K RAM, two 360K floppies, 1 AT 1.2 mb drive, mono amber monitor, par port, ser port, clock and AT type keyboard! You might expect to pay thousands for this system, but Floppy Disk Services, inc. will supply it ready to run with a 1 year warranty. Call for latest quotes on your custom system needs. . .



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CIRCLE 29 ON FREE INFORMATION CARD

Report from the Caribbean

By Glenn Hauser

We're on the move again, visiting six islands during one week this summer. Our objective was not only to monitor and record, but also to visit almost every broadcasting facility on the islands. We came away with a vivid set of visual impressions, preserved in scores of color slides, several hours of recordings, and a notebook full of loggings and notes from interviewing station personnel.

Antigua, home of the BBC and Deutsche Welle Caribbean Relay Station, was our first stop. North American listeners of the BBC owe a great debt to this facility, which provides clearer and more reliable signals than are possible direct from Britain. If you've heard BBC on 11775 in the morning, 6175 in the evening, or 9510 late at night, this is the source of those transmissions.

The site is roughly in the center of the island, just north of a settlement called Sea View Farm. Five large red and white towers arranged in an arc support a network of curtain antennas, the interior towers holding up different curtains on each side. Power demands of the four 250-kW transmitters exceed what the public utility can supply, so each depends on its own diesel generator, as big as a locomotive. They're across the lawn from the transmitter building, where the four senders (each made up of three units) are arranged in a row in a long hall open to the outside. During our visit, in the middle of the afternoon, all were off the air, as is normal during the daytime until 4 pm AST (2000 UTC), so we stuck our head inside one of them and marveled at the size of the huge copper coils, which must be removed by hand when band changes are required. Our cordial host was the engineer in charge, Chris Clemens, who also showed us inside the 65° air-conditioned hut next to the recently installed satellite dish. Not only could we listen in on the feed from London to Antigua, but also a different circuit for Ascension, where we had previously served. Ascension is a much more isolated island, in the South Atlantic, but the fishing is great!

RADIO ANTILLES
930
200.000 WATTS
MONTSERRAT / W.I.

Many satellite dish owners would like to know how to tune in the BBC that way, avoiding the pitfalls of shortwave reception, but Mr. Clemens said this would be impractical without specially-designed equipment, since the audio from London is split into two separate parts, and then recombined for a higher-fidelity signal. Deutsche Welle opted for a different system to accomplish the same end, which on paper was superior to the BBC design, but in practice produces inferior audio.

We also visited the high-frequency receiving site, about 5 miles east. Much of the equipment had been torn out, and more was to follow, as there is no longer any need for it with the advent of satellite-feeding. It was sad to see large holes in the racks, a bank of twelve professional playback recorders going unused, but at least some shortwave receivers were still tuned to 15070 as backup. Barring total failure of the satellite, the only time HF feeds are needed is twice a year for a few days, during a few minutes after sunrise, when there is a solar transit outage. The receiving site has a "pipeline" to Europe, thanks to its rhombic arrays; but it will be mothballed. It occurred to us that with a bit of modification, it could be turned into a relay transmitter site for some other broadcaster . . . .

Antigua is also the home of four mediumwave stations, three of which are often heard in North America. The Voice of America relay is near the northern tip of the island near the airport and next to a US Naval base; a three-tower array broadcasts on 1580 kHz only four hours a night, in English at 0000-0400 UTC (although the carrier goes on an hour earlier for warmup and trouble-shooting, if necessary). The transmitter is an old army portable unit, which has previously seen duty in other parts of the world. There are rumors that VOA will be upgrading this facility as part of its worldwide expansion program.

ZDK, "Magic Radio" is the private commercial outlet, which on 1100 kHz is frequently heard along the east coast of North America as far as Newfoundland, especially around sunset. Its regular audience extends over much of the Caribbean, with a pop music format. Present studios are in a bright blue building near the outdoor market in St. Johns, the country's capital. Within a year, a new building of its own will be ready further east. The transmitter is north of the city, linked by low-power FM on 99.0 MHz.

Caribbean Radio Lighthouse operates on 1165 kHz from the southwestern part of the Island, near Jolly Beach. This conservative Baptist evangelical station also penetrates into North America, thanks to its split frequency. It's deeply involved in indoctrinating the children of this and neighboring islands, through a bible study course by radio. Among all the preachers, who are carefully selected and required not to overdo the solicitation, there is also a classical music program Mon.-Fri. at 9:30-9:55 pm. The organization is also resuming plans to put on another station in Grenada, now that the Marxist government is gone.

Montserrat. We hopped over to this "emerald isle" for a day—it's much more mountainous and scenic than Antigua, and the roads are much better. The major outlet here is Radio Antilles, "The Big RA," broadcasting from a seaside site at the southern end of the island. Though publicized as 200,000 watts on 930 kHz, the transmitter actually runs 135 kW, but the exaggeration comes from a directional pattern toward the south with a two-tower antenna. Its news coverage is highly regarded, and the main program during the daytime is "Caribbean Togetherness."

Since last September, RA has been relaying the Voice of America at 8 pm-midnight. Manager Kristian Knaack, who was kind enough to talk with us for over an hour when we dropped in, is very pleased with this arrangement, since it makes for an increase in quality of listenership to compensate for a decline in quantity during those hours. He also feels that Radio Canada International's audience in the Caribbean has increased 1000% since it began relays on RA, nightly at 7-7:30 pm. He was surprised to hear that this visitor out of nowhere was a regular broadcaster on his station, each Sunday on the RCI relay. VOA, RCI (and Deutsche Welle for relays on shortwave) were picked up from a high-frequency receiving site at St. George's, not far from the studios in the capital, Plymouth—and the audio quality shows on 930. But by now, a line feed should be in operation for VOA, and also for RCI, which first feeds its audio to Washington. Herr Knaack has also produced and written a 25-program series for Caribbean listeners, "The Long War on the Short Waves."

He has a new competitor in Montserrat in the form of "Gem Radio," a partly-American-owned FM station which started in May, 1985. Like RA, it wants to reach as many other islands as possible, either through its 177 kW ERP station near Plymouth on 94.4 MHz, or a network of FM translators it plans, the first of which is already operating from the other side of Montserrat, and thus receivable in Antigua. The 100-watt stereo signal on 93.8 MHz reaches there surprisingly well. ZGM relies on music and news programming from the Satellite Music Network and Satellite News Network; U.S. offices are in Milwaukee.

Anguilla. Our next stop was St. Maarten, but day trips out to other islands, starting with nearby Anguilla, are of more radio interest. The Caribbean Beacon, another U.S.-owned evangelical station, is found in the southeastern part of the island, in a gleaming white building with dark peach colored trim, certainly the nicest facility of all the AM & FM stations we visited. A new modular 50-kW transmitter is the first thing the visitor sees, behind glass, upon walking in. If anything goes wrong, it can usually stay on the air by bypassing the problem through a backup module. It and the old

15-kW transmitter feed a single tower on two separate frequencies, 1610 and 690 kHz, respectively. They were programmed in parallel at the time, but by now 690 should have been turned over to Family Radio (well-known on shortwave as WYFR), fed by satellite.

Thanks to the clear frequency of 1610, The Caribbean Beacon is heard nightly in North America, and frequently all over the world. The engineer said he had even been able to pull in 1610 during the daytime in Miami. The other 15-kW transmitter, no longer used, will be turned over to the Anguillan government's station, Radio Anguilla. That should greatly increase its coverage, except it may abandon the "split" channel of 1505 for an "even" one. That's the likely fate of the few remaining Caribbean splits, thanks to digital receivers which skip past frequencies ending in – 5.

We suggest you not delay in DXing these stations, if you haven't already. With a good selective receiver, sensitive antenna, and a little help from the aurora over a darkness path, the following can be heard in North America: 535 Grenada, 555 St. Kitts, 595 Dominica, 705 St. Vincent, 825 St. Kitts, 885 Montserrat, 1165 Antigua, 1505 Anguilla.

St. Eustatius, one of the Netherlands Antilles, has had a radio station since May 1985, but due to a daytime-only schedule, no DX listeners had heard it. Radio Statia (the common name of the island, pronounced STAY-shuh), PJE3, operates 1 kW on 1120 kHz at 1000-2230 UTC. It doesn't have to sign off at sundown, but prefers to, unless a demand arises for evening broadcasts. If this schedule remains, the only remote chance for North Americans to hear it will be at sign-on and sign-off when the sun is lowest; although sunrise and sunset times vary little in the tropics, keep in mind that during December there'll be more darkness to the north.

Saba was our final, and most enjoyable stop. This smallest of the Netherlands Antilles is also the most vertical—a volcanic peak jutting out of the ocean. Practically every home on the island (pop. 1000) has a terrific panoramic view of the sea, as they are perched on the slope. An "impossible" road connects the airport on one side of the island to The Bottom on the other side, home of the Voice of Saba, PJF1, 1410 kHz. This small station began more than a decade ago on 1445 and 1435 kHz, but after it moved to 1410 it disappeared from the *World Radio TV Handbook* and from the consciousness of DX listeners.

Its affable owner, Max Nicholson, is also acting governor of the island when the governor is away. PJF1 also has a studio in the more populous St. Maarten, on Front Street in Philipsburg. Not only is it a remote studio, but it serves as the relay point (by FM) from the studio on Saba to the transmitter on the other side of Saba! The carrier stays on all night, though programming is limited to 1000-2330 UTC (Sundays from 1700). We suggested that it would be helpful to distant listeners if a continuous ID tape could be played during the "off" period; and since Mr. Nicholson showed us the pairs of crystals he still has for 1445 and 1435, how about a special DX test on one of the old frequencies? However, time was running out, since a brand-new 5-kW transmitter was to be installed by the end of June, and it could not accept the old crystals. Perhaps the old transmitter will remain as a standby.

One sure way to hear the Voice of Saba is to visit the island; our half-day visit was all too short. Saba is beautiful, unspoiled, and away from it all, though easily accessible through St. Maarten. ME

Transconductance Amp

(from page 50)

proved noise and distortion levels make them useable in professional high-end consumer gear. Solid State Microtechnology (2070-B Walsh Ave., Santa Clara, CA 95050) makes several ICs in this category, including the SSM 2024 quad OTA and SSM 2014 vca with a dynamic range of 118 dB and 0.01% distortion!

Curtis Electromusic Specialties (distributed by PAIA Electronics, 1020 W. Wilshire Blvd., Oklahoma City, OK 73116) makes a series of OTA-based chips for audio/musical uses. These include the CEM 3330 and CEM 3360 vcas.

In Closing

From the foregoing, you can see that the operational transconductance amplifier is a highly versatile—though a bit anonymous—op-amp-like device. Hopefully, you will introduce it to your catalog of exciting ICs with which to experiment and to use in practical circuits.

BOOKS

The New Sound of Stereo, By Ivan Berger & Hans Fantel. (New American Library, Soft cover. 265 pages. $12.95.)

Though this book is meant to serve as a guide to buying and using the latest in hi-fi equipment, you will not find page after page of information about current makes and models. This would limit the book's usefulness, since the models would be quickly obsolete. Rather, the authors, both of whom are long-time experts in the hi-fi/stereo field, wisely concentrated on the relatively unchanging principles right through to digital audio gear.

Following a brief background on audio, the book introduces the "system" concept and how to build a component system suitable to one's needs. Actual listening to sound—which is the reason why one buys a hi-fi system in the first place—is emphasized. Much of the book also focuses on the various elements that make up a system: speakers, turntables, tuners, tape decks, etc. To provide maximum detail coverage, the majority of these topics are discussed in more than one chapter, such as "A Sense of Power" and "A Sense of Control" under amplifiers, and the turntable, cartridge and tonearm under "Phonographs." Right up to date, the book covers compact-disc and digital technology, sound-enhancement devices, and portable and car stereo equipment.

Lots of how-it-works information is given, along with pros and cons, helpful advice, drawings and photos. Technical information, consisting mainly of curves that depict power, frequency response, sensitivity, etc., is also given.

An Appendix, titled "When Things Go Wrong," provides a nice touch. It gives sage advice on keeping a system operating and determining when ailing gear needs a repair shop.

New Sound of Stereo is highly recommended for anyone interested in understanding the underlying workings of hi-fi components and what additional functions featured in top-of-the-line, costlier models actually do. Coupled with the text's lucid writing, the book will make you a more judicious buyer.

Enercell Battery Guidebook (Radio Shack. Soft cover. 156 pages. $1.99.)

If you use or specify batteries for electronic products and projects (and that includes just about everyone), this information-packed book reveals most of what you could ever wish to know about batteries. It describes in full technical detail the entire line of Radio Shack's "Enercell" batteries, including common carbon-zinc, all types of "high-energy," alkaline, mercury- and silver-oxide, lithium and rechargeable nickel-cadmium cells and batteries. Though the information is specifically for Radio Shack's Enercell line, almost all of it is also applicable to other manufacturers products.

Opening chapters deal with definitions of the various types of cells available, factors that influence battery performance, selecting the right cell or battery for a given application, recharging cells, etc. Then more than 100 pages is devoted to technical listings. Contained in each listing are a dimensioned drawing of the cell or battery, a table of technical specifications, and in many cases one or more graphed characteristics curves. Provided information includes cell or battery type, suggested current range, terminal voltage at full charge, rated capacity, average weight and volume, etc. A shortcoming is omitting listing of competitive brand numbers—Duracell *et al*—but the price paid for this is made up for by the very low cost of the book.

Maintenance and Repair of Video Cassette Recorders by Matthew Mandl. (Prentice-Hall, Inc. Hard cover. 245 pages. $24.95.)

This book describes how to maintain the mechanical and repair the electronic portions of VCRs. Initial chapters, written to be understood by even readers with no background in electronics, lay the groundwork that leads up to electronic trouble-shooting procedures. Included here are sections on routine maintenance of the mechanical portions of VCR transports, as well as information on the basic VCR signals and systems and the most common problems found in both VHS and Beta VCRs.

Comprehensive descriptions of the VHS and Beta systems are handled in separate chapters. Then comes a rundown on the various test instruments needed to conduct a troubleshooting session. The remainder of the book is devoted to repair procedures and includes instructions on tuning and aligning circuits, isolating and replacing defective parts, pinpointing common VCR troubles, and miscellaneous VCR-related factors. A chapter on Test Equipment covers the use of pattern generators, oscilloscope use with display examples and the vectorscope for adjusting color.

Many schematics and other illustrations support the text, which serve as a strong foundation in understanding how VCRs work, as well as servicing them.

Apple IIc, an Intelligent Guide by Fred Blechman. (CBS Computer Books. Soft cover. 270 pages. $17.95.)

The marketing thrust of the Apple IIc computer is toward users who run and use commercial software. Accordingly, if you want to program, the supplied documentation is woefully inadequate. Moreover, even if the Apple IIc user is familiar with BASIC programming, some Apple IIc peculiarities present an obstacle. This book fills the information hole for programming applications.

The guide starts at square one and successively builds from there, showing you how to create and customize programs on the IIc. Most of the text is given over to fairly in-depth discussions of BASIC programming techniques, with particular emphasis on Apple IIc color and graphics programming.

There are a couple of bonuses, too. One is the helpful information given on printers, modems, disk drives and other non-Apple peripherals that can be added to the IIc relatively easily and inexpensively. The other is an entire chapter containing reviews of 24 commercial software packages that run on Apple II series computers, including the IIc.

NEW LITERATURE

Video Products Catalog. Nearly 200 video accessories and installation hardware are listed and described in RCA's new 42-page, color catalog. New in this edition is a section on camcorder accessories. Other product lines described include cases for VCRs and cameras, tripods and camera mounts, blank videocassette tapes, and more. For a copy of the 1986 RCA Video Accessories catalog, write to: RCA Sales Promotion Services, Deptford, NJ 08096.

Parts & Equipment Catalog. Listed in Fordham Radio's new 164-page Summer '86 catalog are almost 2000 brand-name products ranging from test instruments to tools to video and audio equipment. Other categories include CCTV monitors and equipment; PA equipment; audio accessories; car stereos; CB transceivers; telephones; and more. All items listed are fully described, illustrated and include specifications, applications and pricing information. For a free copy, write to: Fordham Radio 260ME Motor Pkway., Hauppauge, NY 11788.

Terrestrial Interference Filter Catalog. Filters designed to cure terrestrial interference (TI) in TVRO Earth stations are described in the Filters For Suppressing Microwave Terrestrial Interference catalog from Microwave Filter Co. Included are filters designed to cure destructive and nondestructive interference and diagrams tell you where to place the filters in a TVRO system. Among the items described in full detail are an Installer's Kit for diagnosing and curing nondestructive TI in 70-MHz i-f receivers and a Sky Doc Kit that deals with both destructive and nondestructive TI. For a free copy of catalog TVRO/85, write to: Linda DeCoursey, Microwave Filter Co., Inc., 6743 Kinne St., East Syracuse, NY 13057.

Instrument & Accessories Catalog. A full-color short-form catalog that lists a complete range of bench test instruments is now available from O.K. Industries. The 22-page catalog contains complete descriptions, specifications and photos of: function/pulse/sweep generators, frequency and universal counters, digital multimeters, a mini-oscilloscope, thermometers, probes and pulsers, plus such accessories as thermocouples, test-lead kits, carrying cases, a bench rack, test clips, etc. For a free copy of the "Bench Test Instrument" catalog write to: O.K. Industries, Inc., Electronics Division, 3455 Conner St., Bronx, NY 10475.

Darlington Transistor Catalog. A 48-page catalog that describes single- and dual-Darlington power transistor modules is available from Semikron Inc. It contains electrical, mechanical and thermal specifications and data and includes circuit diagrams, dimension drawings and performance curves. For a copy of the Transipack catalog, write to: Martha T. Varney, The Gurrier Co., One Park Ave., P.O. Box 788, Hampton, NH 03842.

Stepper Motor Catalog. Comprehensive performance specifications for its stepper motors and controls are contained in the new full-size, looseleaf-binder-punched 40-page catalog just released by Bodine Electric Co. Test data on the company's high-accuracy 1.8 stepper motors and companion line of application matched L/R modular controls are given. Included is information on Bodine's new encased translator and indexer controls with resonance compensation that minimize mid-frequency resonances and extend usable speed/torque motor range. Also included are a new 8-ampere open chassis translator and inexpensive damping modules. For a free copy of Catalog No. ST-2, write to: Bodine Electric Co., 2500 W. Bradley Pl., Chicago, IL 60618.

R-f Instruments Catalog. Bird's new 60-page R-f Instruments catalog lists and describes the company's Thruline and directional wattmeters, coaxial load resistors and attenuators, calorimeters and r-f components. A Tech-Data section is provided. For a free copy of Catalog No. GC-85, write to: Bird Electronic Corp., 30303 Aurora Rd., Cleveland (Solon), OH 44139.

Ceramic Capacitors Catalog. A 24-page catalog from Cera-Mite Corp. provides comprehensive information about selection and use of a wide variety of ceramic capacitors. Included are sectional drawings that illustrate construction features and curves that illustrate capacitance change versus frequency and temperature and capacitance decrease versus dc voltage bias. Described and defined are ceramic-disc, heavy-duty and feed-through capacitors. The catalog provides such data as marking information, lead style specifications, packaging, performance, general application notes, military and aerospace qualifications and diagrams of typical applications. For a free copy, write to: Cera-Mite Corp., 123 6 Ave., Grafton, WI 53024.

Test & Measurement Peripherals Catalog. Rapid Systems' new newspaper-format catalog contains specifications on that company's digital and enhanced digital oscilloscope, spectrum analyzer, data logger and data acquisition peripherals for Apple, Commodore and IBM personal computers. Also included are a complete description of the company's Digital Signal Processing Lab Course, applications and comparison charts and a distributor list. For a free copy, write to: Rapid Systems Inc., 755 N. Northlake Way, Seattle, WA 98103.

IC/Transistor Selector Guide. A quick-reference selection guide that describes configurable gate arrays, linear ICs, bipolar LSI memory devices, digital ICs and small-signal transistors is available from Raytheon. The 96-page guide gives product descriptions and specifications and cross-reference charts. For a copy of the Product Selection Guide, write on company letterhead to: Marketing Communications Dept., Raytheon Semiconductor, 350 Ellis St., Mountain View, CA 94039.

 (from page 42)

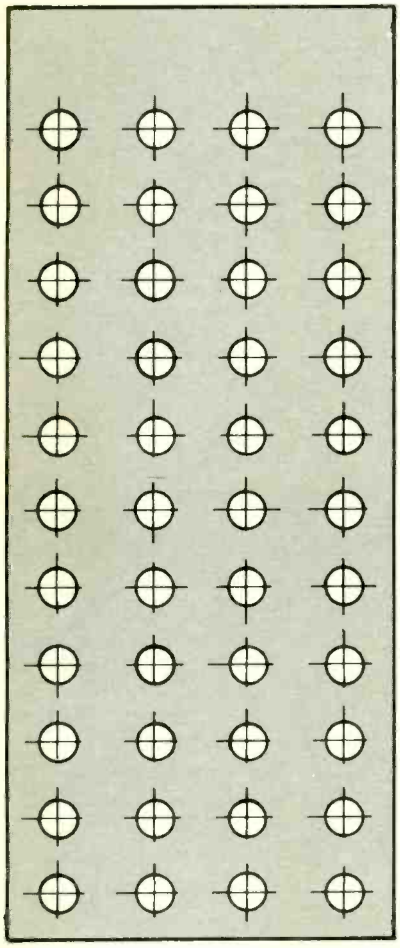

Fig. 5. Actual-size alignment template for LED installation.

the *bottom* of the board. Then prepare a two-conductor zip cord by removing ¼″ of insulation from the conductors at both ends. Tightly twist together the wires in each conductor and tin with solder. Make these cords as long as needed to route between your amplifier and the Power Meter after final installation in your vehicle. Solder one end of this cable to the pads labeled LEFT INPUT and RIGHT INPUT from the bottom side of the board.

Next, connect the red +12-volt and black ground power leads to the pads labeled +12V and GND on the bottom right side of the board. Make these leads long enough to reach the vehicle electrical system's ground and any point that is at +12 volts when the ignition is on and is off

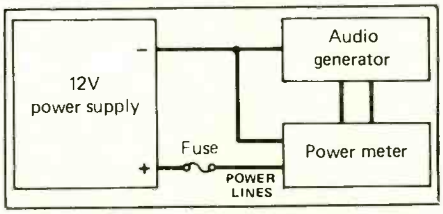

Fig. 6. Test setup for calibration.

when the ignition is off. The +12-volt wire should have an in-line fuse holder in it. Install a 1-ampere fast-blow fuse in the holder.

Any enclosure large enough to accommodate the circuit board and that has one panel that can be replaced with a clear or tinted panel can be used to house the project. An ideal size would have internal dimensions of 7¼″ × 2¼″ × 1½″. You can make such an enclosure from ⅛″-thick Plexiglass or ¼″-thick plywood, or you can modify an existing plastic or metal chassis to suit your needs. Just be sure to make one 7¼″ × 2¼″ panel from bronze or neutral-gray tinted transparent plastic to provide good contrast in relatively bright light for easy viewing of the display. Whichever material you use, paint all inside surfaces of the enclosure, except the faceplate, flat black to cut down on reflections.

Mask from view the left and right portions of the circuit board not in the LED matrix area. This can easily be done by applying black electrical tape or black paint to the appropriate areas on the inside surface of the faceplate.

Mount the circuit board inside the enclosure with four sets of ½″ spacers and 4-40 × ¾″ machine screws, nuts and lockwashers to the faceplate. The lockwashers between the nuts and circuit board are important because they prevent the hardware from working loose due to vibration from the road.

Because the display consists of LEDs whose different colors are self-explanatory, there is no need to label the faceplate. However, if you wish to give your project a more professional appearance, you can apply legends to the outside surface of the faceplate. Typical legends include LEFT LOW FREQUENCY, RIGHT LOW FREQUENCY, LEFT HIGH FREQUENCY and RIGHT HIGH FREQUENCY to the left of the individual bargraphs in the blanked-out areas. Under the bottom bargraph, you can bracket each color grouping and letter LOW POWER, MEDIUM POWER and HIGH POWER legends in the appropriate areas and then run vertical lines to separate the color groups.

All lettering should be done with a white dry-transfer lettering kit applied directly to the front surface of the faceplate. Since this type of lettering is very fragile, you should place an additional ⅛″ thickness of clear Plexiglass over the entire faceplate to protect the lettering. In this event, use 1″-long screws for mounting the board.

Checkout and Calibration

Referring to Fig. 6, connect the Power Meter's dc power leads to a 12-volt dc source. The first column of LEDs at the left (farthest from the transistors) should immediately light, indicating that power has been applied to the project. All other LEDs in the display should be off.

Apply an input signal from an audio signal generator or other audio source between the LEFT INPUT channel lead and the negative power-supply lead. Turn up the sound until the LEDs in the top and/or third row of the display begin to light. The row(s) of LEDs that turn on will depend on the frequency or frequencies delivered to the Power Meter's input.

If you are using an audio signal generator, sweep the frequency control from the low to the high end of the audio spectrum while observing the LED display. The LEDs in the top and third rows come on at frequencies above and below about 3 kHz, respectively.

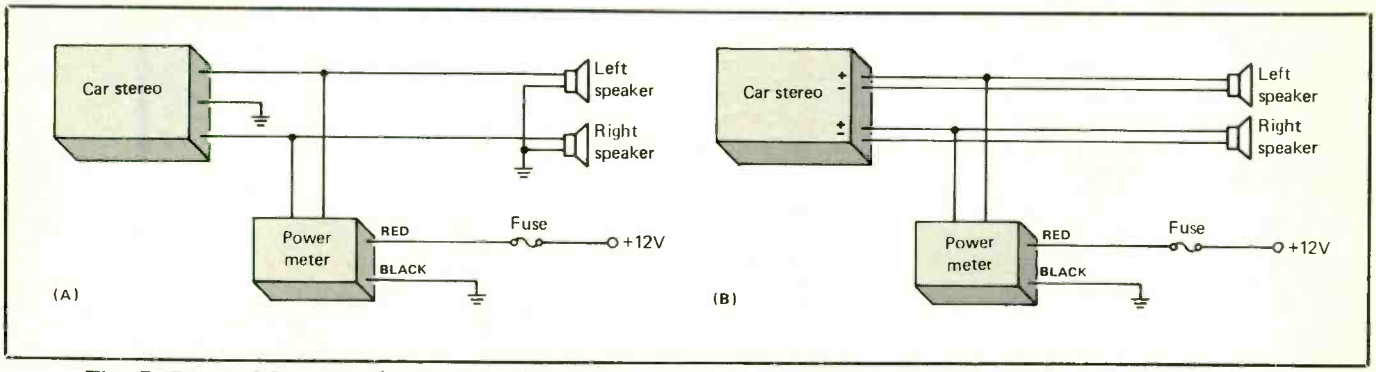

Fig. 7. Power Meter can be connected into conventional grounded (A) and floating ground (B) systems.

Disconnect the signal generator from the LEFT INPUT and connect it to the RIGHT INPUT. Repeat the above test, this time observing that the second and bottom rows of LEDs light when the signal is swept from the high to the low frequencies, respectively.

If everything checks out okay connect the Power Meter to the audio amplifier and electrical system in your vehicle. Refer to Fig. 7 for details. Determine whether your system has a conventional chassis ground or has a floating ground and use the hookup arrangement that applies to your installation. Do not perform final installation until calibration is done.

You can calibrate the Power Meter in either of two ways. One way is to tune to an FM station and turn up the volume control until the sound just begins to distort and then back off until the distortion just disappears. Then adjust the *R7* through *R10* trimmers until just the first red LED (third from the right) in each column comes on. If you are using a mono signal source, perform these adjustments separately for each channel. To make calibration as accurate as possible, set all tone and equalizer controls for a flat frequency response before you adjust the trimmer controls.

(Note: Always set the trimmer controls so that the *first* red LED in each bargraph display comes on with average signal levels. Do *not* set the controls so that all red LEDs come on with average signal levels. If you do, there will be no way you can tell from looking at the display when dangerous power levels and transient high-power peaks are being delivered to your speakers.)

For the second, much more accurate calibration procedure, make a calibration tape on a home cassette recorder. Record a minute or two each of 400-Hz and 5-kHz tones on both stereo tracks simultaneously. Play the tape back on your car stereo system while monitoring the output of your amplifier with an oscilloscope. If you have a 2- or more channel scope, you can observe both amplifier channels simultaneously. Otherwise, you must work on each channel separately. Turn up the volume to the point just before clipping of the signal appears on the scope's screen and adjust the trimmer controls so that the first red LED in each row (again the third from the right) in each of the respective bands comes on. Keep these tests as short as possible to avoid damaging your speakers, your amplifier and your ears!

If you want to use the Power Meter only as a visual display, accurate calibration is not necessary. Simply adjust the controls so that the first of red LEDs come on at your normal highest listening level.

During final installation, mount the Power Meter in a location where the display will be easy to view but not where it will interfere with the driver or passengers or will pose a hazard in an emergency situation. After you install the Power Meter in its final location, route all wiring to and from it so that it is not visible and will not be damaged. ME

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ADVERTISERS' INDEX

NEW PRODUCTS ••• *(from page 15)*

Four basic lessons are included in the educational material. These include basic atomic theory and electron flow; how to use the solderless breadboarding socket; component identification and schematic symbols; and how to read the resistor color code.

CIRCLE 28 ON FREE INFORMATION CARD

High-Resolution VDM

Goldstar's new Model MBH-2003 12″ amber-screen video display monitor is said to provide a 1100-line resolution at screen center, displaying 25 lines of up to 132 text characters per line. The high-resolution monitor features an anti-glare screen and a cabinet to match the IBM PC. Input to the VDM is composite video, which makes it compatible with any computer that has a composite output. Additional features include power, brightness and contrast controls. The MBH-2003 measures 13.8″W × 12.6″H × 10.9″D. $185.

CIRCLE 9 ON FREE INFORMATION CARD

FAX Converter/Printer

New from Universal Electronics Inc. (Columbus, OH) is the Model DES M-800 facsimile converter that allows the user to capture quality photos and graphics using a dot-matrix printer. The microprocessor-controlled converter connects to the audio output of any good AM or FM communications or satellite receiver. The audio is then converted into graphics data that is printed out on most Epson parallel dot-matrix printers. Print size is 8″ wide by as long as needed with a 1:1 aspect ratio. Photos are reproduced in 16 levels of gray.

To use the M-800, one simply tunes the receiver for maximum FAX signal level on the product's "tune" indicator and then selects the appropriate speed. The M-800 then automatically synchronizes and starts printing the picture with a resolution up to 120 dpi, 180 to 220 line pitch. Printing can be left to right or right to left at the user's option, in negative or positive format. An FM mode allows printing of all satellite transmitted weather facsimile, marine facsimile and worldwide news photo services. $599.

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