



# Ultrasonic Sensor

## An Acoustic Medical Application

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Section 2

## Application Idea:

Monitoring fluid levels, especially water is a detrimental task in medical institutes such as hospitals and clinics. Fluids that are attached to patients and medical machines must always be monitored to ensure continuous supply and avoid unwanted complications. The water level indicator using ultrasonic sensor is an application of the acoustic device to help determine the levels of water in a certain container, and signals output that declares the current water level in cm. The ultrasonic sensor, connected to the Arduino, is attached above the water filled. It has two transducers, one that transmits a wave and one that receives it back as it's reflected from the water surface. The time the wave took to go out and back is calculated by the sensor, and since the velocity is constant, we can do a simple calculation to get the distance between the sensor and the water level. Furthermore, output is connected to three light bulbs, each with its own signal queue for low, medium, and high water supply, depending on the distance between the sensor and the water level. When the water supply becomes low, the buzzer starts ringing to alert staff to refill the tank.

## Parameters Related To The Acoustic Signal:

The table below shows the parameters related to the ultrasonic signal that the sensor transmits and their corresponding values for the sensor version we are using, which is HC-SRO4.

| | |
|---|---|
| Operating Frequency | 40,000 Hz |
| Minimum Range | 2 cm |
| Maximum Range | 400 cm |
| Range Accuracy | Up to 3mm |

## Tissue Properties:

The ultrasonic sensor is used to measure the level of water, thus it deals with two mediums, which are air and water. For air, the density is 1.2 $kg/m^3$, and the speed of sound in air as 20°C is 343 m/s. Air has an acoustic impedance of 420 $kg/m^2s$. For fresh water, the density is 1000$kg/m^3$, speed of sound in it is 1480 m/s and its acoustic impedance is $1.48x10^6$ $kg/m^2s$.

## Type of Acoustic-Tissue Interaction:

The ultrasound wave reflection on the water-air boundary layer is the main interaction of this application. The water surface acts as a mirror to the transducer as the ultrasound waves reflect symmetrically, at an angle of 15° with the vertical of the plane normal to the boundary layer. This angle causes all the reflected signal to return to the receiving transducer, and not interfere with the transmitting transducer. However, this is assuming the water-air boundary level is undisturbed. In our case, water used in medical institutes is usually contained in closed and covered containers to ensure cleanliness.

**Implementation:**

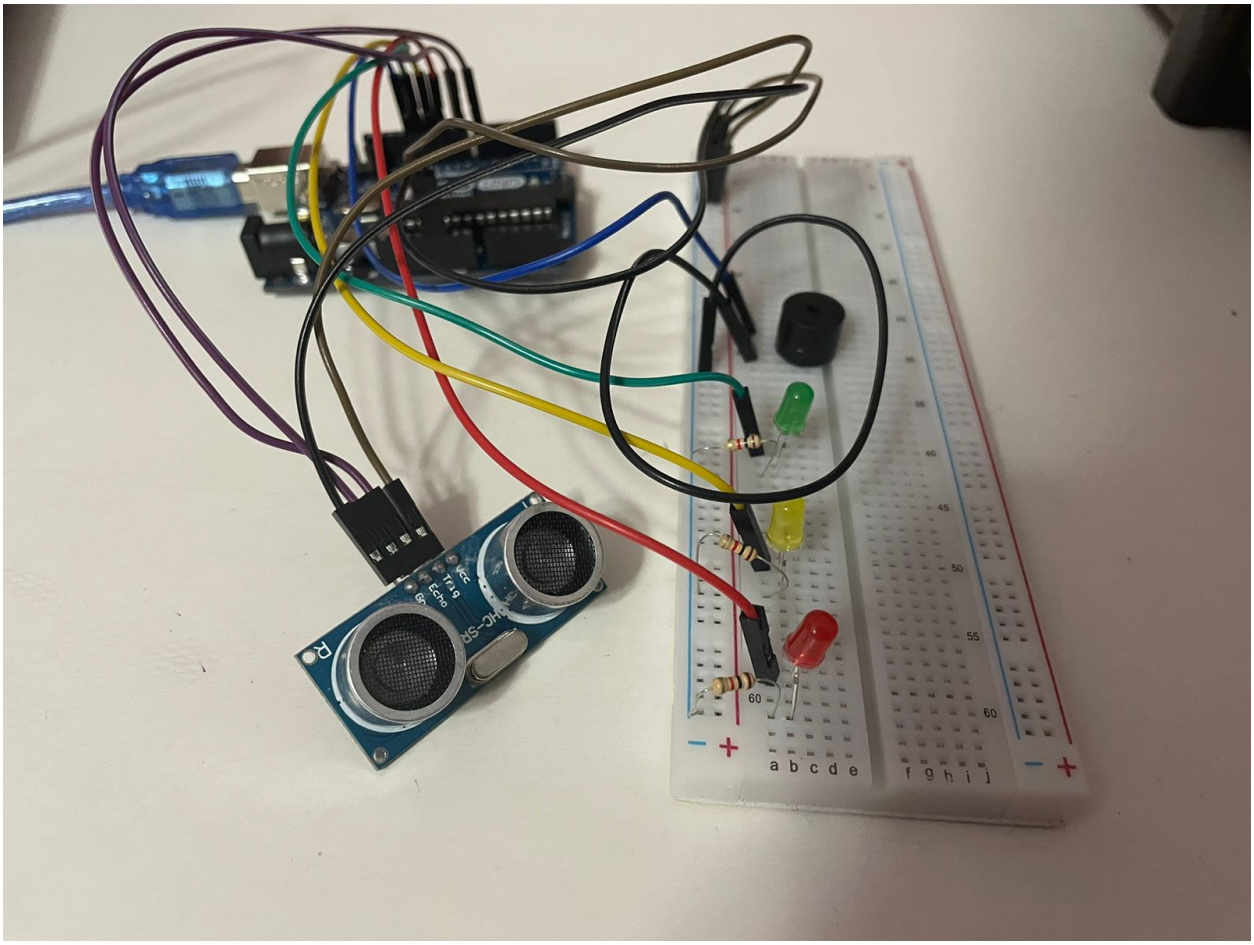


*Figure 1.1: Implementation*

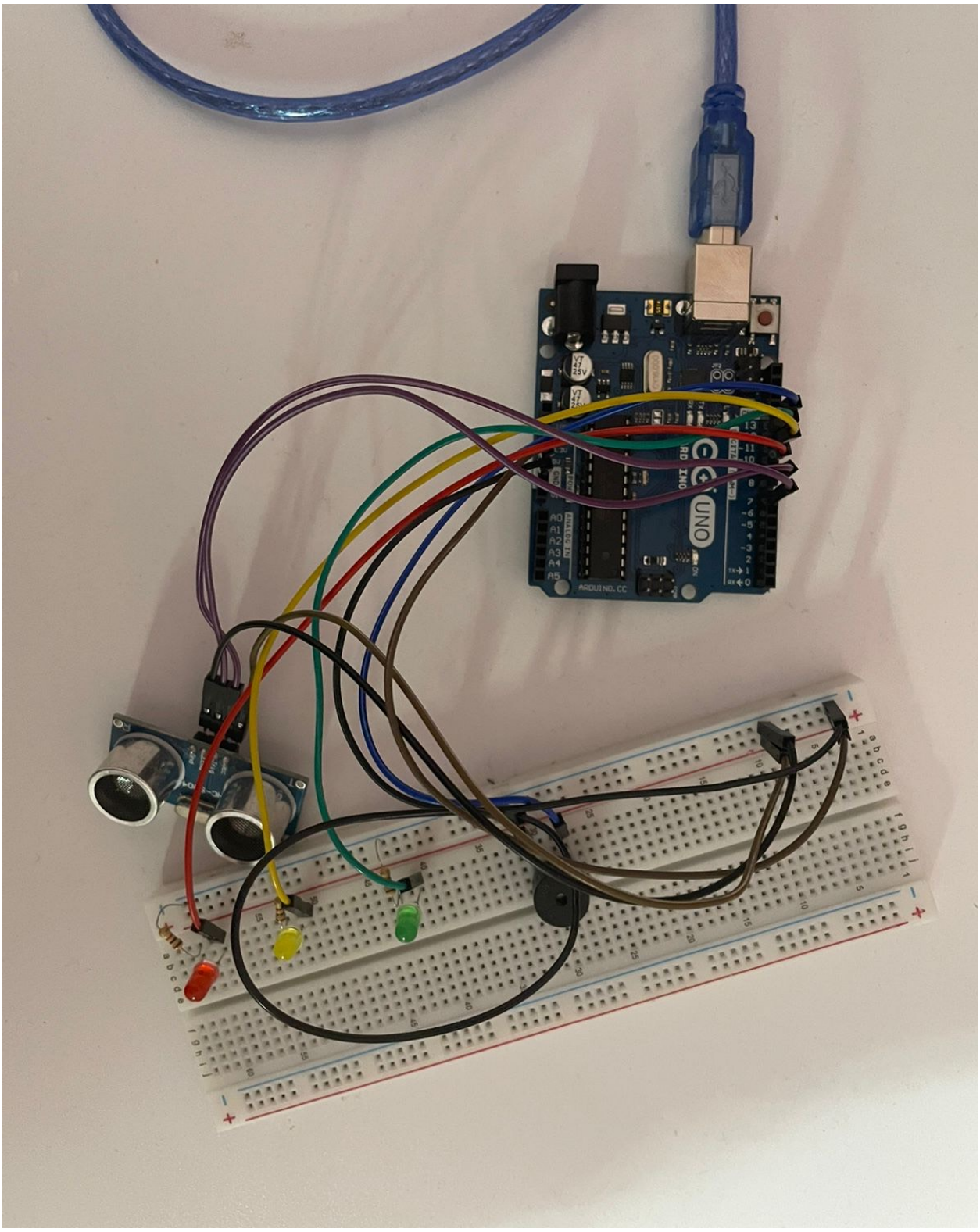


*Figure 1.2: Implementation*

**Schematic Diagram:**

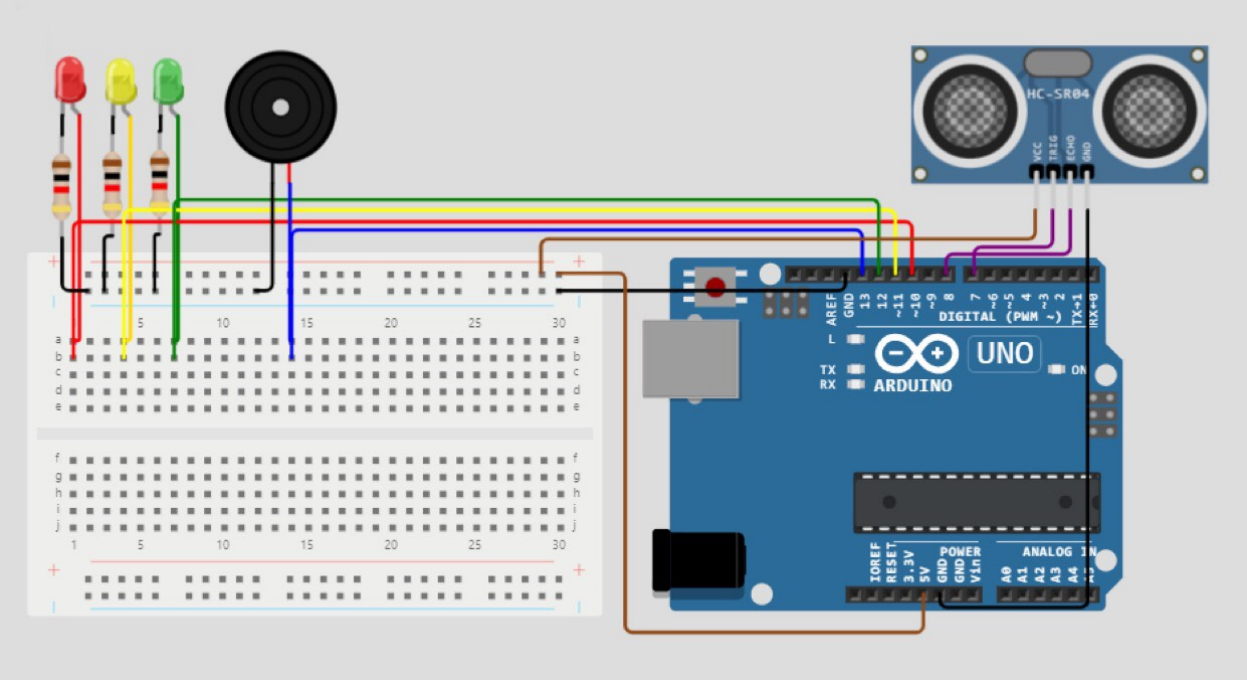


*Figure 2: Connections Diagram*

## Arduino code:

```
#define echoPin 8 //connect echo pin of ultrasonic sensor to D8 of Arduino
#define trigPin 7 //connect trigger pin of ultrasonic sensor to D7 of Arduino
int redLed=10;
int yellowLed=11;
int greenLed=12;
int buzzer=13;
long duration; // declare variables to hold duration and distance
long distance;
void setup() //setup() is used for initialization
{
Serial.begin(9600); //set the baud rate of serial communication to 9600
pinMode(trigPin,OUTPUT); //set trigPin as output pin of Arduino
pinMode(echoPin,INPUT); //set echoPin as output pin of Arduino
pinMode(redLed,OUTPUT);
pinMode(yellowLed,OUTPUT);
pinMode(greenLed,OUTPUT);
pinMode(buzzer,OUTPUT);
}
void loop(){
digitalWrite(trigPin,LOW); //generate square wave at trigger pin
delayMicroseconds(2);
digitalWrite(trigPin,HIGH);
delayMicroseconds(10);
digitalWrite(trigPin,LOW);
duration=pulseIn(echoPin,HIGH);
distance=340*duration/20000;
// pulseIn is used to Reads a pulse (either HIGH or LOW) on a pin.
//For example, if value is HIGH, pulseIn() waits for the pin to
//go HIGH, starts timing, then waits for the pin to go LOW and stops timing.
//Returns the length of the pulse in microseconds
Serial.println(distance);
delay(500);
if (distance>=0 && distance<3 ){
digitalWrite(greenLed,HIGH);
digitalWrite(yellowLed,LOW);
digitalWrite(redLed,LOW);
digitalWrite(buzzer,LOW);
Serial.println("The tank is full.");
delay(500);
}
```

```
else if(distance>=3 && distance<6)
{
digitalWrite(yellowLed,HIGH);
digitalWrite(greenLed,LOW);
digitalWrite(redLed,LOW);
digitalWrite(buzzer,LOW);
Serial.println("The tank is half-full.");
delay(500);

}
else if(distance>=6 && distance<=9) {
digitalWrite(redLed,HIGH);
digitalWrite(yellowLed,LOW);
digitalWrite(greenLed,LOW);
tone(buzzer,100);
delay(500);
noTone(buzzer);
delay(20);
Serial.println("The tank is empty.");
delay(500);
} else if (distance>10) {
digitalWrite(redLed,LOW);
digitalWrite(yellowLed,LOW);
digitalWrite(greenLed,LOW);
noTone(buzzer);
Serial.println("The sensor is not attached to a tank.");
delay (500);
}
delay(500);
}
```

## *Work Cited*


- Vinayak. “Water Level Indicator Using a HC-SR04 and an Arduino | talkingStuff Network.” *talkingStuff Network*, 8 Oct. 2020, www.talkingstuff.net/water-level-indicator-ultrasonic.
- Dejan. “Ultrasonic Sensor HC-SR04 and Arduino – Complete Guide.” *How to Mechatronics*, 18 Feb. 2022, howtomechatronics.com/tutorials/arduino/ultrasonic-sensor-hc-sr04.
- *“Acoustic Impedance and Intensity: From Physclips Waves and Sound*.” www.animations.physics.unsw.edu.au/jw/sound-impedance-intensity.htm.
- Schmitt, P., et al. “Ultrasonic Wave Interaction With Air-water Boundary Layer.” *ResearchGate*, 19 Sept. 2012, www.researchgate.net/publication/329567141_Ultrasonic_wave_interaction_with_air-water_boundary_layer.