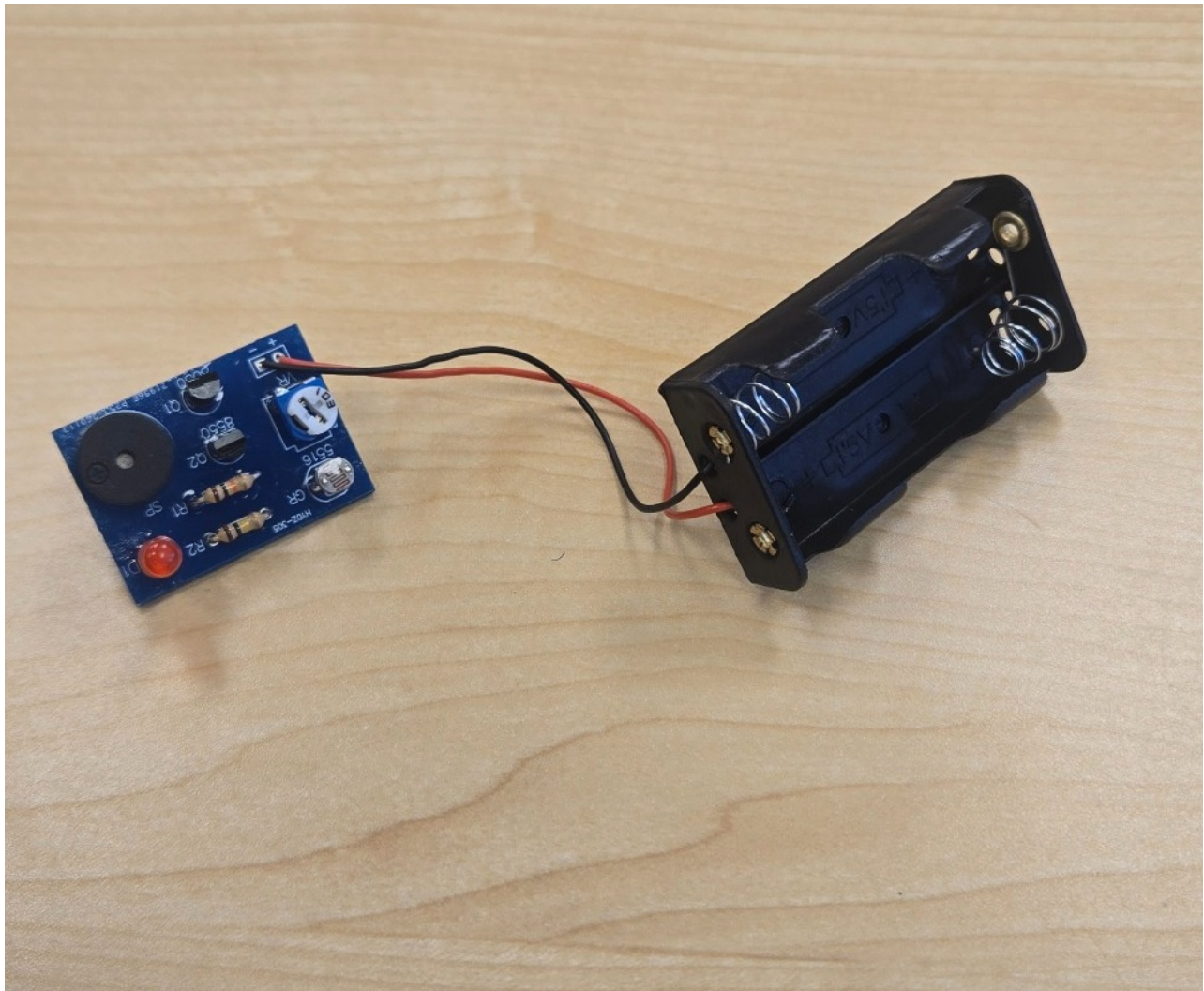


Light-Activated LED and Buzzer Alarm

Technical Project Summary | University of Colorado Colorado Springs



Completed 3 V light-sensing alarm assembly with PCB and battery holder.

PROJECT BACKGROUND

Build and test a light-responsive electronic circuit while developing practical skills in soldering, component identification, schematic interpretation, datasheet use, and troubleshooting.

1. Project Overview

This project is a 3 V light-activated alarm that detects changes in ambient light and produces both a visual output through an LED and an audible output through a buzzer. The adjustable 10 kΩ potentiometer allows the user to select the light level at which the alarm responds.

The activity was designed as an introductory, hands-on electronics build. Students moved from a printed schematic and component set to a soldered, operational PCB, using datasheets and markings to verify polarity, transistor pinout, component values, and supply connections.

2. Objective

The objective was to construct a functional sensor circuit while learning safe and reliable through-hole soldering. Members practiced identifying parts, reading a schematic, interpreting component markings and datasheets, locating positive and negative terminals, checking transistor pin configurations, and testing a completed assembly.

3. Components and Materials

Component	Designation / Value	Purpose
Power supply	3 V battery pack	Provides the positive and negative supply rails.
Photoresistor	GR / 5516 LDR	Changes resistance in response to ambient light.
Variable resistor	VR / 10 kΩ	Adjusts the light-response threshold (sensitivity).
NPN transistor	Q1 / 8050	Acts as the first electronic switch and controls the collector node.
PNP transistor	Q2 / 8550	Acts as a high-side switch for the buzzer.
LED branch	D1 with R2 / 100 Ω	Provides a visual alarm; R2 limits LED current.
Base resistor	R1 / 10 kΩ	Limits current between Q1's collector node and Q2's base.
Buzzer	SP	Produces the audible alarm.

Assembly materials also included the printed circuit board, soldering irons, solder, flush cutters, component datasheets, and a suitable 3 V battery holder.

4. Circuit Schematic

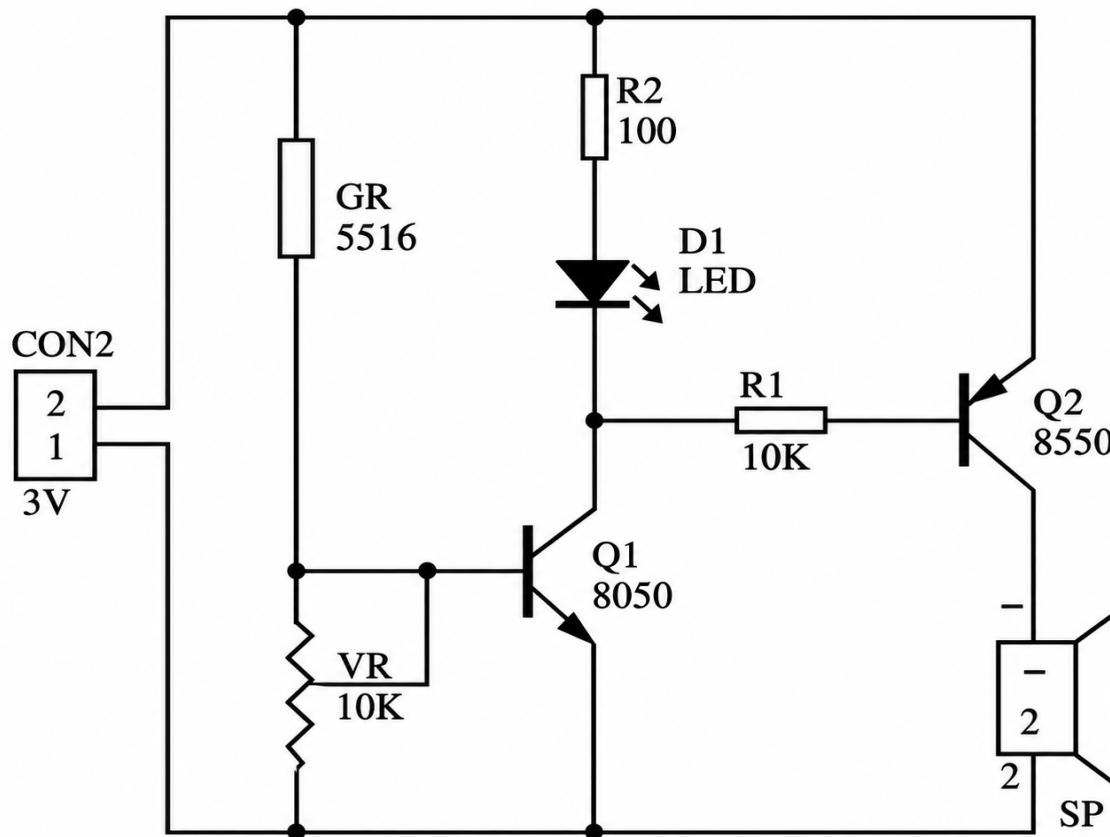


Figure 1. Clean project schematic showing the LDR/potentiometer sensing network, Q1 LED stage, and Q2 buzzer stage.

Signal Path

- The 5516 LDR and 10 kΩ potentiometer establish the voltage applied to the base of Q1.
- Q1 changes the voltage at its collector as the sensed light level crosses the selected threshold.
- The collector node controls the LED branch and, through R1, the base of Q2.
- Q2 supplies current to the buzzer, producing an audible alarm at the same time the LED illuminates.

5. Theory of Operation

Light sensing. A photoresistor is a light-dependent resistor. In darker conditions, its resistance is relatively high. As more light reaches the sensing surface, its resistance decreases. In this circuit, the LDR and variable resistor form an adjustable bias network for the base of Q1.

Sensitivity adjustment. The 10 k Ω variable resistor is wired as an adjustable resistance. Turning it changes the base-bias condition for Q1, thereby changing the amount of light needed to activate the circuit. This lets the alarm be calibrated for different rooms or ambient-light levels.

Q1 switching and visual indication. When the light-dependent base voltage becomes high enough, base current flows into the 8050 NPN transistor. Q1 conducts from collector to emitter and pulls its collector node toward the negative supply rail. Current then flows from the positive rail through R2 and LED D1 into Q1, causing the LED to illuminate.

LED current limiting. R2 is the 100 Ω resistor in series with the LED. It limits current to a safer operating value. A rough design estimate is $I_{LED} = (3\text{ V} - V_F - V_{CE(sat)})/100\text{ }\Omega$. The exact current depends on the LED forward voltage, battery condition, and Q1 saturation voltage.

Q2 switching and audible indication. Q2 is an 8550 PNP transistor connected as a high-side switch. When Q1 pulls the shared collector node low, current is drawn from Q2's base through the 10 k Ω resistor R1. Q2 turns on and supplies current from the positive rail to the buzzer, which completes its path to the negative rail and sounds.

Alarm reset. When the light level falls below the selected threshold, LDR resistance rises, Q1 base drive decreases, and Q1 turns off. Its collector node rises, reducing Q2 base drive. The LED and buzzer then turn off.

6. Assembly Procedure

Students identified each component, matched it to the PCB reference designator, and verified values and orientation before soldering. Special attention was required for the LED polarity, transistor type and pin configuration, buzzer polarity, and red/black battery leads.

- Install and solder the resistors and other low-profile components first.
- Install the LDR, potentiometer, LED, transistors, buzzer, and battery leads in the marked PCB locations.
- Inspect for cold joints, solder bridges, reversed polarized components, or clipped/unsoldered leads.
- Trim excess leads after confirming that every solder joint is complete and correctly placed.
- Perform a final visual inspection before connecting the 3 V battery supply.

7. Testing and Troubleshooting

During initial testing, the circuit operated, but the red LED did not reach the expected brightness. The team used a **Fluke 17B digital multimeter in continuity mode** to check the electrical paths throughout the PCB. The continuity checks indicated that the circuit connections were complete.

Because this was a beginner-level soldering activity, several solder joints were inspected and reflowed to improve their mechanical and electrical quality. **Daniel Bustos and William McGinley** checked the PCB connections and verified the repaired joints. After the solder connections were corrected, the alarm circuit operated successfully; however, the red LED remained noticeably dim.

The team retained the dim LED in the finished assembly as a practical troubleshooting example. Since continuity was verified and the rest of the circuit functioned after the solder repairs, the LED itself was identified as the most likely source of the remaining brightness issue. The component was considered potentially defective or poorly manufactured. Replacing it with a known-good red LED would be the recommended final confirmation.

Troubleshooting Methods

- Connect the 3 V supply, expose the LDR to light, and slowly adjust the potentiometer until the LED and buzzer activate.
- Cover and uncover the LDR to confirm that the circuit switches repeatedly at the selected threshold.
- Use the Fluke 17B continuity function to verify PCB traces and soldered connections before replacing components.
- Inspect and reflow cold, incomplete, or irregular solder joints, then retest the circuit.
- Verify battery voltage and polarity, LED polarity, transistor placement and pinout, and buzzer polarity.
- If the circuit operates but an LED remains dim, measure the LED voltage and branch current, then substitute a known-good LED to confirm whether the original component is defective.

8. Engineering Concepts Learned

- Light-dependent resistance and adjustable bias networks.
- Voltage, current, resistance, polarity, and current limiting.
- NPN and PNP bipolar junction transistors used as electronic switches.
- Cutoff and saturation operating regions.
- Translating schematic symbols and reference designators into a physical PCB assembly.
- Datasheet interpretation, soldering workmanship, testing, and systematic troubleshooting.

9. Possible Improvements

- Add test points and record the Q1 base voltage, Q1 collector voltage, and activation threshold under measured light levels.
- Replace the adjustable-resistance bias with a comparator circuit for a sharper, more repeatable switching threshold.
- Add hysteresis to prevent the LED and buzzer from rapidly switching near the trigger point.
- Interface the sensor with a microcontroller for timing, data logging, selectable alarm patterns, or remote notification.

10. Completed Project and Contributors

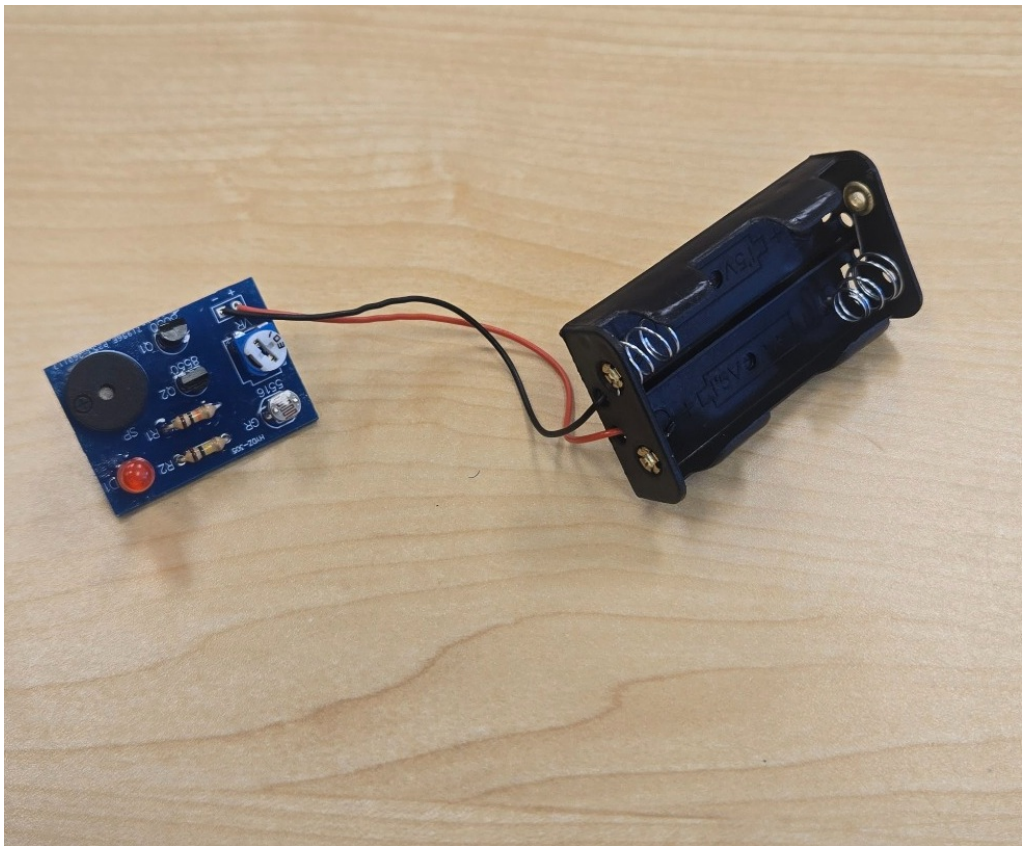


Figure 2. Completed student-assembled PCB connected to its two-cell battery holder.

Role	Contributors
Project Management	Daniel Bustos; William McGinley
Schematic	Lerry Lara; Antonio Magana; Noah Cromwell
Soldering and Assembly	Lerry Lara; Kaeden Wellman; William Hester; Antonio Magana; Riley Snyder; John Johnson
Technical Documentation	Lerry Lara; Kaeden Wellman; William Hester

The finished alarm demonstrates how a small sensor signal can control coordinated visual and audible outputs. The project connects circuit theory with practical construction and provides members with a foundation for future sensor, analog, and embedded-system projects.

Prepared by the Wire Lion Engineering Club for project documentation, student outreach, Mountain Lion Connect, and career-fair presentation.