Lightning Early Warning System

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

By Tom Fox

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

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

About the Circuit

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

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

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

Detecting Electrical Storms

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

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

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

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

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

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

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

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

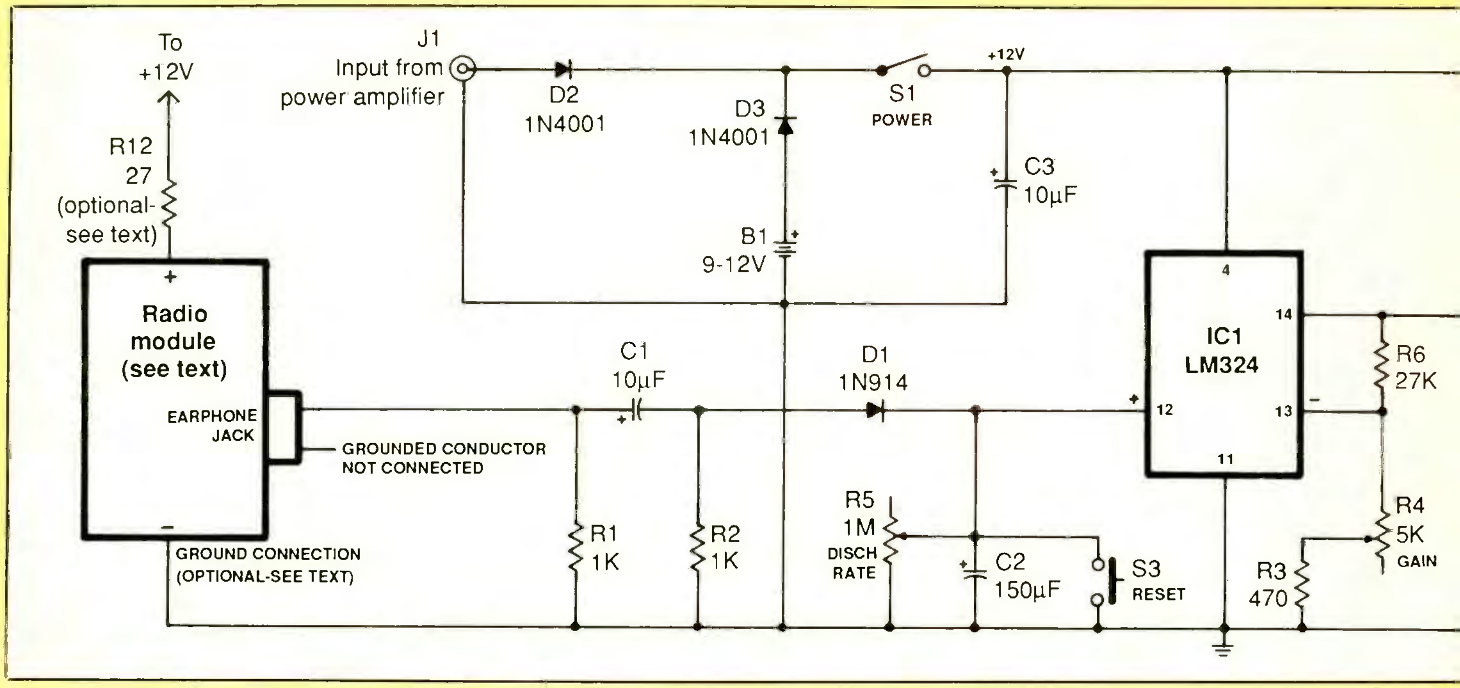
Resistor *R12* drops the system's 12-volt dc supply to a safe 9 volts for use by the radio. This resistor is not necessary if the project is powered by a 9-volt battery. Bear in mind, too, that some pocket radios are designed to be operated from either a 9- or 12-volt supply. If this is the case with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

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

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

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

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



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

Construction

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

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

Start wiring the board by installing a 14-pin DIP socket in the IC1 location. Do *not* install the IC in the socket until after voltage checks have been made. Next, plug into the specified holes the leads of the fixed resistors and solder them to the copper pads on the bottom of the board. Determine whether or not you need *R12* (you do if the AM radio with which the project is used requires a 9-volt dc supply and do not if it will accommodate a 12-volt power supply). If your project needs this resistor, install and solder it into place in the R12 location. If it does not, install and solder into place a solid bare wire in place of the resistor.

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

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

Strip ¼ inch of insulation from both ends of two 6-inch lengths of hookup wire, preferably with red and black insulation. If you are using stranded wire, tightly twist together the fine conductors at both ends of both wires and sparingly tin with solder. Plug one end of the black-insulated wire into the hole labeled LED1 K and one end of the red-insulated wire into the unidentified LED1 hole. Solder both into place.

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

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

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

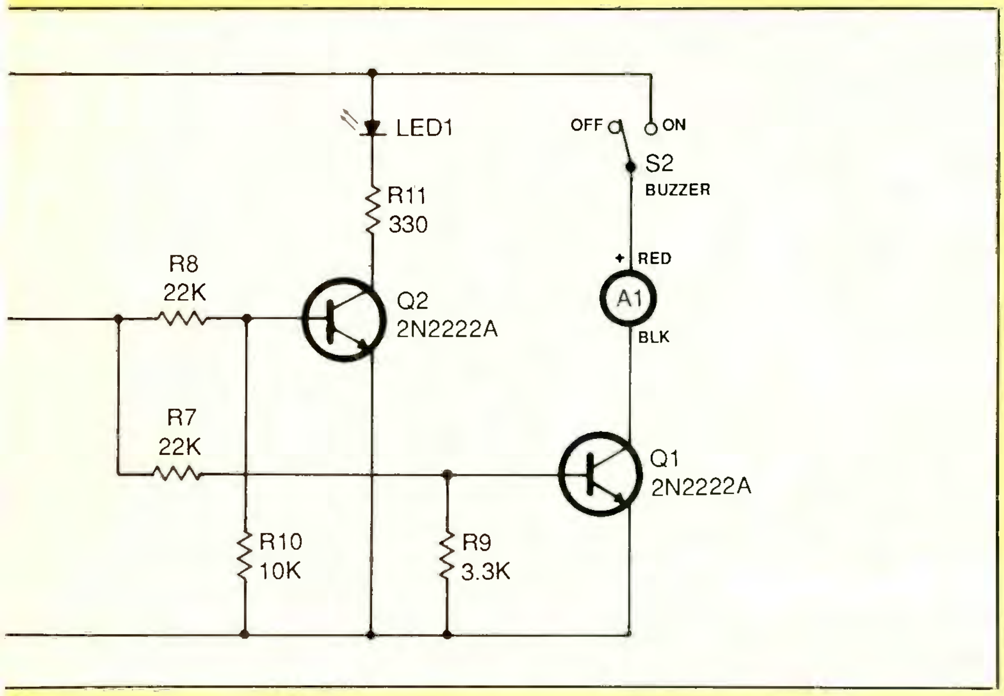


Fig. 1. Complete schematic of the Lightning Early Warning (LEW) device minus its dc power supply.

PARTS LIST (LEW system circuit)

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

Capacitors
C1,C3—10-μF, 50-volt electrolytic
C2—150-μF, 25-volt electrolytic

Resistors (¼-watt, 5% tolerance)
R1,R2—1,000 ohms
R3—470 ohms
R6—27,000 ohms
R7,R8—22,000 ohms
R9—3,300 ohms
R10—10,000 ohms
R11—330 ohms
R12—27 ohms, 1-watt (see text)
R4—5,000-ohm, vertical-mount pc-type trimmer potentiometer
R5—1-megohm, horizontal-mount pc-type trimmer potentiometer

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

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

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

To determine where to drill the mounting holes for the circuit-board assembly, orient the assembly, solder side down and with the buzzer to the left, on the outside of the front panel. Leave enough space between the assembly and left and right edges of the panel on which to mount the switches where they will not interfere with each other. Use a pencil to mark on the panel where to drill the holes.

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

Now measure the horizontal and vertical distances from the top-right board mounting holes to the center of the adjustment slot on horizontal trimmer control *R5*. Transfer these dimensions to the front panel and make an X mark in the indicated location. Feed a 4-40 × 1¼- or 1½-inch machine screw into each of the board's four mounting holes from the solder side of the board. Follow up with a 1-inch spacer on each and a 4-40 machine screw. Now measure how far down from the *nut end* of the spacers and how far from the bottom-right mounting hole is the center of the adjustment slot on vertical trimmer control *R4*. Transfer these dimensions to the right wall of the enclosure (take into account the thickness of the front panel, which is usually about 1/16 to 3/32 inch).

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

(Continued on page 82)

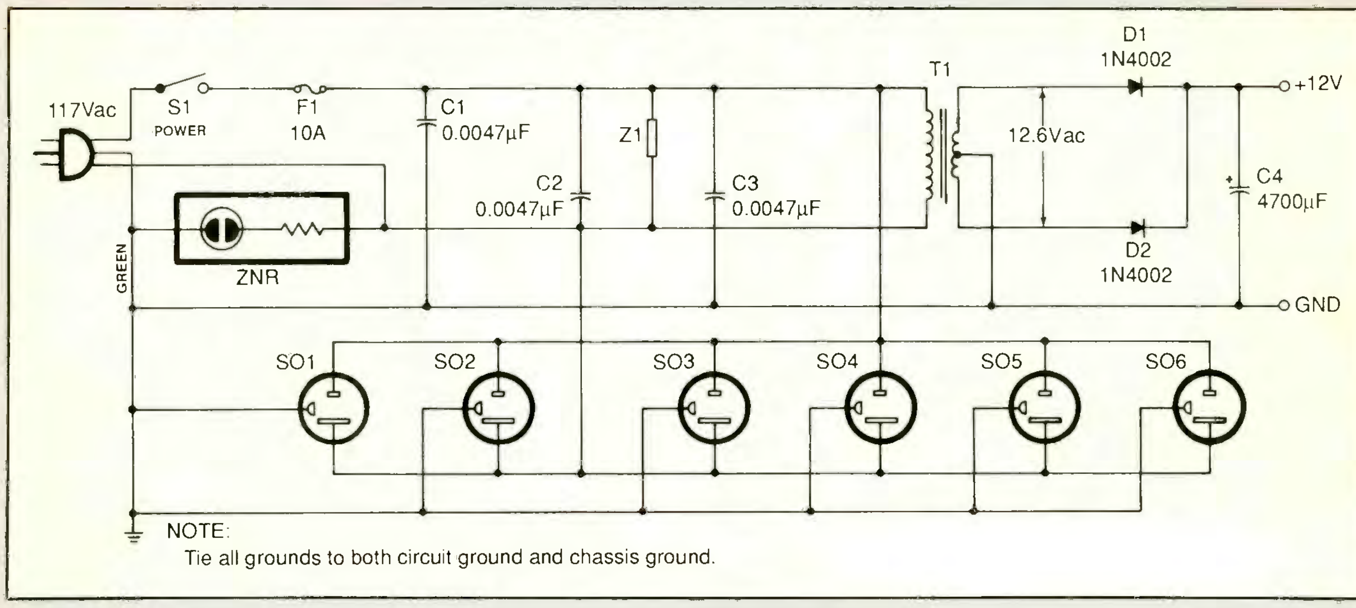


Fig. 2. Complete schematic diagram of an optional power strip/surge protection system you can build. Use as many (up to a maximum of six) ac receptacles as are needed for your particular computer system.

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

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

PARTS LIST (Outlet box)

Semiconductors

D1,D2—1N4002 silicon rectifier diode

Capacitors

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

C4—4,700-µF, 50-volt electrolytic

Miscellaneous

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

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

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

T1—12.6-volt center-tapped power transformer

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

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

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

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

Slide a 1-inch length of small-diameter heat-shrinkable or other insulating plastic tubing over the free ends of both wires coming from the LED1 holes in the circuit-board assembly. Identify the cathode lead of the LED and cut it to ½ inch long. Form a small hook in the cut end and crimp and solder it to the free end of the *LED1* cathode (identified by a K in Fig. 4). Then do the same with the anode lead and the free end of the other *LED1* wire. Push the tubing up flush with the bottom of the LED's case and shrink into place.

As noted in Fig. 1, you can use 9 to 12 volts dc for the *B1* battery. Therefore, decide now if you want to use a 9-volt transistor battery or eight 1.5-volt AA cells to provide 12 volts dc. Depending on which arrangement you use, drill a mounting hole for the 9-volt battery clip or as many holes as needed to mount the two 4-cell AA holders through the rear panel of the enclosure.

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

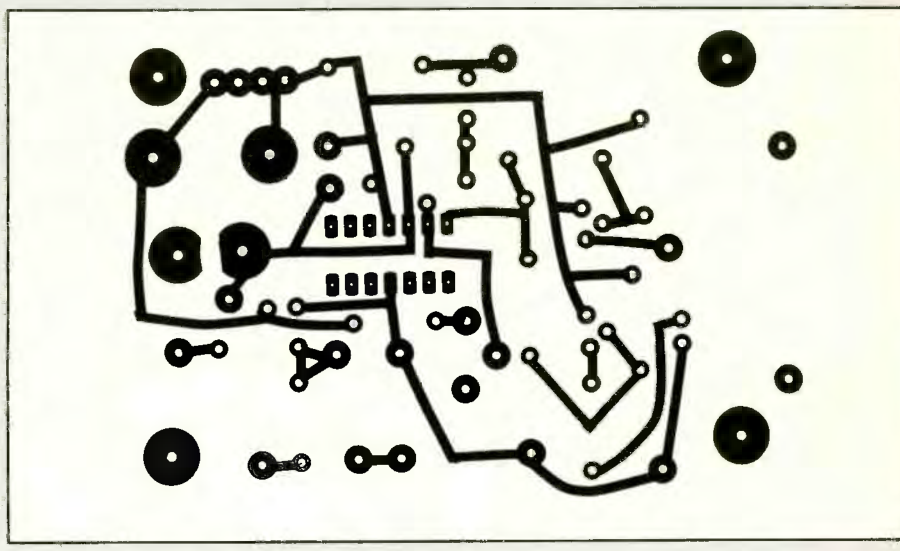


Fig. 3. Actual-size etching-and-drilling guide for the LEW project.

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

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

Finish wiring the circuit board assembly by soldering 6-inch lengths of hookup wire into the holes labeled B1+ and GROUND. If possible, use a red-insulated wire for the B1+ connection and a black-insulated wire for the GROUND connection. Connect and solder the free end of the GROUND wire to the negative (–) lug on one AA-cell holder and the B1+ wire to the positive (+) lug on the other AA-cell holder. Then connect and solder a short length of hookup wire between the + lug on the first holder and – lug on the second holder to place all eight cell holders in series.

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

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

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

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

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

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

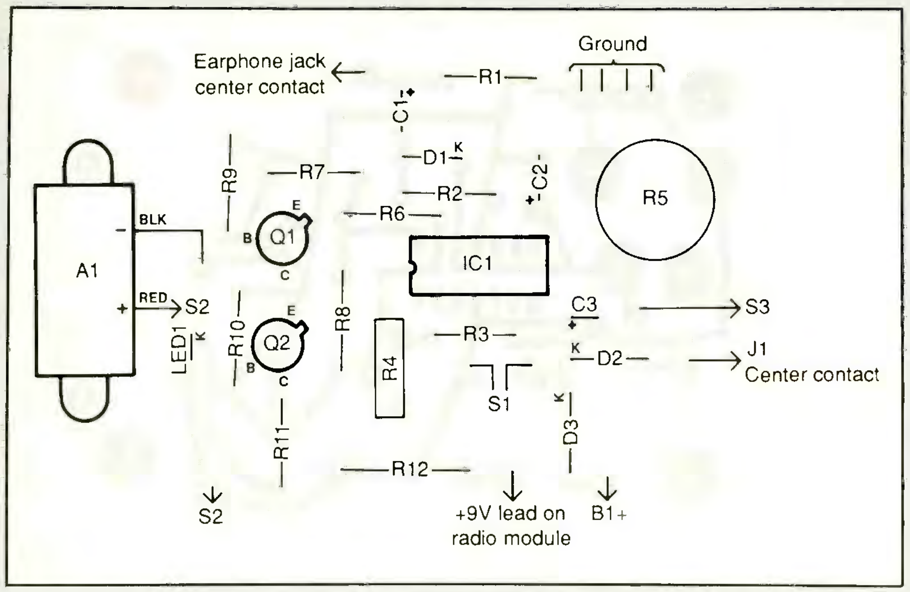


Fig. 4. Wiring diagram for LEW's printed-circuit board. Use this as a rough guide to component layout if you wire the circuit on perforated board.

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

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

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

If you decide to modify an existing multiple-outlet power strip, use all existing components but substitute a bayonet-type fuse holder and fast-blow fuse for the built-in circuit breaker if it has one. Also, use a separate metal utility box, which can be mechanically fastened to the power strip with machine hardware, to house the power transformer and filter capacitor *C4*. If you prefer, you can simply mount the transformer to an outside surface of the power strip with machine hardware and have its primary and secondary leads enter the strip's enclosure through rubber-grommet-lined holes, assuming that there is enough space inside the strip to accommodate the rest of the add-in components. If you do this, make certain that there is no possibility for the primary leads of the power transformer to become electrically exposed and create a shock hazard.

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

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

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

Terminate the other end of the cable in a plug that mates with the POWER jack on the LEW project. Make sure the identified conductor goes to the plug's "hot" contact lug and the other goes to the plug's ground or reference lug. If in doubt, use an ohmmeter or continuity tester to make sure.

Checkout, Adjustment & Use

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

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

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

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

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

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

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

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

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

If you note several false alarms in a short period of time, due to an unusually noisy electrical environment, set the BUZZER switch to OFF. The LED is sufficient to alert you to an approaching electrical storm. Of course, make a mental not to periodically glance at the project to see if the LED is on. If false alarms continue for a long period of time, make appropriate readjustments of the LEW's controls or/and move the project to a less-noisy location.

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

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

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

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