Blackout/Brownout Alarm

Sounds a buzzer when ac line power drops below a certain level or disappears altogether

By Istvan Mohos

Brief power outages and "brownouts" can occur fairly often during periods of peak power demand and severe electrical storms. When either occurs when you could not be aware of it because you are not using electricity apparent to you at the moment or are sleeping, you will appreciate the audible Blackout/Brownout Alarm described here. It will save you from oversleeping because your alarm clock could not do its job, alert you early to the possibility that meat in your freezer could spoil, and so on.

A novel design approach is used in our Blackout/Brownout Alarm. Instead of a battery that must be periodically replaced, the project uses a super capacitor that can store enough energy to power its piezoelectric audible signaling device for a minute or so. This should be long enough to alert anyone who is in hearing range to the fact that a power "emergency" has occurred. Because no battery ever has to be replaced in this project, you have the option of sealing it in epoxy potting compound or building it into a conventional enclosure. All components specified for the Alarm are readily available from Radio Shack or other local sources.

About the Circuit

Shown in Fig. 1 is the complete schematic diagram of the Blackout/Brownout Alarm circuit. The circuit forms a power loop when *PL1* is plugged into any ac receptacle. When the project is plugged into an ac receptacle and the power loop is interrupted by the contacts of relay *K1*, the Alarm is in its "standby" condition. It is placed in its "armed" condition by briefly pressing and releasing momentary-action pushbutton switch *S1*.

Pressing *S1* causes current to flow through the coil of *K1*. This energizes the relay, causing its upper contacts to latch the relay on and maintain current through its coil even after *S1* is released.

Whenever *K1* is energized, neon indicator lamp *I1* glows to indicate that the Alarm is armed. Full-wave bridge rectifier *RECT1* converts the incoming 117 volts from the ac line and delivers a pulsating-dc waveform between the + and − points of the rectifier. Because peak values of the rectified potential can reach as high as 180 volts, it is important that the bridge rectifier selected for *RECT1* have a rating of at least 200 volts.

As you can see, the lower set of relay contacts is in series with piezoelectric buzzer *PB1* and super capacitor *C1*. With the relay energized, the ground return bus for *PB1* is broken and no driving power appears across the buzzer. Thus, the buzzer is silent.

The pulsating dc voltage is fed through current-limiting resistor *R2* to zener diode *D1*. The avalanche path through *D1* provides a low-impedance sink for any dc potential in excess of 5 volts. The 5 volts dc maintained across *D1* charges super capacitor *C1* at an approximately 0.5-milliampere rate. Thus, several minutes of charging is required for *C1* to assume a full charge.

When a blackout or brownout occurs, ac power is either no longer delivered to the circuit or is too low in amplitude to maintain the relay in its energized condition. This being the case, *K1* deenergizes. The contacts of

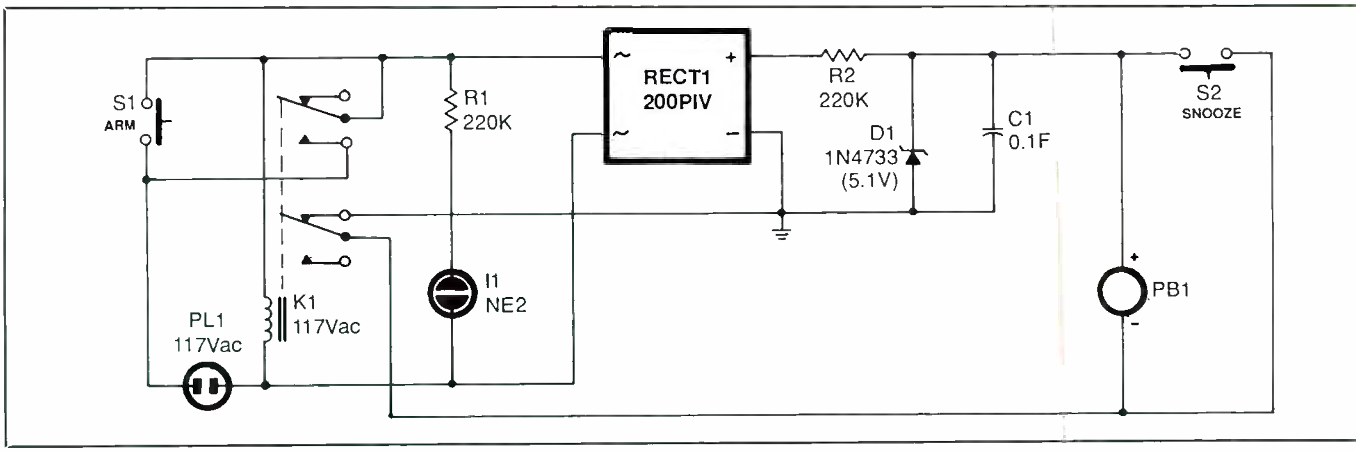

Fig. 1. Complete schematic diagram of the Blackout/Brownout Alarm's circuit.

PARTS LIST

Semiconductors
D1—1N4733 or similar 5.1-volt, 1-watt zener diode
RECT1—200-PIV minimum bridge rectifier (Radio Shack Cat. No. 276-1173 or similar)

Capacitors
C1—0.1-F super capacitor (Radio Shack Cat. No. 272-1440 or similar)

Resistors (¼-watt, 10% tolerance)
R1,R2—220,000 ohms

Miscellaneous
I1—NE2 neon lamp or panel-mount neon-lamp assembly with built-in limiting resistor—see text)
K1—Dpdt, 117-volt ac, 15-mA, 4,500-ohm relay (Radio Shack Cat. No. 275-217 or similar)
PB1—Pulsing piezoelectric buzzer (Radio Shack Cat. No. 273-066 or similar)
PL1—Quick-connect ac plug or ac line cord with plug (see text)
S1,S2—Miniature normally-open, momentary-action pushbutton switch
Printed-circuit board or perforated board and suitable soldering hardware (see text); 2-fluid-ounce clear epoxy potting compound or suitable enclosure (see text); materials for making potting frame (see text); hookup wire; solder; etc.

K1 now assume their standby configuration. That is, the latching action of the upper contacts is defeated as the contacts spring open, and *I1* extinguishes. More importantly, the ground-return line of the piezo buzzer is completed and the energy stored in *C1* is applied directly across *PB1*, which then emits an audio tone that serves as the audible alarm. Enough energy is stored in the fully charged super capacitor to cause the buzzer to continue to sound for a minute or so.

When power is restored or comes up to a level that permits normal circuit operation, *PB1* will continue to sound (assuming that the power outage was for a shorter period of time than it takes to deplete the charge on *C1*). The only way to shut off the audible signaling device and restore the alarm to its "armed" condition is to briefly press and then release *S1* to latch the relay on, as detailed above.

Switch *S2* is an option that was added to the circuit to provide a "snooze" capability. Momentarily pressing and releasing this switch short-circuits the super capacitor and silences the piezo buzzer.

Construction

Owing to the fact that there are no restrictions on component placement or conductor routing, you can use any traditional means of wiring to build the Blackout/Brownout Alarm. However, a printed-circuit board, the actual-size guide for which is shown in Fig. 2, is recommended for this project if you plan on potting the finished assembly. If you decide not to pot the circuit-board assembly, you can use perforated board and suitable soldering hardware instead of the pc board.

After etching the printed-circuit board according to Fig. 2, cut the narrow slots at the top for the prongs of the ac plug. One way to do this is to drill a small hole at both ends of each slot and chip out the unwanted board substrate with a sharp safety knife. As you work, periodically plug the prongs of the plug into the slots to check your progress. When the slots are finished, trim the board to size. Then scrub the copper-trace side of the board with scouring powder until the traces are shiny bright, and thoroughly rinse the board and dry it.

You will notice that very little copper has been removed during the etching process. The reason for this is that the epoxy potting compound is a poor conductor of heat. Therefore, by leaving behind the maximum amount of excellent heat-conducting copper on the board, the copper itself will serve as an adequate heat sink for the circuit.

Whichever method of mounting

and wiring together the components, refer to the wiring diagram shown in Fig. 3 for component placement and orientation. Note in Fig. 3 that when wiring the pc board that the components mount on the *conductor* side, using a technique similar to that employed for surface-mount components.

Begin populating the printed-circuit board by trimming the leads of the two resistors and zener diode to appropriate lengths according to the conductor pattern. Carefully bend the leads so that they will safely bridge copper traces they are not supposed to contact. Tack-solder the leads of both resistors to the appropriate points on the copper traces as shown. (Note: if you are planning to house the circuit-board assembly inside a conventional enclosure, you can substitute a panel-mount neon-lamp assembly that has a built-in limiting resistor for the separate *R1* resistor and *I1* lamp called for in the Parts List. If you, do this, do not install *R1* on the circuit board.)

Set the zener diode in place to determine where on the copper traces its leads will touch. Tin with solder both touch points and then tack-solder the diode's leads into place, using heat judiciously and waiting for the first connection to cool before making the second connection. Make sure the zener diode is properly oriented before soldering either lead into place.

Carefully bend all four leads of the rectifier assembly so that they are in line with the rear of the assembly and parallel to each other. When the assembly is laid flat on its back, the leads and rear surface should be in the same plane.

Pretin the copper traces on the board to which the leads of the rectifier assembly are to be soldered. Set the rectifier in place and solder its leads to the appropriate copper traces. Again, make sure the assembly is properly oriented before soldering into place any leads, use heat

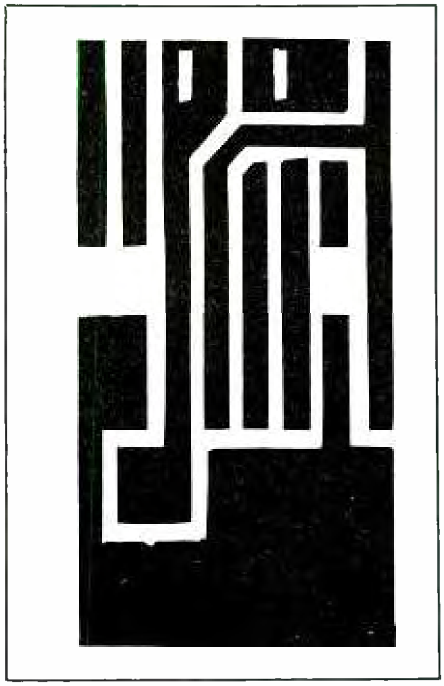

Fig. 2. Actual size etching guide for the printed-circuit board for the project.

judiciously and permit the assembly to cool after each soldering operation is performed.

Bend the leads of the super capacitor outward and clip them so that only about 3/16 inch protrudes beyond the housing. Making sure the capacitor is properly oriented, tack-solder its leads to the appropriate copper traces on the board.

Note in Fig. 3 that a jumper wire is needed, shown just above where *R2* is mounted. Use a suitable length of insulated hookup wire for it.

Strip ¼ inch of insulation from one end of three 4-inch-long hookup wires. Remove an additional ½ inch of insulation from one wire. Thread the stripped end of this wire through the large lug to the specified smaller lug of the relay as shown. Solder both connections. Then crimp and solder the stripped ends of the other two wires to the indicated lugs of the relay.

Strip ⅛ inch of insulation from the free ends of the three wires attached to the relay. Carefully tack solder these wires to the appropriate copper traces near the top of the pc board.

Strip ¼ inch of insulation from one end and ⅛ inch from the other end of two 2-inch-long hookup wires. Crimp and solder the ends from which the ¼ inch of insulation was removed to the remaining large and the indicated small lugs on the relay. Then tack-solder the free ends of both wires to the indicated points on the board.

If you are planning to pot the project, tack-solder the leads of the piezoelectric buzzer to the indicated copper conductors at the top-left of the pc board, making sure you observe proper polarity. Leave the leads of the buzzer full length. If you are planning on housing the project inside a standard enclosure, do nothing with the piezo buzzer at this point.

Again, if you are sealing the circuit-board assembly in potting compound, slide over both leads a 1-inch length of plastic tubing to insulate them from each other and the rest of the components on the board. If necessary, trim the leads of the lamp so that only about ⅛ inch protrudes beyond the ends of the tubing. Tack-solder the leads to the two indicated conductors on the board. Otherwise, wait until after the circuit-board assembly is mounted inside its enclosure to connect the lamp to it.

Connection of the two switches (assuming you have decided to include SNOOZE switch *S2*) depends on whether the circuit-board assembly is to be potted or housed inside a conventional enclosure. If the former, you can tack-solder the lugs of each switch directly to the copper traces on the board, making sure that both switches sit perpendicular to the surface of the board. If you are planning on using a conventional enclosure, connect the switches into the circuit via suitable-length hookup wires.

Finish wiring the circuit-board assembly by installing and soldering into place plug *PL1*. If the assembly is to be potted, you need only the insert portion—the part with the prongs—

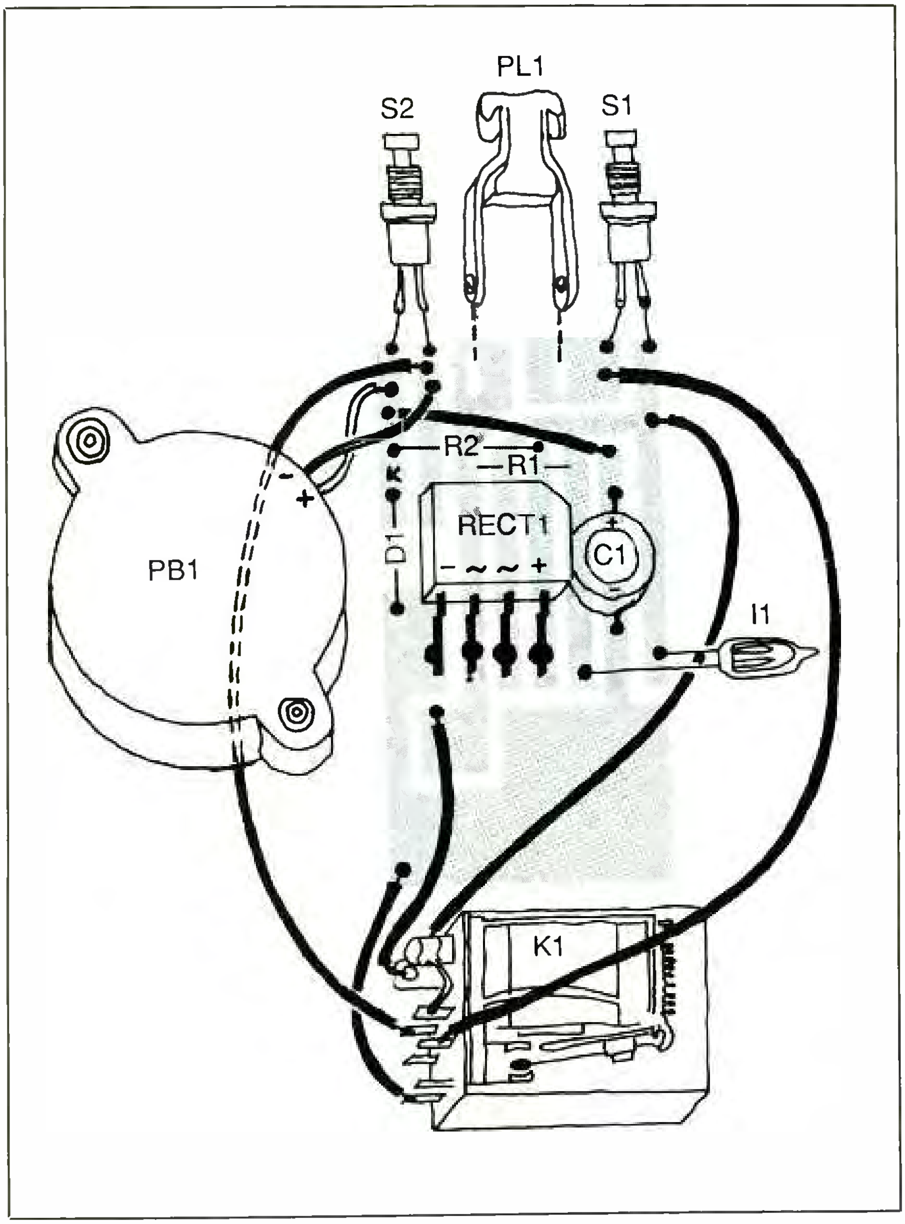

Fig. 3. Wiring diagram for pc board. Note that all components mount on the copper-trace side of the board.

of a quick-connect ac plug here. Discard the shell in this case. If you attempt to use the insert portion as is, the prongs will be shorter by the thickness of the board and may not provide solid plugging action. To offset this, use a saw or file to trim enough of the anvil-like plastic porion between the prongs to restore full length when they are inserted into the slots in the board.

Now insert the prongs in the narrow slots cut for them from the component side of the board and solder the prong sides to the copper conductors along the accessible edges. Make these connections mechanically sound, using as much solder as possible. Otherwise, use a standard ac line cord with plug, which will be wired into the circuit after the circuit-board assembly is mounted inside the selected enclosure.

Should you decide to use a conventional enclosure in which to house your Blackout/Brownout Alarm, you can choose one that is all metal, all plastic or a combination of the two. Machine the enclosure as needed: drill mounting holes for the neon lamp assembly, both switches and the buzzer and the entry holes for the ac line cord and buzzer leads. If you drill any holes through metal, deburr them and line the ones for the ac line cord and buzzer leads with small rubber grommets.

Route the free end of the line cord through its hole and into the enclosure. Tie a strain-relieving knot in it inside the enclosure about 2 inches from the free end. Tightly twist together the fine wires in each conductor and tin with solder. Trim the bare tinned conductors to about ¼ inch long and tack-solder them to the copper traces.

Mount the circuit-board assembly to the floor of the enclosure with thick double-sided foam tape. You can now mount the relay with the same tape, fastening it to the area reserved for it at the bottom of the board or on the wall of the enclosure near the bottom of the board.

It is more convenient to replace the separate *R1* resistor and *I1* neon lamp with a panel-mount neon-lamp assembly with built-in limiting resistor. If you do this, mount the lamp assembly in its hole and secure it with the supplied clip. Tack-solder one lead to the copper trace to which the left end of *R1* in Fig. 3 is shown connected. Then tack-solder the other lead to the trace to which the right lead of the lamp is shown connected. Of course, if you do this, eliminate *R1* from the circuit. Plug the switches into their respective mounting holes and secure them in place with the hardware supplied with them.

Route the leads of the buzzer through their hole and mount the buzzer in place with suitable machine hardware. Tack-solder the positive (+) buzzer lead to the trace at the upper-left of the board and the negative

(–) lead to the trace right next to it.

Readers who wish to encapsulate the circuit-board assembly in epoxy potting compound should first conduct a test to assure that the project has been wired and is working properly. When you conduct this test, practice extreme caution because you will be dealing with potentially lethal 117-volt ac line power.

You will need an extension cord to conduct the operational test for a project that is to be encapsulated but not for one that it to be housed inside an enclosure. Plug *PL1* on the project into the extension cord and place the project on an insulating surface. Plug the extension cord into a convenient ac outlet. The alarm should not sound and the neon lamp should be dark. Carefully press and release ARM switch *S1*. The neon lamp should now be lit but the buzzer should not sound. Allow the project to sit in this condition for several minutes to allow the super capacitor to charge up.

When sufficient energy has been built up in *C1*, pull the plug of the extension cord from the ac outlet. The neon lamp should now extinguish and the buzzer should sound. While the buzzer is sounding, press and release SNOOZE switch *S2*. The buzzer should immediately silence.

When conducting the operational test on a project that is housed inside an enclosure, be sure to have the enclosure closed. Also, plug the project's line cord—without benefit of an extension cord—into the ac outlet. Conducting an operational test on this version of the project requires no special precautions.

If you do not obtain the proper responses from the project, unplug it from the ac outlet and carefully recheck all wiring and component installations. Make certain that zener diode *D1*, bridge rectifier *RECT1* and piezoelectric buzzer *PB1* are all installed in proper polarity.

Check all soldering. If you suspect a connection reflow the solder on it (and add solder if needed). If you discover a solder bridge where there should not be one, use desoldering braid or a vacuum-type desoldering tool to remove it. Do *not* attempt to encapsulate the project or put a nonfunctioning project into service.

When you are certain that the project is operating properly, you can encapsulate the circuit-board assembly in epoxy potting compound. To do so, you will use the "frame-and-pour" method, similar to framing and pouring concrete walkways only in miniature.

A slab of lumber of any type with a hole cut in it for the prongs of the ac plug protruding from the bottom of the circuit-board assembly makes up the bottom of the frame. Lay this flat on your work surface. The walls of the frame are made from four pieces of thin lumber that have been cut to a size to form a surround that has the same inner dimensions as the length and width of the circuit-board assembly and is 1 inch deep. Hold the frame together with rubber bands or tape.

Use double-sided tape to line all surfaces that are to come into contact with the potting compound with strips of clear acrylic or acetate. In a pinch, any transparent plastic film can be used. I have had good results with strips cut from the "bubbles" used on display packages, soft-drink bottles and other plastics. The plastic will not adhere to the epoxy potting compound, allowing the lined strips of wood to easily pop off after about 24 hours as the compound sets.

Once the frame is ready, place the circuit-board assembly inside it, blank side down. The relay now becomes the "cornerstone" of the unit. After mixing a small amount of the two parts that make up the potting compound, pour a thin layer of it in the area in which the relay is to mount and push the relay into it, squaring it up against the lower-right corner of the frame. Work with the epoxy potting compound in a well-ventilated location.

Mix another small batch of the compound and pour it over the rest of the board, positioning the indicator lamp so that it will easily be seen when the project is in operation. Place a strip of tape over the sound-exit hole in the buzzer and use some already setting compound to cover the three small holes in the bottom of the buzzer and allow it to set awhile. This will prevent liquid compound from entering the buzzer and interfering with its operation. Mix some more compound, pour it into the frame and press the buzzer into the liquid compound.

Mix some more of the compound and pour this into the frame. Continue mixing and pouring until you have filled the frame up to the shoulders of the switch frames and the buzzer is encased in what will become a rigid block of epoxy. The process may take as many as 10 mixings and pourings to complete. Use a home-made plastic spatula to smooth each layer of compound as it is poured.

As you approach the end of the potting operation, you will notice that the potting compound tends to run up the sides of the frame, making the surface slightly concave, with ridges at the edges. This does no harm to the finished project but can be less than aesthetically appealing. To correct for this, you can cut a template from some more clear plastic with holes cut or punched for top of the buzzer and switch buttons.

With template in hand, mix and pour the last thin layer of potting compound, smoothing it to the top of the wall. Place the template over this layer, rolling it over the top of the form to avoid trapping any air bubbles between it and the compound.

Allow the assembly to sit undisturbed for at least 24 hours to allow the potting compound to fully cure. When the compound has cured, remove the rubber bands or tape and snap away the wood and plastic strips. The project is now ready to be put into service. ME