A Light Minder for the Blind

Simple project indicates when lights are on and where

By Adolph A. Mangieri

A blind person can check the status of lights by touching wall switches, by listening for the hum of fluorescent lights, and by feeling for heat radiated by turned-on table lamps. However, stairwells often have three-way switches that make it impossible to for a blind person to be absolutely sure if the light is on or off. Too, a blind person cannot tell if the bulb in a ceiling fixture has burnt out. The Light Minder described here helps to alleviate at least these two of the many uncertainties with which blind people must contend.

The Light Minder detects ambient lighting and audibly signals whether it is on or off. It can be swept around an area to permit the user to locate the direction from which the light is coming. Additionally, it can signal light intensities between full on and full off by sounding tones of different frequencies.

It is simple in design, low in cost and easy to build. It requires very little time and no special skills to learn how to use it effectively. With it, a blind person can feel more in step with his environment as he provides the lighting needed by visitors and knows when to turn it off when no sighted people are around.

About the Circuit

Shown in Fig. 1 is the complete schematic diagram of the Light Minder. CMOS 555 timer *IC1* is configured here to operate as a continuously running multivibrator. When normally open pushbutton switch *S1* is pressed, capacitor *C1* begins to charge at a rate determined by the sum of the values of resistor *R1* and the values of the parallel combination of resistor *R2* and cadmium-sulfide light-dependent resistor *LDR1*.

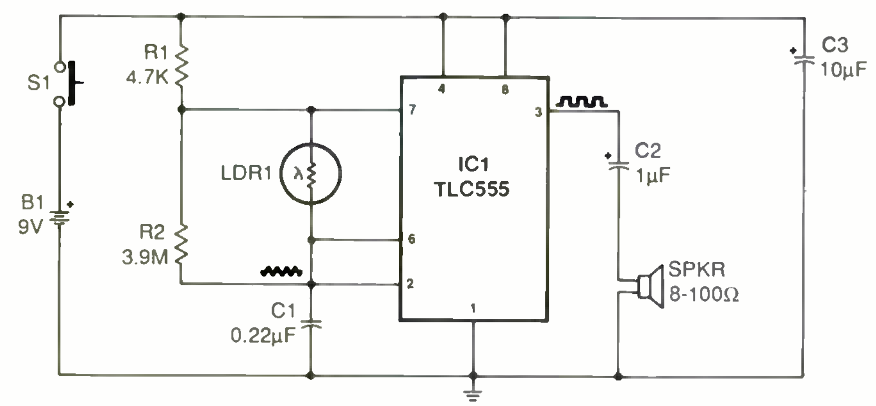
When the potential across *C1* reaches $0.667V_{CC}$, the capacitor discharges to $0.033V_{CC}$ through *R2* and *PC1*. The capacitor then charges up again and discharges at $0.667V_{CC}$, and the cycle repeats for as long as power is applied to the circuit.

A sawtooth-like waveform voltage developed across *C1* is fed into *IC1* at trigger pin 2 and controls an output flip-flop in the timer. This flip-flop delivers a square-wave output voltage at pin 3, which is applied to speaker *SPKR* through dc blocking capacitor *C2*.

The resistance of the light-dependent resistor decreases with increasing light. This causes the frequency of the audio signal generated by the timer chip to increase. In total darkness, *LDR1*'s resistance rises to greater than 4 megohms.

The audio output from *IC1* is a train of brief non-symmetrical pulses that occur at a rate of one or two per second. The value of resistor *R2* assures that the pulse rate is never less than one per second, which, in turn, assures the user that the Light Minder is operating as it should.

At medium light-intensity levels, the resistance of *LDR1* is comparable to that of *R1*, resulting in a square-wave output from *IC1* at a middle audio frequency. Under high light-level conditions, *LDR1*'s resistance is well below that of *R1*, now resulting in a non-symmetrical square wave at high audio frequency. Thus,



PARTS LIST

B1—9-volt battery
C1—0.22-µF, 15-volt ceramic disc capacitor
C2—1-µF, 15-volt electrolytic capacitor
C3—10-µF, 15-volt electrolytic capacitor
IC1—TLC555 CMOS timer (Radio Shack Cat. No. 276-1718 or equivalent)
LDR1—Cadmium-sulfide light-dependent resistor (Radio Shack Cat. No. 276-1657 or similar)
R1—4,700-ohm, ¼-watt, 5% tolerance resistor
R2—3.9-megohm, ¼-watt, 5% tolerance resistor
S1—Normally open spst pushbutton switch
SPKR—Miniature 8- to 100-ohm speaker
Misc.—Printed-circuit board or perforated board and suitable soldering or Wire Wrap hardware (see text); socket for IC1; snap connector and mounting clip for B1; suitable enclosure (see text); spacers; machine hardware; hookup wire; solder; etc.

Fig. 1. Complete schematic diagram of Light Minder's circuit.

the user knows simply by the pitch of the generated tone whether lights are on or off.

Construction

The Light Minder's circuit is very simple in terms of component count and requires no special component placement during assembly. Therefore, you can assemble the project using any traditional wiring technique that suits. If you wish, you can fabricate a printed-circuit board for the project, using the actual-size etching-and-drilling guide shown in Fig. 2 and wire it as shown in Fig. 3. Alternatively, you can mount the components on perforated board that has holes on 0.1-inch centers using suitable soldering or Wire Wrap hardware, as was done for the original prototype of the Light Minder shown in Fig. 4.

Whichever wiring technique you decide to use, it is a good idea to use a socket for *IC1* both to facilitate easy troubleshooting should this become necessary and to make it easy to replace the timer chip as needed.

If you make your own pc board, wire it exactly as shown in Fig. 3, starting with the IC socket and proceeding with the resistors, capacitors and light-dependent resistor. (You can use any cadmium-sulfide unit that has a resistance of between 200 and 2,000 ohms under average room lighting conditions for *LDR1*.) Make sure you install electrolytic capacitors *C2* and *C3* in the correct polarity. Do *not* install the timer chip in the socket yet.

Strip ¼ inch of insulation from both ends of six 4-inch-long hookup wires. If you are using stranded hookup wire, twist together the fine conductors at both ends of all wires and the leads of the battery snap connector and sparingly tin with solder. Plug one end of the wires into the holes labeled S1, LDR1 and SPKR and solder them into place. Then, taking care to observe proper polarity, plug the leads of the battery snap connector into the holes labeled B1 and solder them into place.

Clip the common lead of a dc voltmeter or a multimeter set to the dc volts function to the free end of the wire coming from the SPKR hole near the edge of the board. Make sure the other SPKR wire and the two *LDR1* wires touch nothing in the circuit. Temporarily short together the free ends of the two *S1* wires and snap a fresh 9-volt battery into the connector. Then touch the meter's "hot" probe to pins 4 and 8 of the *IC1* socket and note the reading in both cases. If all is well, the readings should both be +9 volts. If not, power down the circuit and rectify the problem before proceeding.

When the correct voltages appear at pins 4 and 8 of the IC socket, power down the circuit by removing the battery from the connector. Then temporarily short-circuit *C3* with a wire jumper and plug the timer chip into the socket, observing correct orientation and making sure that no pins overhang the the socket or fold under between IC and socket. Separate the *S1* wires. (Note: If you assemble and wire the circuit on perforated board, use the same general component layout shown in Fig. 3 and wire the components together by referring back to Fig. 1.)

Use any enclosure that will comfortably accommodate the circuit-board assembly, battery, speaker and switch. An old defunct shirt-pocket-size radio makes an ideal enclosure, after removing from it the electronic circuitry but leaving in place the speaker. (You can use any miniature speaker rated at between 8 and 100 ohms with this project.)

Machine the enclosure for mounting the components, using a metal clip for holding the battery in place. If you use a standard utility box, drill mounting holes for the circuit-board assembly and switch, a number of holes in the area over which the speaker will be mounted to allow the sound to escape, and a ⅜-inch-diameter hole directly over the light-dependent resistor when the circuit-board assembly is mounted in place. If you are not using a salvaged pocket radio case, mount the speaker in place with a narrow bead of silicone adhesive around its frame.

After mounting the speaker and switch in their respective locations, mount the circuit-board assembly in place, using short spacers and No. 4 machine hardware. Then determine exactly where to drill the hole directly in line with the LDR in the other wall of the enclosure. Drill that hole.

Crimp and solder the two wires coming from the holes labeled S1 on the circuit-board assembly to the lugs of the switch. Similarly, crimp and solder the wires coming from the holes labeled SPKR to the lugs of the speaker. The "+" wire goes to the identified "hot" lug on the speaker, the other wire to the remaining lug. If you are using the case of a pocket radio, use black plastic electrical tape to block all light from entering the case through the transparent bezel or hole in the case. The only light that should enter the enclosure should do so through the ⅜-inch hole you drilled for the LDR.

Snap a battery into the connector and assemble the enclosure.

Using the Project

At night, place the Light Minder in total darkness for several minutes to allow the resistance of the LDR to increase to near its maximum value. Press and hold the button on *S1* to verify that an audio tone of one to three ticks per second is being generated. If the tone is much higher in frequency, reduce it by using a larger capacitance value for *C1*. Do this by shunting the capacitor already in place with another one of smaller value. Of course, if the tick rate is much slower than the one to three ticks it should be, remove the existing capacitor from the *C1* location and replace it with a capacitor of lower value.

While you are at it, check the volume of the tone under average room lighting. If it is objectionably loud, decrease the value of *C2* to 0.5 microfarads or to suit.

The circuit draws 3 milliamperes of current when using a CMOS version of the popular 555 timer chip and 12 milliamperes when using the bipolar version. Obviously, the CMOS version is preferable and will allow an alkaline battery for *B1* to last about a year under normal conditions.

Perform operational tests at night with an adjoining darkened room. As the project is swept past the en-

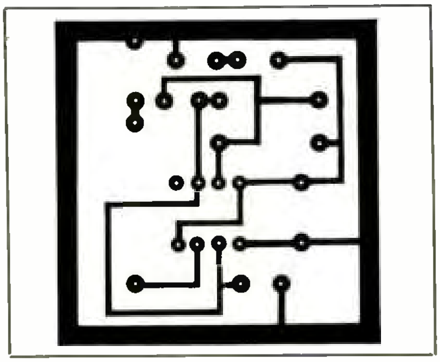


Fig. 2. Actual-size etching-and-drilling guide for fabricating printed-circuit board.

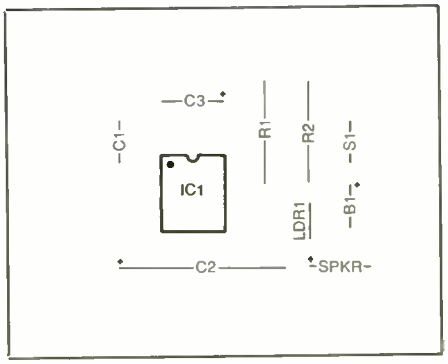


Fig. 3. Wiring guide for pc board. Use this as a rough guide to component layout when assembling project on perforated board.

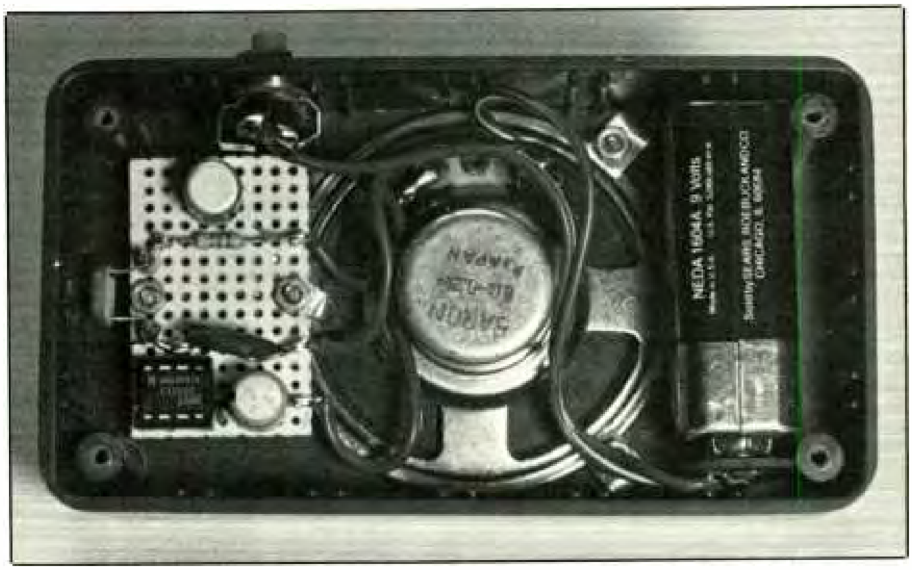


Fig. 4. Interior view of author's prototype housed inside a project box. This project was assembled using perforated board and point-to-point wiring.

trance to the darkened room, the pitch of the tone emitted by it should suddenly drop. In effect, the Light Minder is using audio tones to "map" the environment as the project is swept completely around the room. Thus, although a blind person may know his orientation in a room by touch, the Light Minder can confirm and reinforce that knowledge.

A user might be interested in equating the audio tones with light levels so that he can adjust lighting to suit the needs of sighted individuals. To this end, describe the lighting conditions while the blind user scans his environment with the project. The typical blind person should easily be able to discern and interpret at least three—and probably as many as five—light levels (audio tones).

A ticking sound that occurs less than two times per second indicates total or near total darkness, or a condition under which a sighted person will not be able to or just barely be able to make out objects. A rapid tick or low-frequency buzz in the range of 10 to 100 Hz indicates that there is enough light to see objects but not enough to read printed matter. At audio tones of about 400 Hz and beyond, the lighting should be sufficient for reading purposes. Tones of around 2 kHz indicate that the light level is quite high, as when the project is detecting a bright light source. Direct sunlight and very close detection of a bright lamp will cause the project to generate even higher-pitched tones.

From the foregoing, it should be obvious that the Light Minder is a very utilitarian project for the sight impaired. It not only lets a blind user know when lights are on, it can also be used to scan the environment to inform the user of the direction from which the light is coming. Additionally, the unsighted user can use the project to scan his entire environment to assist him in becoming familiar with a new or different room.

Of course, the Light Minder is not a panacea for the blind. Some users may become intrigued with the project and attempt to extract whatever information they can from it. But caution any user that the Light Minder can supplement but does *not* replace normal procedures for establishing one's orientation and movement within a given environment. If any confusion occurs when using the Light Minder, instruct the blind user to ignore the project and return to normal procedures for determining orientation. ME