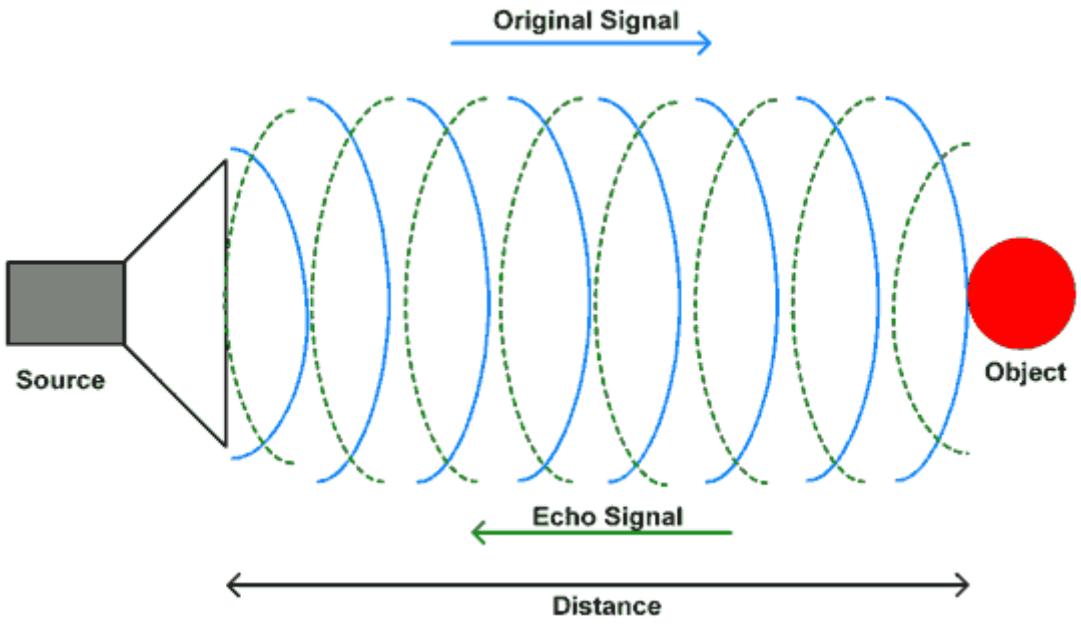
Ultrasonic Sensor HC-SR04

Introduction

The ultrasonic sensor works on the principle of SONAR and RADAR system which is used to determine the distance to an object.

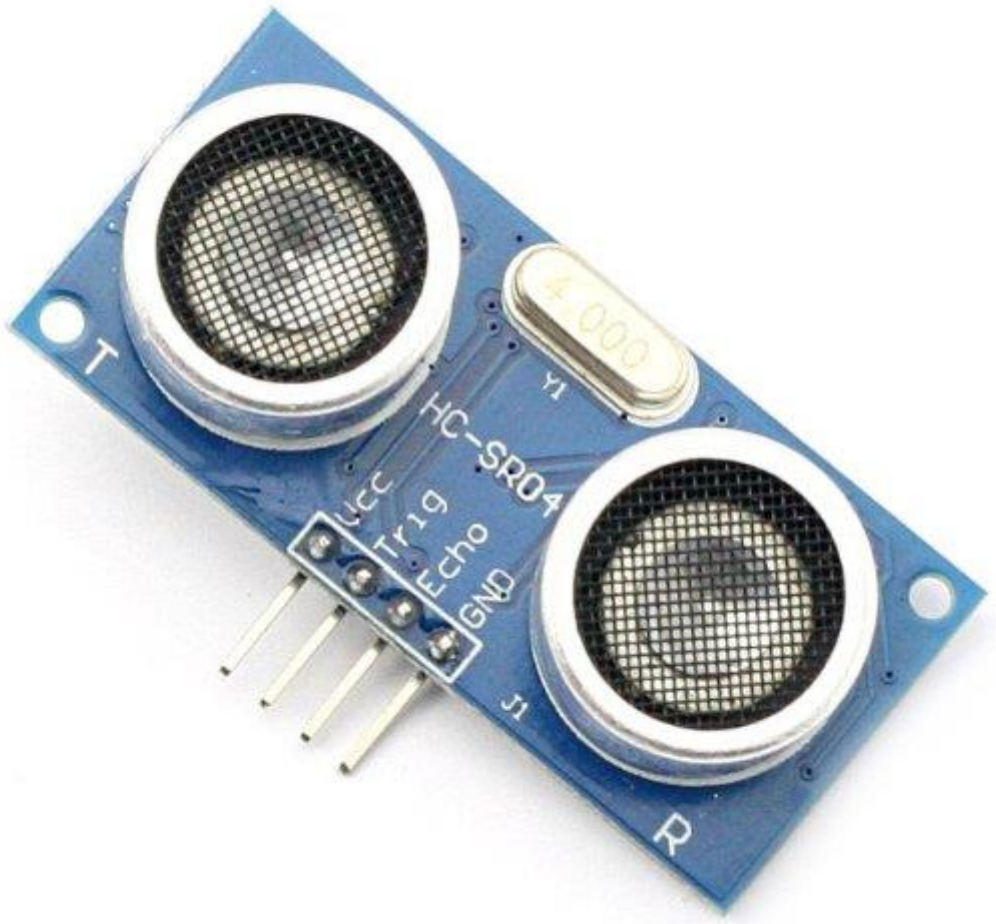
An ultrasonic sensor generates the high-frequency sound (ultrasound) waves. When this ultrasound hits the object, it reflects as echo which is sensed by the receiver as shown in below figure.



Ultrasonic Working Principle

By measuring the time required for the echo to reach to the receiver, we can calculate the distance. This is the basic working principle of Ultrasonic module to measure distance.

HC-SR-04 Ultrasonic Module



Ultrasonic Module

HC-SR-04 has an ultrasonic transmitter, receiver and control circuit.

In ultrasonic module HCSR04, we have to give trigger pulse, so that it will generate ultrasound of frequency 40 kHz. After generating ultrasound i.e. 8 pulses of 40 kHz, it makes echo pin high. Echo pin remains high until it does not get the echo sound back. So the width of echo pin will be the time for sound to travel to the object and return back. Once we get the time we can calculate distance, as we know the speed of sound.

HC-SR04 can measure up to range from 2 cm - 400 cm.

The module has only 4 pins, Vcc, Gnd, Trig, and Echo.

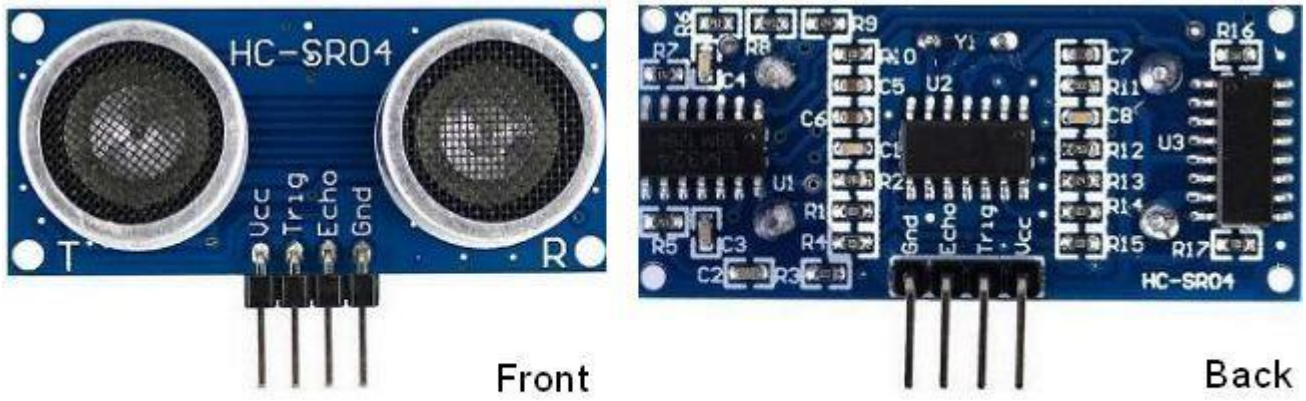
When a pulse of 10µsec or more is given to the Trigerg pin, 8 pulses of 40 kHz are generated. After this, the Echo pin is made high by the control circuit in the module.

The echo pin remains high till it gets an echo signal of the transmitted pulses back.

The time for which the echo pin remains high, i.e. the width of the Echo pin gives the time taken for generated ultrasonic sound to travel towards the object and return.

Using this time and the speed of sound in air, we can find the distance of the object using a simple formula for distance using speed and time.

HC-SR04 Pin Description



HC-SR04

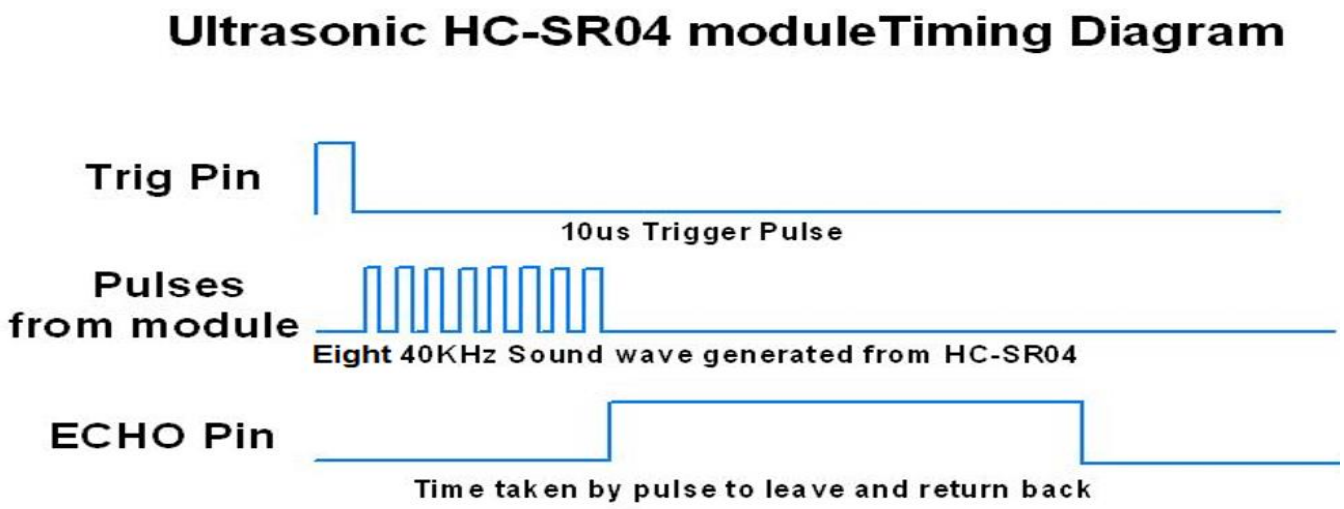
VCC - +5 V supply

TRIG – Trigger input of sensor. Microcontroller applies 10 us trigger pulse to the HC-SR04 ultrasonic module.

ECHO–Echo output of sensor. Microcontroller reads/monitors this pin to detect the obstacle or to find the distance.

GND – Ground

HC-SR04 Working Principle



HC-SR04 Ultrasonic Module Timing Diagram

1. We need to transmit trigger pulse of at least 10 us to the HC-SR04 Trig Pin.
2. Then the HC-SR04 automatically sends Eight 40 kHz sound wave and wait for rising edge output at Echo pin.
3. When the rising edge capture occurs at Echo pin, start the Timer and wait for falling edge on Echo pin.
4. As soon as the falling edge is captured at the Echo pin, read the count of the Timer. This time count is the time required by the sensor to detect an object and return back from an object.

Now how to calculate distance?

We know that,

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

The speed of sound waves is 340 m/s.

So,

Total Distance = $\frac{340 * \text{Time of High(ECHO)} Pulse}{2}$

Total distance is divided by 2 because signal travels from HC-SR04 to object and returns to the module HC-SR-04.

Steps of Programming

1. ATmega16 microcontroller needs to transmit at least 10 us trigger pulse to the HC-SR04 Trig Pin.
2. After getting a trigger pulse, HC-SR04 automatically sends eight 40 kHz sound waves and the microcontroller waits for rising edge output at the Echo pin.
3. When the rising edge capture occurs at the Echo pin which is connected to an input of ATmega16, start Timer of ATmega16 and again wait for a falling edge on the Echo pin.
4. As soon as the falling edge is captured at the Echo pin, the microcontroller reads the count of the Timer. This time count is used to calculate the distance to an object.

Here we are using the Input Capture unit on PD6(ICP1) pin.

Calculation (distance in cm)

Sound velocity = 340.00 m/s = 34000 cm/s

The distance of Object (in cm) = $\frac{340000 * \text{Time}}{2}$

= 17000 * Time

Now, here we have selected an internal **8MHz** oscillator frequency for ATmega16, with Prescaler **F_CPU/8** for timer frequency. Then time to execute 1 instruction is 1 us.

So, the timer gets incremented after 1 us time elapse.

= 17000 x (TIMER value) x 1 x 10^-6 cm

= 0.017 x (TIMER value) cm

= (TIMER value) / 58.8 cm

Note TIMER VALUE is the pulse width time calculated by the ICU.

Thanks and Good Luck

Eng | Mohamed Tarek