

Al-Mustaqbal University
College Of Engineering & Technology
Department of Computer Engineering Techniques
(Stage: 3)

Digital Control

Lecture 5

Arduino programming

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HC-SR04 UltraSonic Hardware Overview

The UltraSonic is an affordable and easy to use distance measuring sensor which has a range from 2cm to 400cm (about an inch to 13 feet).

The sensor is composed of two ultrasonic transducers. One is transmitter which outputs ultrasonic sound pulses and the other is receiver which listens for reflected waves.

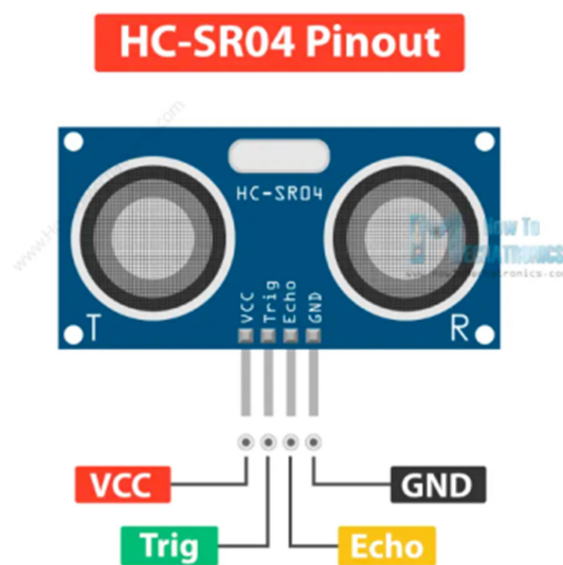
main specifications:

Operating Voltage	5V DC
Operating Current	15mA

Operating Frequency	40KHz
Min Range	2cm / 1 inch
Max Range	400cm / 13 feet
Accuracy	3mm
Measuring Angle	<15°
Dimension	45 x 20 x 15mm

HC-SR04 Ultrasonic Sensor Pinout

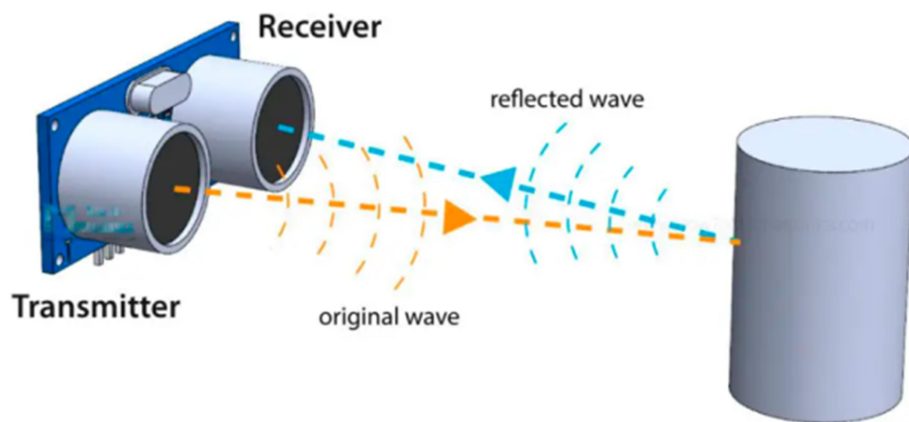
Here's the pinout of the sensor:



The sensor has 4 pins. **VCC** and **GND** go to **5V** and **GND** pins on the Arduino, and the **Trig** and **Echo** go to any digital Arduino pin. Using the **Trig** pin we send the ultrasound wave from the transmitter, and with the **Echo** pin we listen for the reflected signal.

How the HC-SR04 Ultrasonic Distance Sensor Works?

It emits an ultrasound at 40 000 Hz which travels through the air and if there is an object or obstacle on its path It will bounce back to the module. Considering the travel time and the speed of the sound you can calculate the distance.

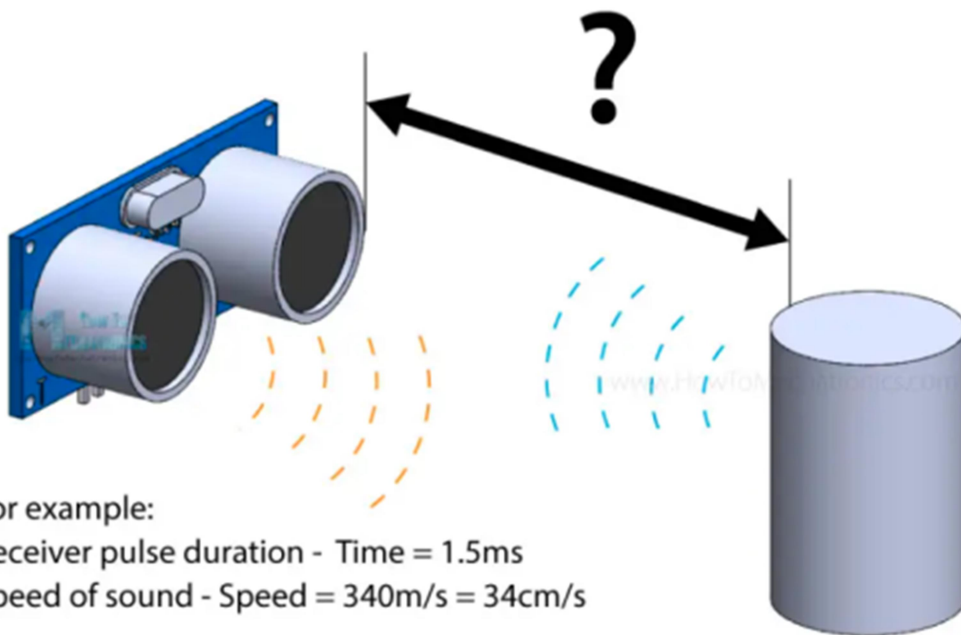


In order to generate the ultrasound we need to set the Trig pin on a High State for 10 μ s. That will send out an 8 cycle ultrasonic burst which will travel at the speed of sound. The Echo pins goes high right away after that 8 cycle ultrasonic burst is sent, and it starts listening or waiting for that wave to be reflected from an object.

For that purpose we are using the following basic formula for calculating distance:

$$\text{Distance} = \text{Speed} \times \text{Time}$$

We actually know both the speed and the time values. The time is the amount of time the Echo pin was HIGH, and the speed is the speed of sound which is 340m/s. There's one additional step we need to do, and that's divide the end result by 2. and that's because we are measuring the duration the sound wave needs to travel to the object and bounce back.



For example:

Receiver pulse duration - Time = 1.5ms

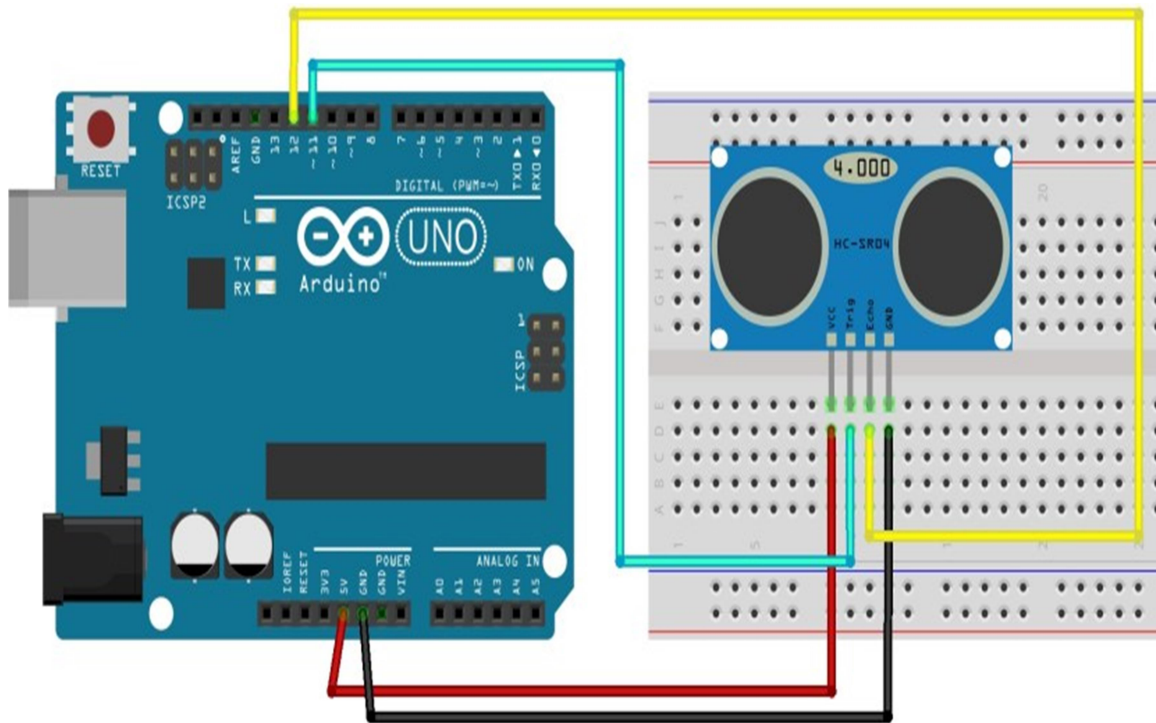
Speed of sound - Speed = 340m/s = 34cm/s

$$\text{Distance} = (\text{Speed} \times \text{Time}) / 2$$

$$\text{Distance} = (34\text{cm/ms} \times 1.5\text{ms}) / 2 = 25.5\text{cm}$$

How to Connect HC-SR04 Ultrasonic Sensor to Arduino

Here's how we need to connect the HC-SR04 sensor to an Arduino board.



The Ground and the VCC pins of the module needs to be connected to the Ground and the 5 volts pins on the Arduino Board respectively and the trig and echo pins to any Digital I/O pin on the Arduino Board.

HC-SR04 Ultrasonic Sensor Arduino Code

Here's a code for measuring distance using the HC-SR04 ultrasonic sensor and Arduino.

```

/*
  Ultrasonic Sensor HC-SR04 and Arduino Tutorial
*/
// defines pins numbers
const int trigPin = 11;
const int echoPin = 12;
// defines variables
long duration;
int distance;
void setup() {
  pinMode(trigPin, OUTPUT); // Sets the trigPin as an Output
  pinMode(echoPin, INPUT); // Sets the echoPin as an Input
  Serial.begin(9600); // Starts the serial communication
}
void loop() {
  // Clears the trigPin
  digitalWrite(trigPin, LOW);
  delayMicroseconds(2);
  // Sets the trigPin on HIGH state for 10 micro seconds
  digitalWrite(trigPin, HIGH);
  delayMicroseconds(10);
  digitalWrite(trigPin, LOW);
  // Reads the echoPin, returns the sound wave travel time in
microseconds
  duration = pulseIn(echoPin, HIGH);
  // Calculating the distance
  distance = duration * 0.034 / 2;
  // Prints the distance on the Serial Monitor
  Serial.print("Distance: ");
  Serial.println(distance);
}

```

Code Explanation

First we have to define the Trig and Echo pins. In this case they are the pins number 9 and 10 on the Arduino Board and they are named trigPin and echoPin. Then we need a Long variable, named "duration" for the travel time that we will get from the sensor and an integer variable for the distance.

```
// defines pins numbers
const int trigPin = 11;
const int echoPin = 12;

// defines variables
long duration;
int distance;Code language: Arduino (arduino)
```

In the setup we have to define the trigPin as an output and the echoPin as an Input and also start the serial communication for showing the results on the serial monitor.

```
void setup() {
  pinMode(trigPin, OUTPUT); // Sets the trigPin as an Output
  pinMode(echoPin, INPUT); // Sets the echoPin as an Input
  Serial.begin(9600); // Starts the serial communication
}Code language: Arduino (arduino)
```

In the loop first we have to make sure that the trigPin is clear so you have to set that pin on a LOW State for just 2 μ s. Now for generating the Ultra sound wave we have to set the trigPin on HIGH State for 10 μ s.

```
// Clears the trigPin
digitalWrite(trigPin, LOW);
delayMicroseconds(2);

// Sets the trigPin on HIGH state for 10 micro seconds
digitalWrite(trigPin, HIGH);
delayMicroseconds(10);
digitalWrite(trigPin, LOW);Code language: Arduino (arduino)
```

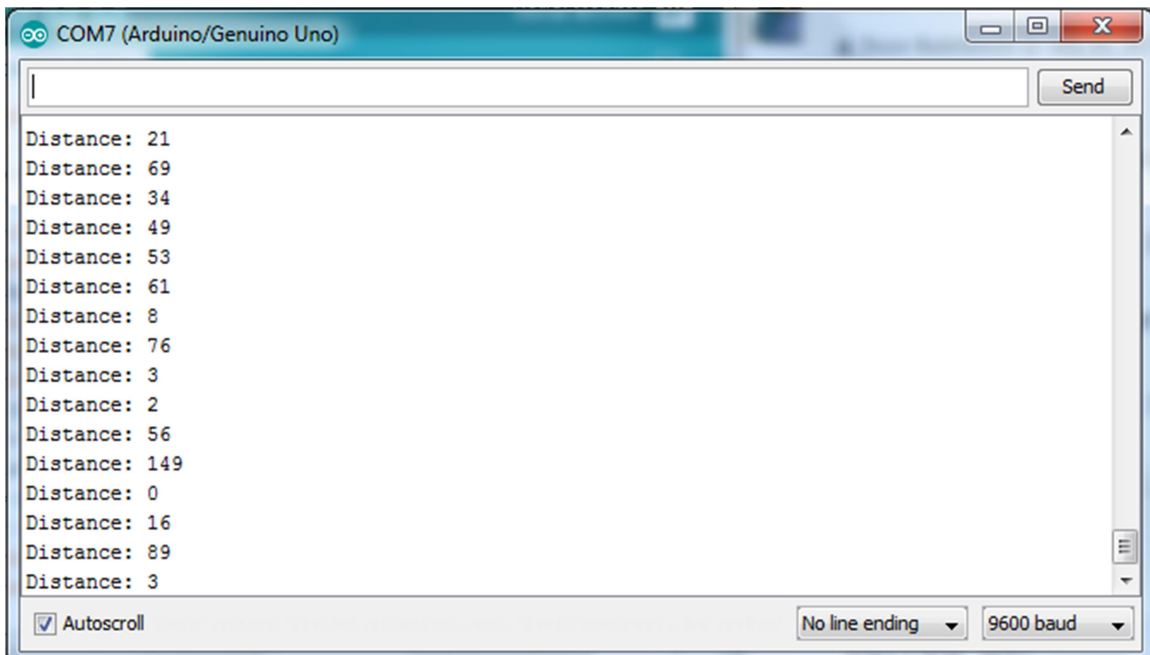
Using the [pulseIn\(\) function](#) we read the travel time and put that value into the variable "duration". This function has 2 parameters, the first one is the name of the Echo pin and for the second is the state of the pulse we are reading, either High or Low.

```
// Reads the echoPin, returns the sound wave travel time in microseconds  
duration = pulseIn(echoPin, HIGH);
```

In this case, we need this set to it HIGH, as the HC-SR04 sensors sets the Echo pin to High after sending the 8 cycle ultrasonic burst from the transmitter. This actually starts the timing and once we receive the reflected sound wave the Echo pin will go to Low which stops the timing. At the end the function will return the length of the pulse in microseconds.

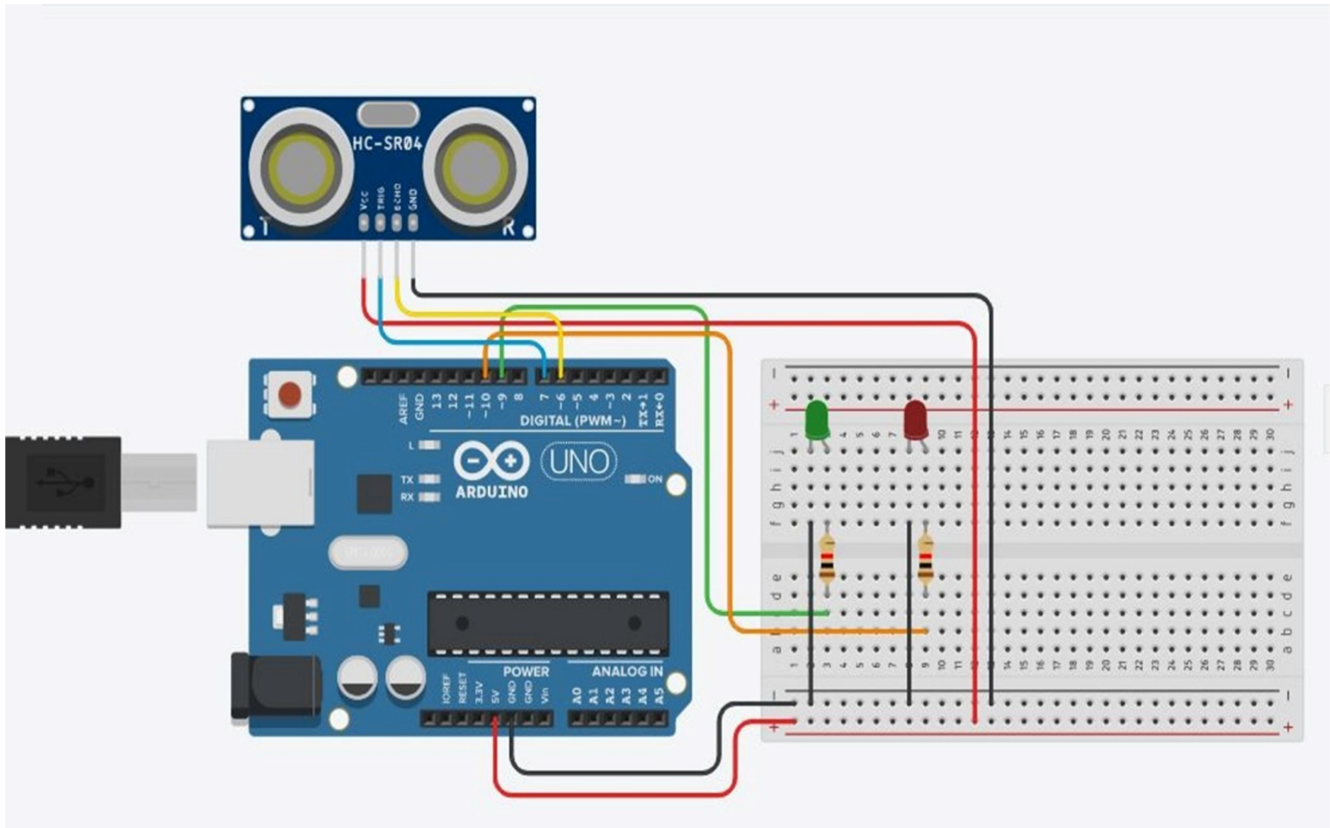
For getting the distance we will multiply the duration by 0.034 and divide it by 2 as we explained this equation previously.

```
// Calculating the distance  
distance= duration*0.034/2;  
// Prints the distance on the Serial Monitor  
Serial.print("Distance: ");  
Serial.println(distance);
```



Controlling LED's Using Ultrasonic Distance Sensor

Turns the 2 LED's on and off by calculating the distance of the object from the Ultrasonic Sensor.



```
#define Trigpin 7
#define Echopin 6
#define low_led 9
#define high_led 10
float distance;
int duration;

void setup() {
  pinMode (Trigpin, OUTPUT);
```

```

pinMode (low_led, OUTPUT);
pinMode (high_led, OUTPUT);
pinMode (Echopin, INPUT);
Serial.begin(9600);

digitalWrite (low_led, LOW);
digitalWrite (high_led, LOW);
}

void loop()
{
digitalWrite(Trigpin, LOW);
delayMicroseconds(2);
digitalWrite(Trigpin, HIGH);
delayMicroseconds(10);
digitalWrite(Trigpin, LOW);
duration = pulseIn(Echopin, HIGH);
distance = duration * 0.034 / 2;
delay (700);
Serial.println (" ");
Serial.print ("Distance = ");
Serial.print (distance);
Serial.print (" CM");
Serial.println (" ");

if (distance>=30)
{

digitalWrite (low_led, HIGH);
delay (500);
digitalWrite (low_led, LOW);
delay (500);
digitalWrite (low_led, HIGH);
}
}

```

```
else
{
    digitalWrite (high_led, HIGH);
    delay (100);
    digitalWrite (high_led, LOW);
    delay (100);
    digitalWrite (high_led, HIGH);
    delay (100);
}
}
```