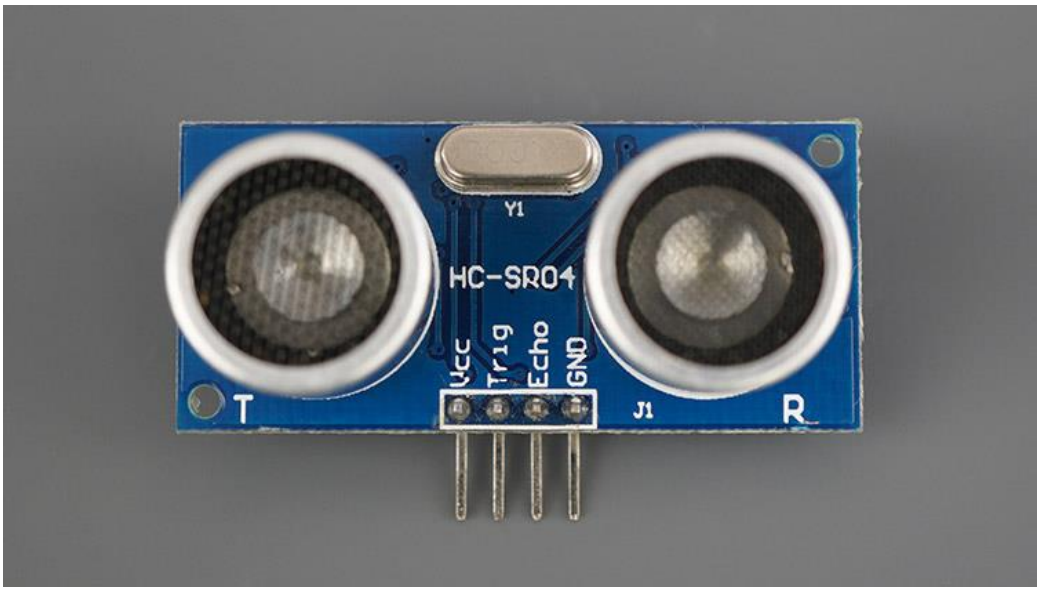
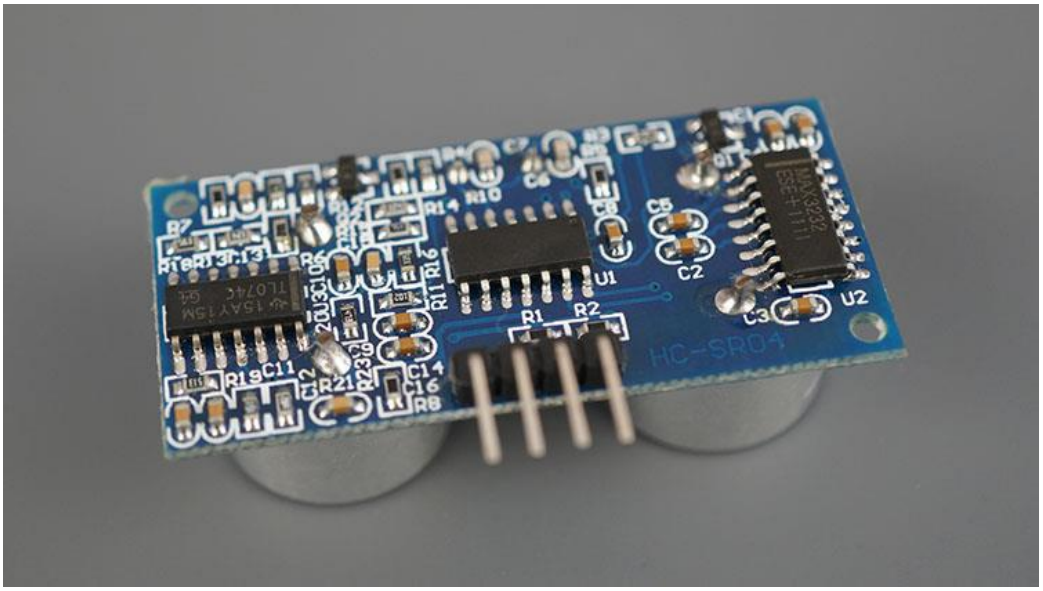
Complete Guide for Ultrasonic Sensor HC-SR04 with Arduino

Description

The HC-SR04 ultrasonic sensor uses sonar to determine the distance to an object. This sensor reads from 2cm to 400cm (0.8inch to 157inch) with an accuracy of 0.3cm (0.1inches), which is good for most hobbyist projects. In addition, this particular module comes with ultrasonic transmitter and receiver modules.

The following picture shows the HC-SR04 ultrasonic sensor.





Features

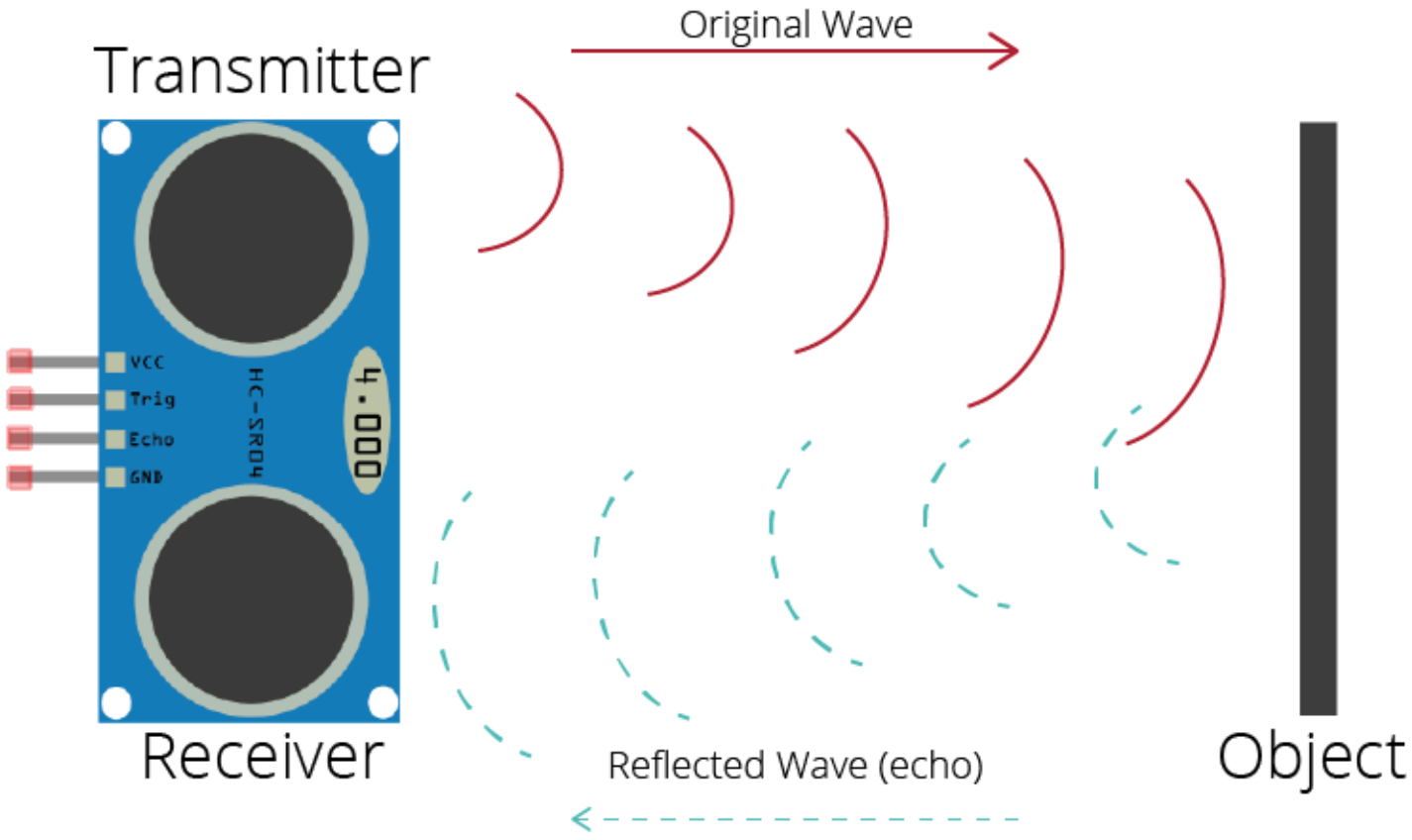
Here's a list of some of the HC-SR04 ultrasonic sensor features and specs—for more information, you should consult the sensor's datasheet:

- Power Supply :+5V DC
- Quiescent Current : <2mA
- Working Current: 15mA
- Effectual Angle: <15°
- Ranging Distance : 2cm – 400 cm/1" – 13ft
- Resolution : 0.3 cm
- Measuring Angle: 30 degree
- Trigger Input Pulse width: 10uS TTL pulse
- Echo Output Signal: TTL pulse proportional to the distance range
- Dimension: 45mm x 20mm x 15mm

How Does it Work?

The ultrasonic sensor uses sonar to determine the distance to an object. Here's what happens:

1. The ultrasound transmitter (trig pin) emits a high-frequency sound (40 kHz).
2. The sound travels through the air. If it finds an object, it bounces back to the module.
3. The ultrasound receiver (echo pin) receives the reflected sound (echo).



The time between the transmission and reception of the signal allows us to calculate the distance to an object. This is possible because we know the sound's velocity in the air. Here's the formula:

distance to an object = ((speed of sound in the air)*time)/2

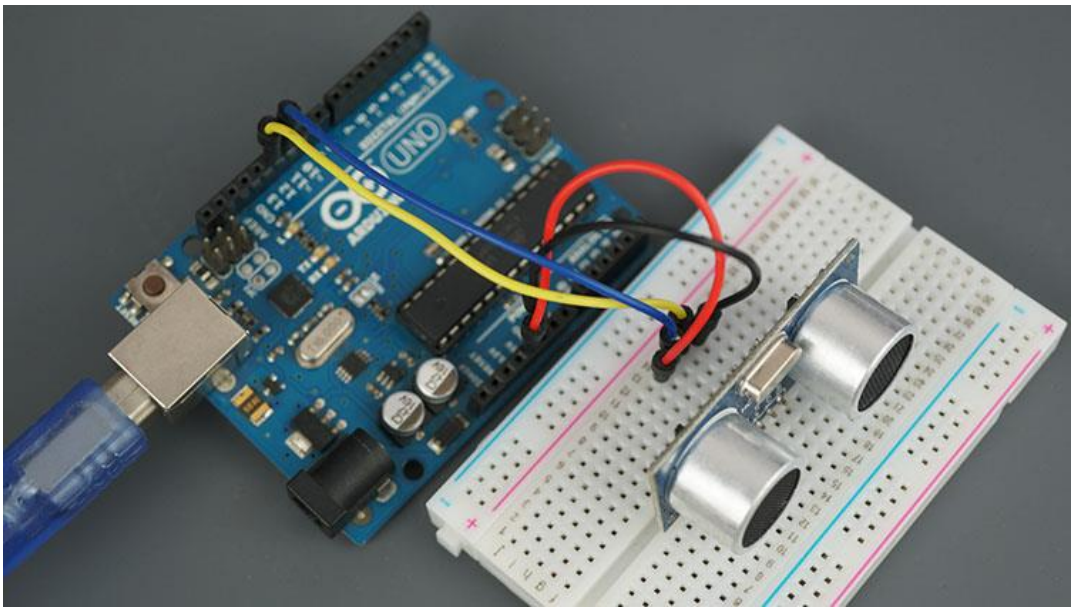
- speed of sound in the air at 20ºC (68ºF) = **343m/s**

HC-SR04 Ultrasonic Sensor Pinout

Here's the pinout of the HC-SR04 Ultrasonic Sensor.

VCC	Powers the sensor (5V)
Trig	Trigger Input Pin
Echo	Echo Output Pin
GND	Common GND

Arduino with HC-SR04 Sensor

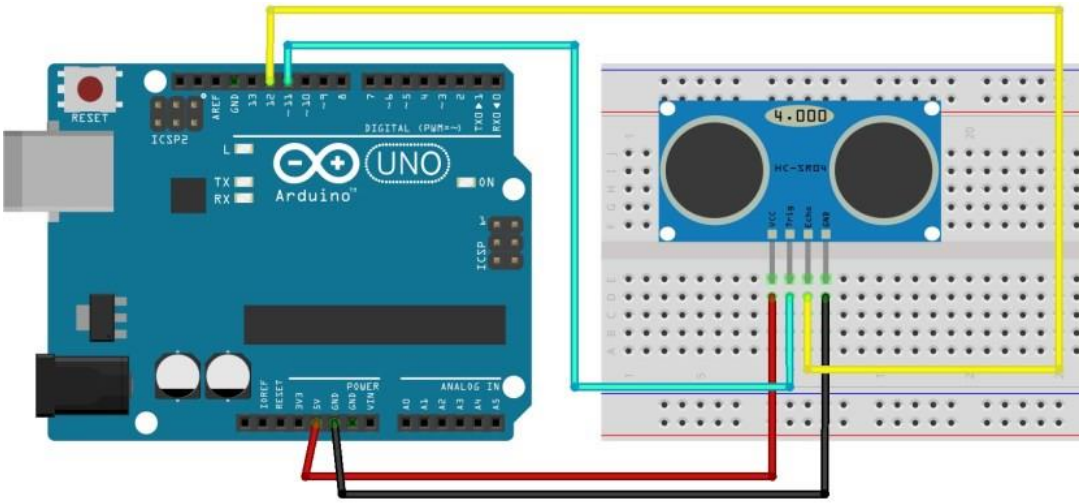


This sensor is very popular among Arduino tinkerers. So, here we provide an example of how to use the HC-SR04 ultrasonic sensor with the Arduino. In this project, the ultrasonic sensor reads and writes the distance to an object in the serial monitor.

The goal of this project is to help you understand how this sensor works. Then, you should be able to use this example in your own projects.

Arduino with HC-SR04 Sensor Wiring

Follow the next schematic diagram to wire the HC-SR04 ultrasonic sensor to the Arduino.



The following table shows the connections you need to make:

Ultrasonic Sensor HC-SR04	**Arduino**
VCC	5V
Trig	Pin 11
Echo	Pin 12
GND	GND

Code

Upload the following code to your Arduino IDE.

```
/*
 * created by Rui Santos, https://randomnerdtutorials.com
 *
 * Complete Guide for Ultrasonic Sensor HC-SR04
 *
    Ultrasonic sensor Pins:
        VCC: +5VDC
        Trig : Trigger (INPUT) - Pin11
        Echo: Echo (OUTPUT) - Pin 12
        GND: GND
 */

int trigPin = 11;    // Trigger
int echoPin = 12;    // Echo
long duration, cm, inches;

void setup() {
  //Serial Port begin
  Serial.begin (9600);
  //Define inputs and outputs
  pinMode(trigPin, OUTPUT);
  pinMode(echoPin, INPUT);
}

void loop() {
  // The sensor is triggered by a HIGH pulse of 10 or more microseconds.
```

```
  // Give a short LOW pulse beforehand to ensure a clean HIGH pulse:
  digitalWrite(trigPin, LOW);
  delayMicroseconds(5);
  digitalWrite(trigPin, HIGH);
  delayMicroseconds(10);
  digitalWrite(trigPin, LOW);

  // Read the signal from the sensor: a HIGH pulse whose
  // duration is the time (in microseconds) from the sending
  // of the ping to the reception of its echo off of an object.
  pinMode(echoPin, INPUT);
  duration = pulseIn(echoPin, HIGH);

  // Convert the time into a distance
  cm = (duration/2) / 29.1;     // Divide by 29.1 or multiply by 0.0343
  inches = (duration/2) / 74;   // Divide by 74 or multiply by 0.0135

  Serial.print(inches);
  Serial.print("in, ");
  Serial.print(cm);
  Serial.print("cm");
  Serial.println();

  delay(250);
}
```

View raw code

How the Code Works

First, you create variables for the trigger and echo pin called `trigPin` and `echoPin`, respectively. The trigger pin is connected to digital Pin 11, and the echo pin is connected to Pin 12:

```
int trigPin = 11;
int echoPin = 12;
```

You also create three variables of type long: `duration` and `inches`. The `duration` variable saves the time between the emission and reception of the signal. The `cm` variable will save the distance in centimeters, and the `inches` variable will save the distance in inches.

```
long duration, cm, inches;
```

In the `setup()`, initialize the serial port at a baud rate of 9600, and set the trigger pin as an `OUTPUT` and the echo pin as an `INPUT`.

```
//Serial Port begin
Serial.begin (9600);
//Define inputs and outputs
```

```
pinMode(trigPin, OUTPUT);
pinMode(echoPin, INPUT);
```

In the loop(), trigger the sensor by sending a HIGH pulse of 10 microseconds. But, before that, give a short LOW pulse to ensure you'll get a clean HIGH pulse:

```
digitalWrite(trigPin, LOW);
delayMicroseconds(5);
digitalWrite(trigPin, HIGH);
delayMicroseconds(10);
digitalWrite(trigPin, LOW);
```

We use the pulseIn() function to get the sound wave travel time:

```
duration = pulseIn(echoPin, HIGH);
```

The pulseIn() function reads a HIGH or a LOW pulse on a pin. It accepts as arguments the pin and the state of the pulse (either HIGH or LOW). It returns the length of the pulse in microseconds. The pulse length corresponds to the time it took to travel to the object plus the time traveled on the way back.

Then, we calculate the distance to an object, taking into account the sound speed.

distance = (traveltime/2) x speed of sound

The speed of sound is: 343m/s = 0.0343 cm/uS = 1/29.1 cm/uS

Or in inches: 13503.9in/s = 0.0135in/uS = 1/74in/uS

We need to divide the travel time by 2 because we have to consider that the wave was sent, hit the object, and then returned to the sensor.

```
cm = (duration/2) / 29.1;
inches = (duration/2) / 74;
```

Finally, we print the results in the Serial Monitor:

```
Serial.print(inches);
Serial.print("in, ");
Serial.print(cm);
Serial.print("cm");
Serial.println();
```

Source code with NewPing Library

You can also use the NewPing library. Download the library here.
After installing the NewPing library, you can upload the code provided below.

```
/*
 * Posted on https://randomnerdtutorials.com
```

```
 * created by http://playground.arduino.cc/Code/NewPing
*/

#include <NewPing.h>

#define TRIGGER_PIN 11
#define ECHO_PIN 12
#define MAX_DISTANCE 200

// NewPing setup of pins and maximum distance
NewPing sonar(TRIGGER_PIN, ECHO_PIN, MAX_DISTANCE);

void setup() {
  Serial.begin(9600);
}

void loop() {
  delay(50);
  unsigned int distance = sonar.ping_cm();
  Serial.print(distance);
  Serial.println("cm");
}
```

View raw code

How the Code Works

Getting the distance to an object using the NewPing library is much simpler.

You start by including the NewPing library:

```
#include <NewPing.h>
```

Then, define the trigger and echo pin. The trigger pin is connected to the Arduino digital Pin 11 and the echo to Pin 12. You also need to define the MAX_DISTANCE variable to be able to use the library.

```
#define TRIGGER_PIN 11
#define ECHO_PIN 12
#define MAX_DISTANCE 200
```

Then, you create a NewPing instance called sonar:

```
NewPing sonar(TRIGGER_PIN, ECHO_PIN, MAX_DISTANCE);
```

In the setup(), you initialize the Serial communication at a baud rate of 9600.

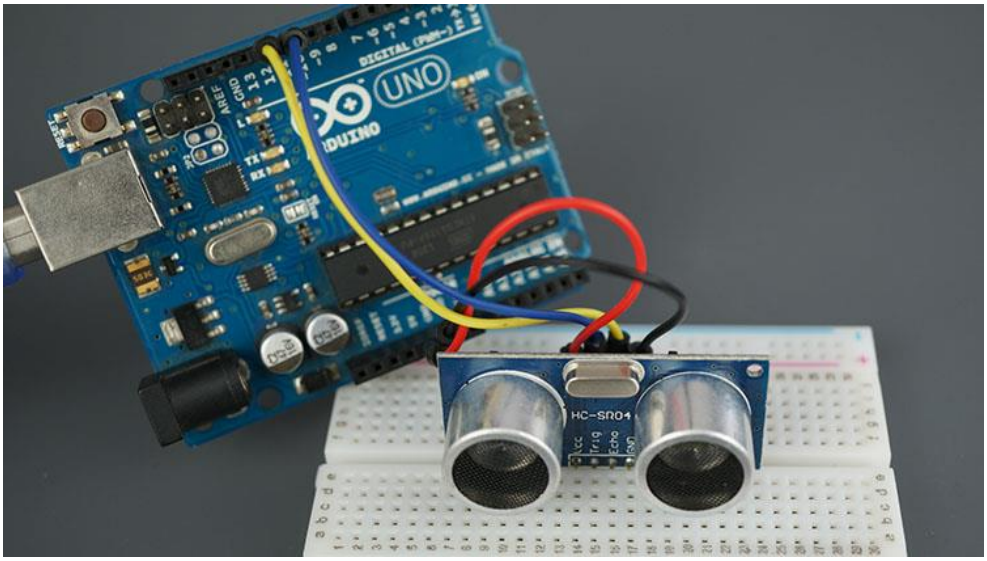
```
Serial.begin(9600);
```

Finally, in the `loop()`, you just need to use the `ping_cm()` method on the `sonar` object to get the distance in centimeters.

```
unsigned int distance = sonar.ping_cm();
```

If you want to get the distance in inches, you can use `sonar.ping_in()` instead.

Demonstration



Upload the code to your Arduino board. Then, open the Serial Monitor at a baud rate of 115200.

The distance to the nearest object is printed in the Serial Monitor window.