Technical specifications for

Ultrasonic sensor to measure distances

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Technical specifications submitted by:

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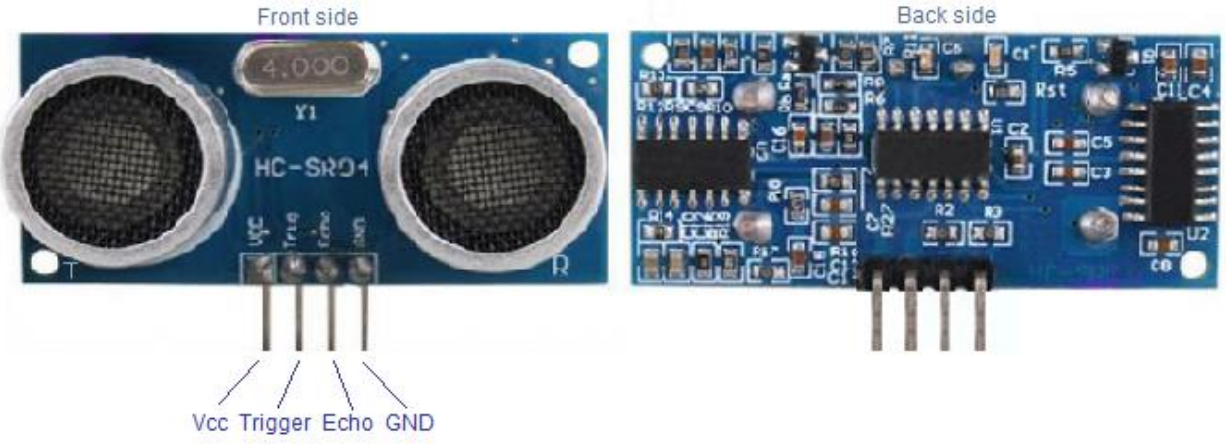
I. Introduction:

In order to measure distance between our device and target/object, we need an ultrasonic sensor that can send a sound wave and receive the same after it gets reflected from target/object and also measure the time it required. The microcontroller can then find the distance by using the time measured and speed of sound.

II. Ultrasonic HC-SR04 Sensor Module:

Ultrasonic Module HC-SR04 works on the principle of SONAR and RADAR system.

- The HC-SR04 module has ultrasonic transmitter, receiver and control circuit on a single board.
- The module has only 4 pins, Vcc, Gnd, Trig and Echo.



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

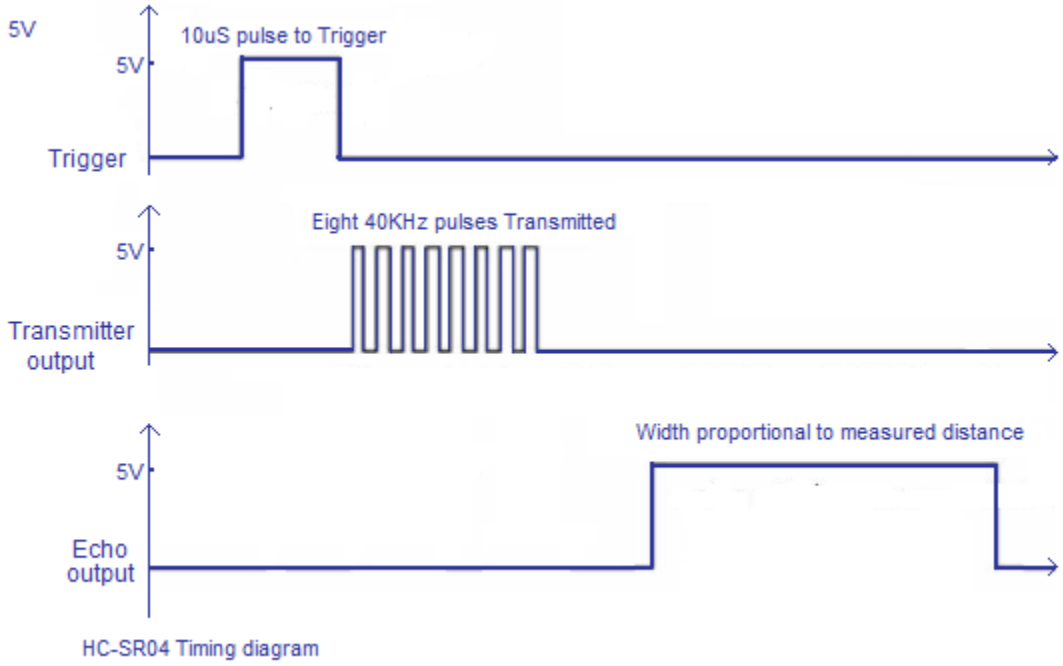
Justification for using HC-SR04:

- This particular sensor satisfies all the requirements as given below:
- This sensor is accurate up to 4mm and has range of 5m.
- It works in presence of smoke, dust and similar environments where optical sensors are not effective.
- HC-SR04 uses sound wave thus it works without contacting the medium to be measured.
- It has ability to detect and measure moving objects because sound waves propagate at high speed i.e., about 343 m/s in air. The target/object is expected to move relatively slower than sound.
- We assume that the object is in solid or liquid state. The density of the object should be good enough so that sound wave is reflected off it.
- Sound waves are reflected from the surface of object regardless of shape, color, transparency or surface texture of that object.

III. Working:

1. 8051 microcontroller needs to transmit at least 10 us trigger pulse to the HC-SR04 Trig Pin. Therefore, we need to use timer of 8051.
2. After getting trigger pulse, HC-SR04 automatically sends eight 40 kHz sound wave and waits for rising edge output at Echo pin.
3. When the rising edge capture occurs at Echo pin which is connected to the input of 8051, start Timer of 8051 and again wait for falling edge on Echo pin.
4. As soon as the falling edge is captured at the Echo pin, stop the timer of microcontroller read the count of the Timer. This time count is used to calculate the distance to an object.

5. Timing diagram:



HC-SR04 Timing diagram

Calculation (distance in cm):

$$Distance = \frac{SoundVelocity * time}{2}$$

Where,

Sound Velocity = 34300 (in cm per second)

Here, oscillator frequency of AT89C51RD2 (8051) is 11.0592 MHz then timer frequency of 8051 will be 921.6 kHz. So, time required to execute 1 instruction is 1.085 us.

So, timer gets incremented after 1.085 us time elapse.

e.g.

$$= \frac{34300 * TimerCount * 1.085 * 10^{-6}}{2}$$

IV. Communicating the results to other devices:

- The distance that is computed by microcontroller is then send to external devices which is going to use this information.
- Here we assume that the device could be anything that the user of this system wants. For example, in case of car parking assist (collision prevention), this information is sent to the dashboard/display of the car to assist the driver.
- Serial communication in 8051 microcontroller can be used to relay this information further. This method is suitable as serial communication will remain compatible to wide range of external devices.