

## Intruder Sensor — Project Synopsis

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**Project type:** Arduino project in the Robotics & AI Lab, built and tested in the Electroblocks simulator

### Introduction

The Intruder Sensor is an Arduino-based alarm that switches on an LED whenever a person or object comes within 10 cm of an ultrasonic sensor. It shows students how a machine can "notice" someone approaching a door, cupboard or school bag without being watched.

The project uses the HC-SR04 ultrasonic sensor, which works like a bat's echolocation. It sends out a 40 kHz sound pulse that humans cannot hear, listens for the echo, and converts the echo time into distance. The Arduino UNO compares that distance with a set limit and decides whether to raise the alarm.

Students learn the science behind ultrasound and echoes, build the circuit, and program it with block code in Electroblocks. No physical hardware is needed, as the simulator supplies all components on screen.

### Aim and objectives

**Aim:** To use an ultrasonic distance sensor to detect an intrusion and raise an alert when something comes within 10 cm.

#### Objectives:

1. Identify sensors used in security systems and compare how each detects an intruder.
2. Explain ultrasound and how the HC-SR04 uses echoes to measure distance.
3. Apply the formula  $\text{Distance} = (\text{Speed of sound} \times \text{Time}) \div 2$  to calculate distance from echo time.
4. Connect an Arduino UNO, an ultrasonic sensor and an LED alarm circuit.
5. Program the alarm logic using an if-then-else decision in Electroblocks.
6. Test the program with simulated distances and relate block code to Arduino C.

### Components and circuit

| Component                 | Qty | Role                                             |
|---------------------------|-----|--------------------------------------------------|
| Arduino UNO               | 1   | Reads the distance and controls the alarm        |
| HC-SR04 ultrasonic sensor | 1   | Measures distance (about 2–400 cm) on 5 V        |
| LED                       | 1   | Alarm light that glows when an intruder is close |

| Component                   | Qty       | Role                              |
|-----------------------------|-----------|-----------------------------------|
| 220 $\Omega$ resistor       | 1         | Limits current to protect the LED |
| Jumper wires and breadboard | As needed | Solder-free connections           |

#### Connections:

| From          | To                                               | Purpose                                  |
|---------------|--------------------------------------------------|------------------------------------------|
| Sensor VCC    | Arduino 5V                                       | Powers the sensor                        |
| Sensor Trig   | Arduino pin 7                                    | Arduino signals the sensor to send sound |
| Sensor Echo   | Arduino pin 8                                    | Sensor returns the echo time             |
| Sensor GND    | Arduino GND                                      | Completes the sensor circuit             |
| Arduino pin 2 | 220 $\Omega$ resistor $\rightarrow$ LED long leg | Switches the alarm light                 |
| LED short leg | Arduino GND                                      | Return path for current                  |

### Working principle and methodology

The sensor's transmitter (T) sends a short burst of ultrasound; the sound bounces off an object and the receiver (R) picks up the echo. The longer the echo takes, the farther away the object is. Since the sound travels to the object and back, the time is halved:

$$\text{Distance (cm)} = \frac{0.0343 \times \text{Echo time } (\mu\text{s})}{2}$$

For example, an echo time of 583  $\mu\text{s}$  gives  $(0.0343 \times 583) \div 2 \approx 10$  cm, which is exactly the alarm threshold.

#### Program logic (runs forever in a loop):

1. Read the distance in cm from the ultrasonic sensor.
2. If the distance is 10 cm or less, turn the alarm LED ON and wait 2 seconds.
3. Otherwise, turn the alarm LED OFF and wait 2 seconds.
4. Repeat.

In Electroblocks this uses the Setup Ultrasonic Sensor block, an if-then-else block, a "distance in cm  $\leq$  10" comparison, LED number 2 on/off blocks and 2-second wait blocks. The same logic is also shown in Arduino C using `pulseIn` on the Echo pin and the distance formula above.

**Testing:** The simulator was run for 4 loops with test distances of 9, 10, 11 and 12 cm.

| Loop run      | 1 | 2  | 3  | 4  |
|---------------|---|----|----|----|
| Distance (cm) | 9 | 10 | 11 | 12 |

|           |    |    |     |     |
|-----------|----|----|-----|-----|
| Loop run  | 1  | 2  | 3   | 4   |
| Alarm LED | ON | ON | OFF | OFF |

The alarm is ON at exactly 10 cm because the condition uses "less than or equal to" ( $\leq$ ) rather than "less than" ( $<$ ).

## Applications and extension

### Real-world applications:

- **Security alarms:** detecting someone near a door, locker or museum display
- **Parking sensors:** beeping faster as a car nears a wall
- **Robots:** spotting obstacles and turning before a crash
- **Smart homes:** auto-opening dustbin lids or lights that switch on as you approach
- **Water tanks:** measuring the water level from above
- **Assistive technology:** smart canes that warn visually impaired users of obstacles

**Extension assignment:** Students upgrade the project into a two-level alarm with a buzzer. At 10 cm or closer, both the LED and buzzer switch on; between 11 and 30 cm, only the LED glows as a warning; beyond 30 cm, everything is off. This uses a nested if-then-else. As a stretch task, the buzzer beeps faster as the intruder gets closer, like a car parking sensor.

**Learning outcomes:** Students understand ultrasound and echolocation, apply a physics formula in code, use conditional logic with comparison operators, and see the sense–decide–act pattern behind smart devices.

## Conclusion

The ultrasonic sensor measures distance using sound echoes, and the Arduino raises an alert whenever something comes within 10 cm. Simulation results matched the expected output: the alarm glowed at 9 and 10 cm and stayed off at 11 and 12 cm. The project gives students a hands-on, hardware-free route into sensors, measurement and decision-making in code, and prepares them for larger builds such as obstacle-avoiding robots and smart assistive devices.