HC-SR04 Ultrasonic Sensor

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This file focuses on explaining the working of HC-SR04 Ultrasonic Sensor and giving a brief explanation about the working of ultrasonic sensors in general. It also explains how to wire the sensor up to a microcontroller and how to take/interpret readings with a few recommendations to check for errors or bad readings.

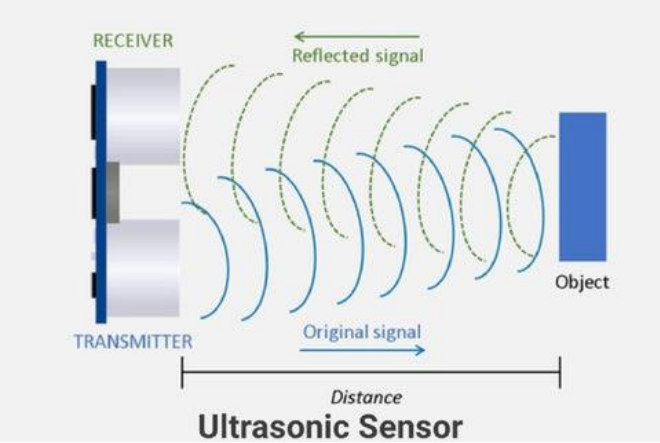
1. Ultrasonic sensor and its working

Ultrasonic sensors are widely used in projects for distance measurement as well as obstacle detectors. If the ultrasound hits an object or obstacle in its path, it will then bounce back towards the sensor. This sensor works on the principle of the SONAR and RADAR systems, which are used to determine the distance to an object.

There are 3-pin modules, 4-pin as well as 5-pin modules. The generally available ones are 4-pin or 5-pin modules.

One of the widely used ultra sonic sensor in IoT is HC-SR04, which is an affordable and easy-to-use distance-measuring sensor that has a range from 2cm to 400cm (about an inch to 13 feet). The sensor is composed of two ultrasonic transducers. One acts as a transmitter that converts the electrical signal into 40 KHz ultrasonic sound pulses. The other acts as a receiver and listens for the transmitted pulses. When the receiver receives these pulses, it produces an output pulse whose width is proportional to the distance of the object in front.It's basically a SONAR, which is used in submarines for detecting underwater objects.

The HC-SR04 is a versatile and reliable ultrasonic sensor suitable for various applications in robotics, industrial automation, consumer electronics, and agriculture.



2. HC-SRO4 Specifications

This section contains the specification and features of the sensor module

•Power Supply: DC 5V

•Working Current: 15mA

•Working Frequency: 40Hz

•Ranging Distance : 2cm – 400cm/4m

•Resolution : 0.3 cm

•Measuring Angle: 15 degree

•Dimension: 45mm x 20mm x 15mm

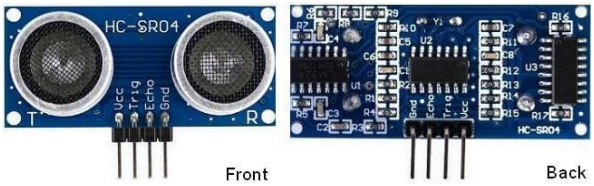
•Trigger Input Pulse width: 10uS Works at +5V DC

•Measuring angle of 30 degrees

•Comes with four pins: VCC, echo, trigger, and ground

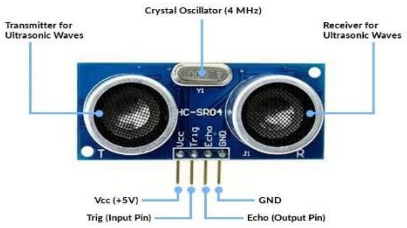
•Possible integration with Arduino

•Excellent accuracy at 3mm



HC-SR04

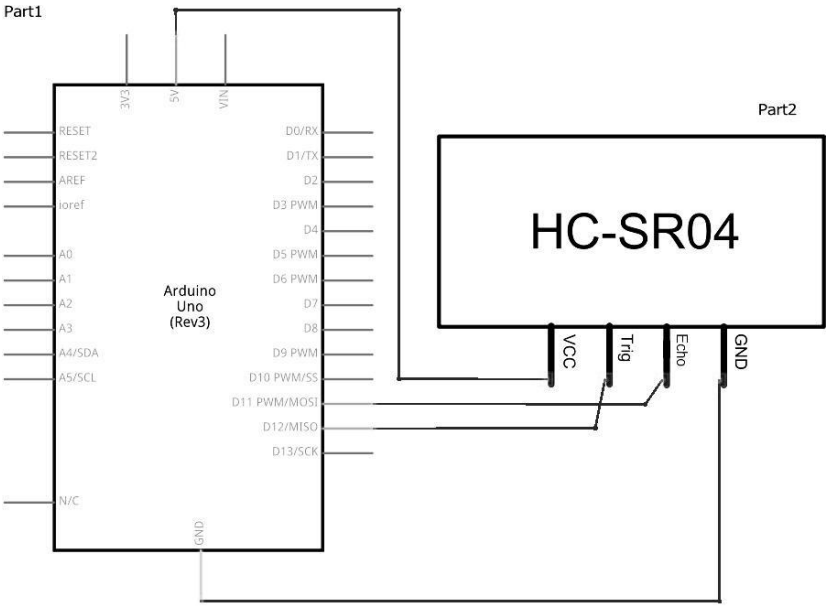
3. Pin explanations and Taking Measurements



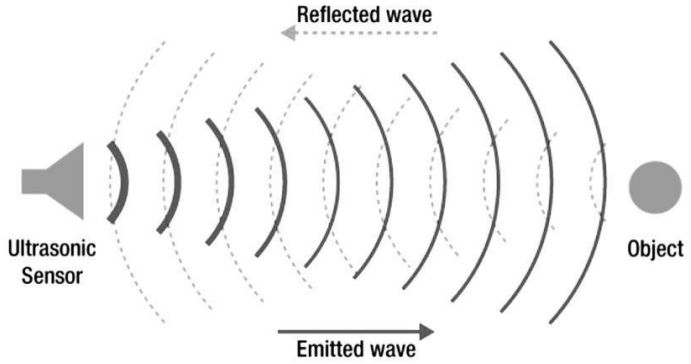
The HC-SR04 ultrasonic sensor has four pins, each with a specific role:

1. VCC (supply voltage): VCC provides power to the sensor; it requires 5V DC for proper operation and is typically connected to the 5V power supply pin on your microcontroller.
2. GND (ground): This provides a reference point for the voltage levels of the other pins and is typically connected to the ground pin on your microcontroller.
3. Trig (trigger): This pin initiates the distance measurement process. It also requires a 10µs high pulse sent to this pin to trigger the sensor to emit an ultrasonic pulse. The trigger is typically connected to a digital output pin on your microcontroller.
4. Echo (Echo): Outputs a pulse signal representing the time it takes for the sent ultrasonic pulse to bounce off an object and return to the sensor. Here, the pulse width is proportional to the measured distance. Echo is typically connected to a digital input pin on your microcontroller.

Pin	Function	Voltage	Connection
VCC	Supply Voltage	5V DC	5V Power Supply
GND	Ground	0V	Ground Pin
Trig	Trigger	Digital signal pulse (10µs high)	Digital Output Pin
Echo	Echo	Pulse signal proportional to distance	Digital Input Pin



The ultrasonic sensor has a sender to emit the ultrasonic waves and a receiver to receive the ultrasonic waves. The transmitted ultrasonic wave travels through the air and is reflected by hitting the object. Arduino calculates the time taken by the ultrasonic pulse wave to reach the receiver from the sender.

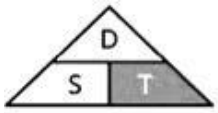


How to calculate distance for Ultrasonic HC-SR04 Module?

The width of the received pulse is used to calculate the distance from the reflected object. This can be worked out using the simple distance-speed-time equation we learned in high school. An easy way to remember the equation is to put the letters in a triangle.

Distance = Speed x Time

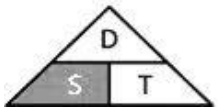
We know that, Distance = Speed x Time



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

The speed of sound waves is 343 m/s.

So,

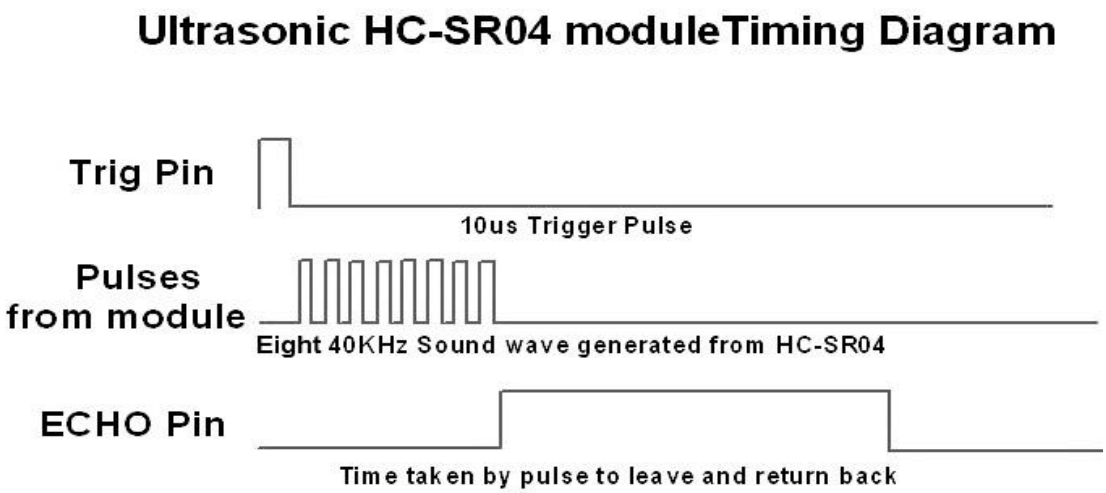


$$\text{Speed} = \frac{\text{Distance}}{\text{Time}}$$

Total Distance = (343*Time Of High (Echo) Pulse)/2

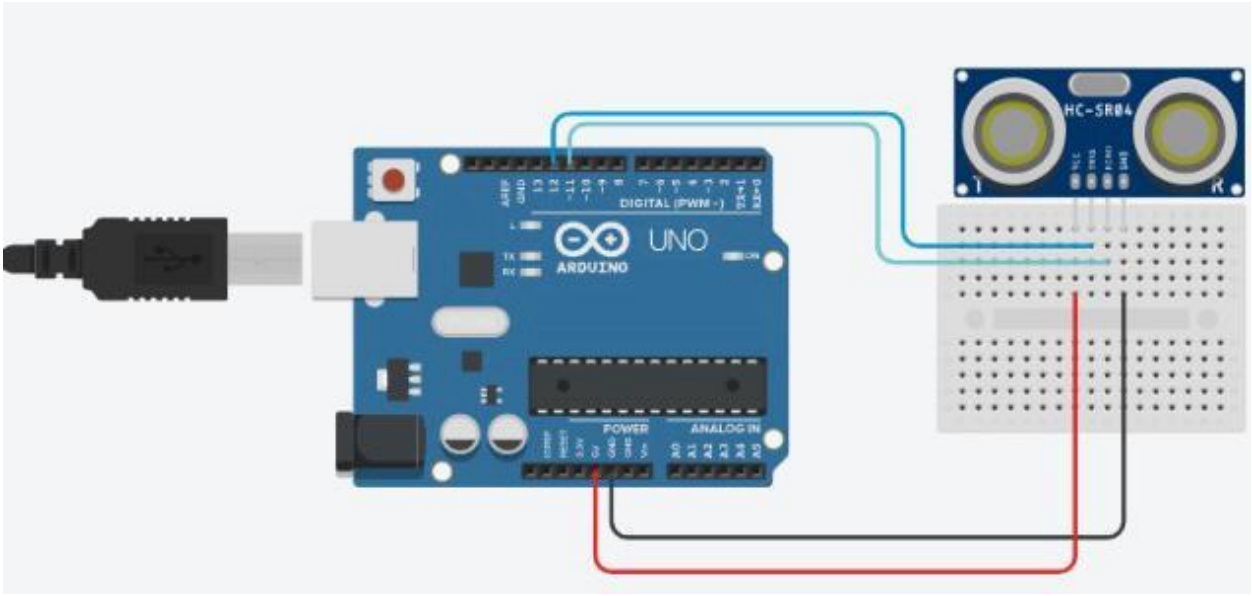
Total distance is divided by 2 because signal travels from HC-SR04 to object and returns to the module HC-SR04.

In order to work with the HC-SR04 Ultrasonic sensor the pulseIn() function is used which reads a pulse (either HIGH or LOW) on a pin.



4. Wiring HC-SRO4 with a microcontroller

Here's how we can connect the HC-SR04 sensor to an Arduino Uno 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.

The following table lists the pin connections:

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

5. Errors and Bad Readings

1. Blind zone: HC-SR04 has an area directly in front of the sensor (around 2-3cm) where objects might not be detected due to the sensor's internal workings. This affects the accuracy of the data that we need to obtain.

2. Environmental factors: Factors like temperature, humidity, and loud noises can influence sound wave propagation and cause inaccurate readings.

3. Wiring issues: Loose connections, incorrect pin assignment, or voltage fluctuations can disrupt the sensor's operation. It is advised to check all connections and then proceed.

4. Software errors: Programming mistakes or outdated libraries can lead to misinterpretation of the sensor's output. One should be careful.

5. Inaccurate readings: This can manifest as consistently wrong distances, fluctuating values, or complete failure to detect objects.