PROJECT ON

Application of ULTRASONIC SENSOR (distance measurement)

ULTRASONIC SENSORS

Ultrasonic sensor is an instrument that measures the distance to an object using ultrasonic sound waves. Ultrasonic sensors are a type of sensors divided into three broad categories: transmitters, receivers and transceivers. The transmitters convert electrical signals into ultrasound, receivers convert ultrasound into electrical signals and transceivers can both transmit and receive ultrasound.

PRINCIPLE OF ULTRASONIC SENSORS

Before going ahead and learning about the principle, it is necessary that we should know **sound waves** are.

Sound waves – they are mechanical waves travelling through the mediums, which may be a solid, liquid or gas. Sound waves can travel through the mediums with specific velocity depending on the medium of propagation. The sound waves which are having high frequency reflect from boundaries and produces distinctive echo patterns.

Laws of physics for sound waves – sound waves have specific frequencies or number of oscillations per second. Humans can detect sounds in a frequency range from about 20Hz to 20KHz. However the frequency range normally employed in ultrasonic detection is 100KHz to 50MHz. the velocity of ultrasound at a particular time and temperature is constant in a medium.

$$W = C/F \quad \textbf{(OR)} \quad W = CT$$

(W is the wavelength, C is velocity, F is frequency and T is time period)

The most common methods of ultrasonic examination utilize either longitudinal waves or shear waves. Ultrasonic detection introduces high frequency sound waves into a test object to obtain information about the object without altering or damaging it in any way. Two values ar measured in ultrasonic detection.

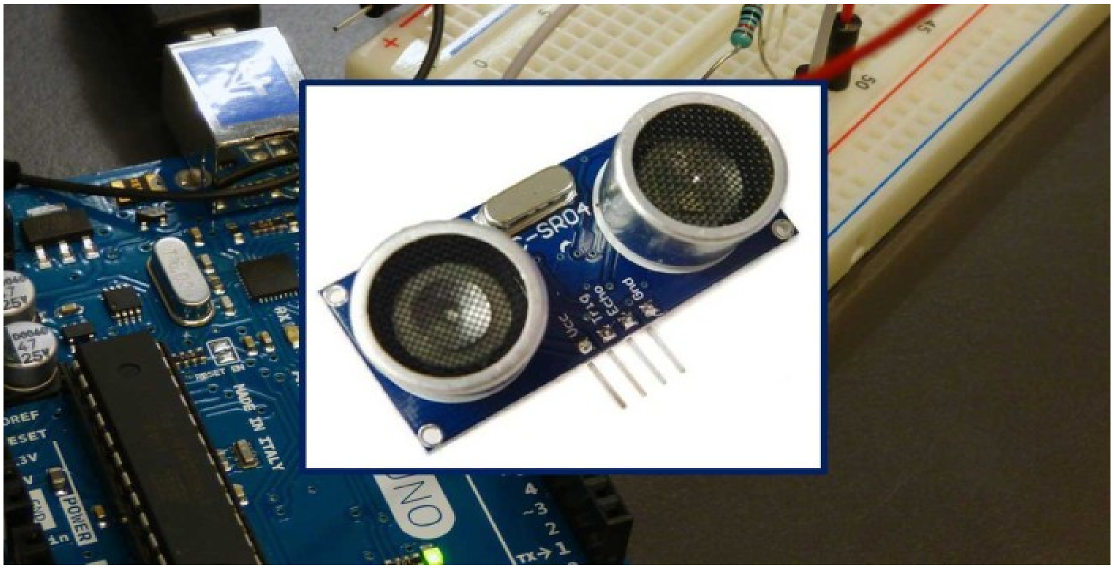
The amount of time taken by the sound to travel through the medium and amplitude of the received signal based on velocity and time, thickness can be calculated.

The basic principle involved—

These ultrasonic sensors emit short, high frequency sound waves at regular intervals. These propagate in the air at the velocity of sound. If they strike an object, then they are reflected back as echo signals to the sensor, which itself computes the distance to the target based on the time span between emitting the signal and receiving the echo.

As the distance to an object is determined by measuring the time of light and not by the intensity of the sound, ultrasonic sensors are excellent at suppressing background the interference.

ULTRASONIC SENSOR DESCRIPTION

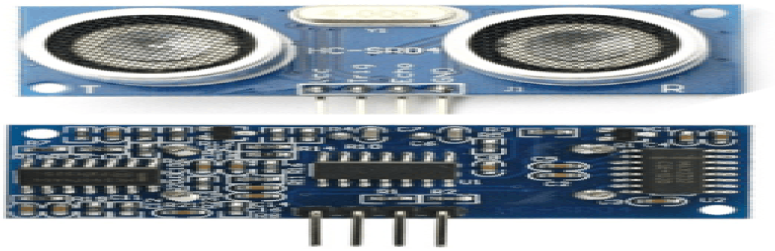


The HC-SR04 ultrasonic sensor uses sonar to determine distance to an object like bats do. It offers excellent non-contact range detection with high accuracy and stable readinds in an easy to use package. Its operation is not affected by sunlight or sharp rangefinders. It comes complete with ultrasonic transmitter and receiver module

Features:

- **POWER SUPPLY : +5V DC**
- **QUIESCENT CURRENT : <2mA**
- **WORKING CURRENT : 15mA**
- **EFFECTUAL ANGLE : <15 DEGREES**
- **RANGING DISTANCE : 2cm to 400cm**
- **RESOLUTION : 0.3 cm**
- **MEASURING ANGLE : 30 DEGREES**
- **TRIGGER INPUT PULSE WIDTH : 10micro sec**
- **DIMENSION : 45mm*20mm*15mm**

Pins:



- **VCC : +5V DC**
- **TRIG : TRIGGER(INPUT)**
- **ECHO : ECHO(OUTPUT)**
- **GND : GND**

Precisely Measure Distances with Ultrasonic Sensor

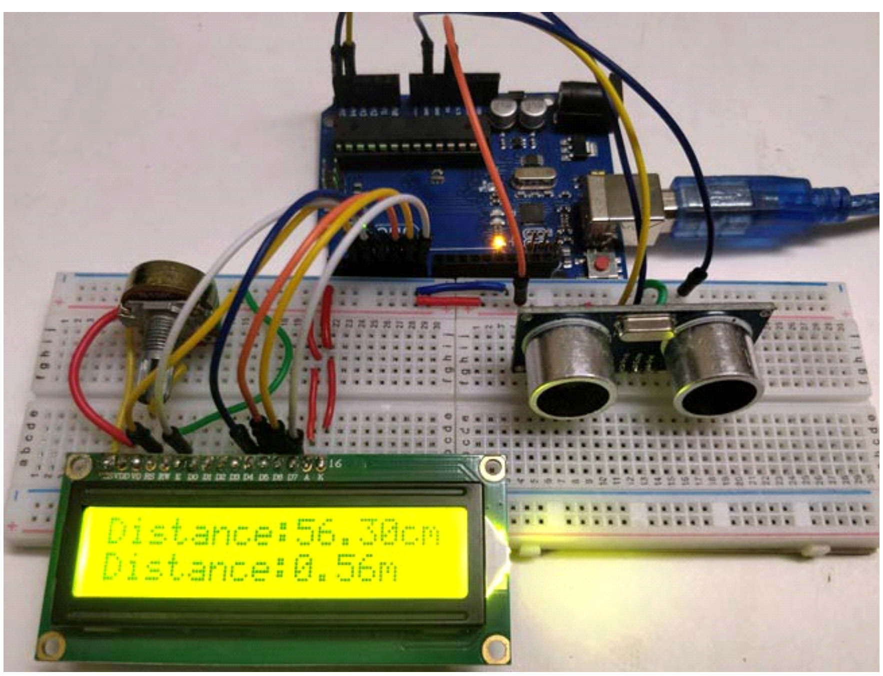
Migatron ultrasonic sensors can precisely measure the distance to a target object. Among the advantages of ultrasonic sensors over traditional sensors is the ability to detect and measure moving objects. Ultrasonic sensors are not affected by the color of the object and they can detect small objects over long distances.

Ultrasonic sensors can measure the distance to a wide range of objects regardless of shape, color or surface texture. They are also able to measure an approaching or receding object. By using "non-contact" ultrasonic sensors, distances can be measured without damage to the object. They're easy to use and, in many cases, can be used in place of other traditional sensors when the environmental conditions make traditional sensors unusable.

Distance Measurement Sensor Applications

Migatron ultrasonic sensors can detect the distances to a variety of objects ranging from small spheres to large rolls of steel, and from bulk material on a conveyor belt to the liquid level in a storage tank and countless other distance measurements applications that need an ultrasonic sensor to get the job done. Ultrasonic distance measurement sensors are used in a wide array of industries like petroleum, chemical and manufacturing. Some examples of industry uses are roll diameter (either wind or unwind), bulk material conveyors and hopper/feeder level control.

Ultrasonic sensors are great tools to measure distance without actual contact and used at several places like water level measurement, distance measurement etc. This is an efficient way to measure small distances precisely. In this project we have used an **Ultrasonic Sensor** to determine the distance of an obstacle from the sensor. Basic principal of ultrasonic distance measurement is based on ECHO. When sound waves are transmitted in environment then waves are return back to origin as ECHO after striking on the obstacle. So we only need to calculate the travelling time of both sounds means outgoing time and returning time to origin after striking on the obstacle. As speed of the sound is known to us, after some calculation we can calculate the distance.

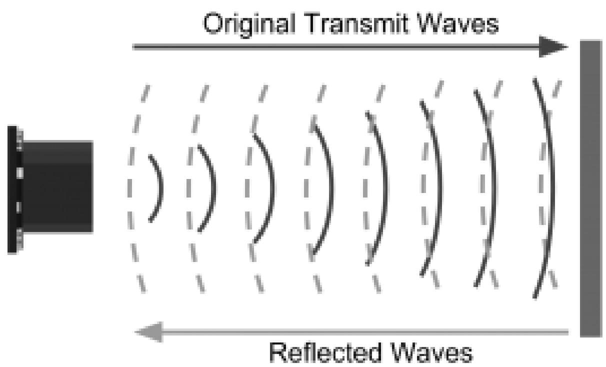


How Ultrasonic Sensors Work.

Ultrasonic sound vibrates at a frequency above the range of human hearing.

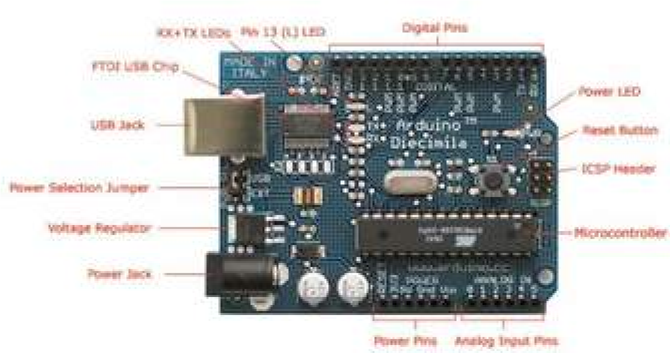
Transducers are the microphones used to receive and send the ultrasonic sound.

Our ultrasonic sensors, like many others, use a single transducer to send a pulse and to receive the echo. The sensor determines the distance to a target by measuring time lapses between the sending and receiving of the ultrasonic pulse.



<u>MATERIALISTIC REQUIREMENTS :</u>

- ARDUINO UNO OR PRO MINI



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Arduino is an open-source hardware and software company, project and user community that designs and manufactures single board microcontroller kits for building digital devices and interactive objects that can sense and control objects in the physical and digital world

Features of Arduino Uno Board

- Arduino Uno comes with USB interface i.e. USB port is added on the board to develop serial communication with the computer.
- Atmega308 microcontroller is placed on the board that comes with a number of features like timers, counters, interrupts, PWM, CPU, I/O pins and based on a 16MHz clock that helps in producing more frequency and number of instructions per cycle.

  It is an open source platform where anyone can modify and optimize the board based on the number of instructions and task they want to achieve.

- ULTRASONIC SENSOR MODULE

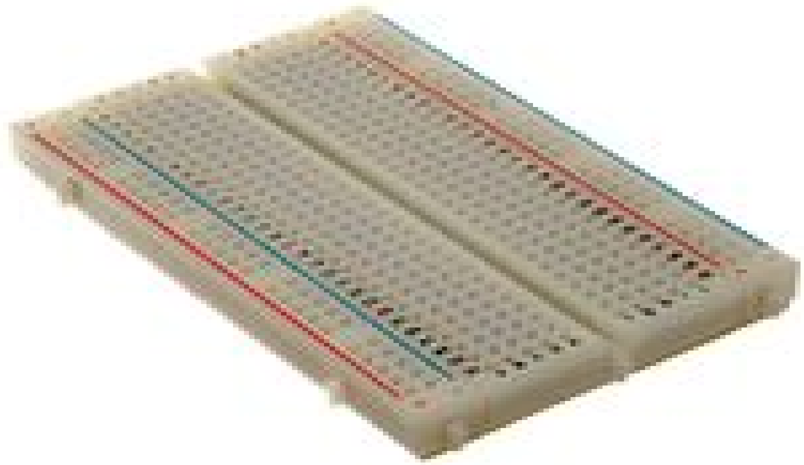
This is the HC-SR04 ultrasonic ranging sensor. This economical sensor provides 2cm to 400cm of non contact measurement functionality with a ranging accuracy that can reach up to 3mm. Each HC-SR04 module includes an ultrasonic transmitter, a receiver and a control circuit.

- 16*2 LCD

A LCD has two registers namely command and data. The register select is used to switch from one register to other. RS=0 for command register, whereas RS=1 for data register.
It is an electronic display module which uses liquid crystal to produce a visible image. The 16*2 LCD display is very basic module commonly used in circuits. The 16*2 translates on a display 16 characters per line in 2 such lines.

- SCALE
  It is being used to measure the distance of the obstacle

- BREAD BOARD



This is a construction base for prototyping of electronics.
These boards require absolutely no soldering.
The top and bottom rows(the rows indicated by the blue) and are usually the (+) and (-) power supply holes and these move horizontally across the breadboard, while the holes for the components move vertically. Each hole is connected to the many metal strips that are running underneath. Each wire forms a node.

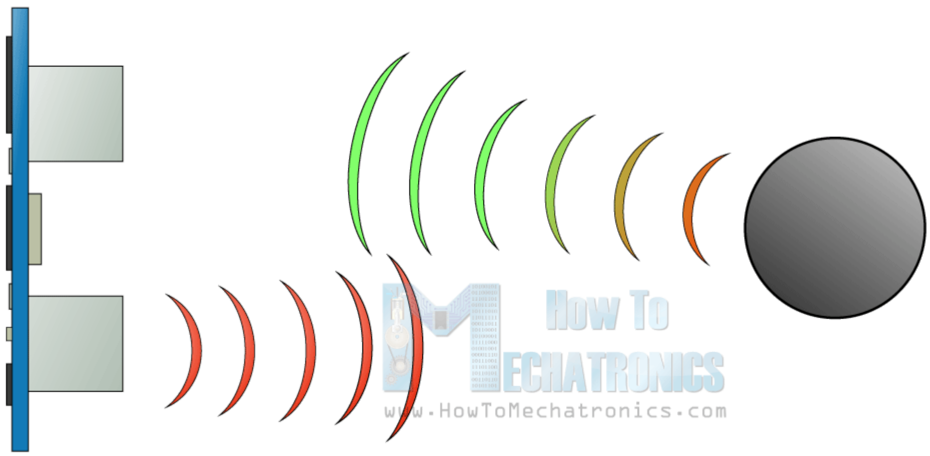
- 9 VOLT BATTERY

These nine volt batteries are a common size of battery that was introduced for the early transistor radios. It has a rectangular prism shape with rounded edges and a polarized snap connector at the top.

- CONNECTING WIRES

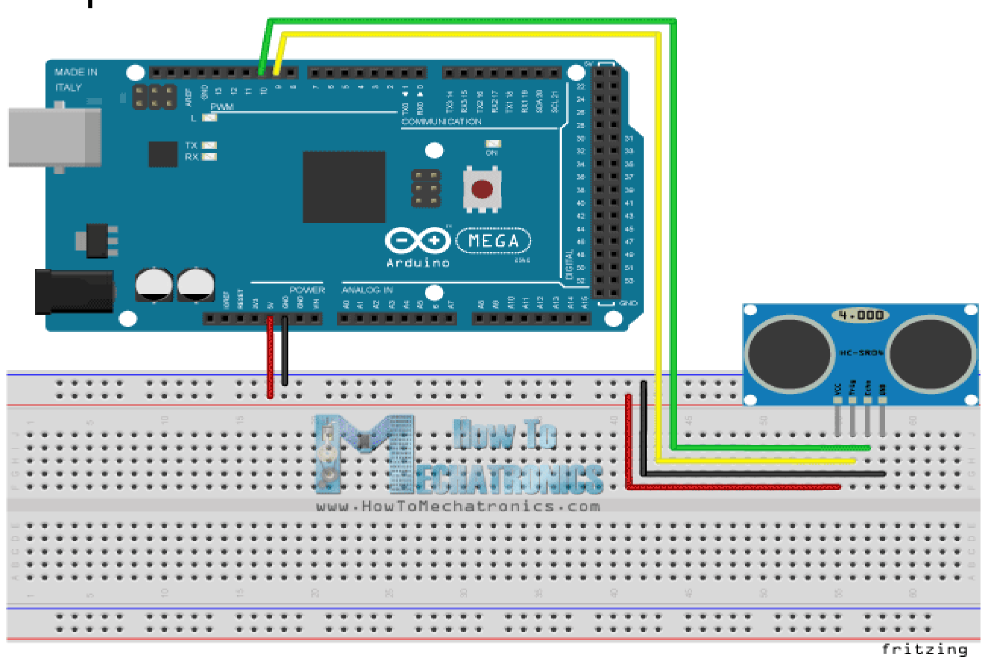
These wires are single, usually cylindrical, flexible strand or rod of metal. Wires are used to bear mechanical loads or electricity and telecommunications signals. Wire is commonly formed by drawing the metal through a hole in a die or draw plate. They are covered in rubber or plastic coating called insulation to prevent accidental contact with other conductors of electricity, which might result in an unintentional electric current through those other conductors

PROCEDURE(Experimentation):

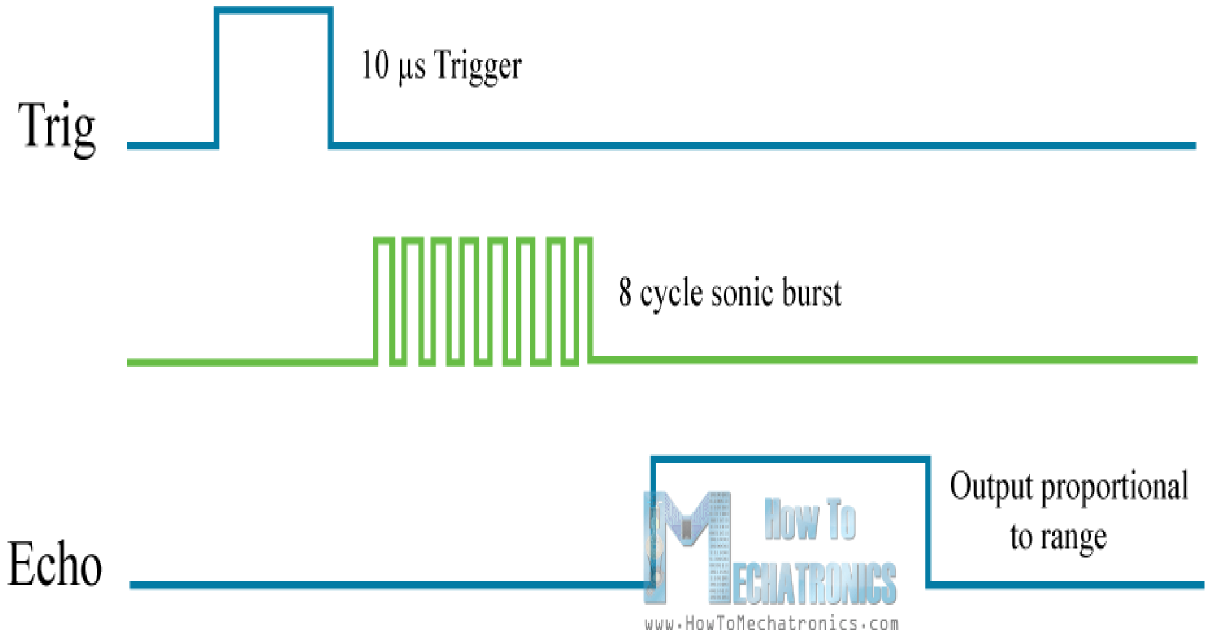


The HC-SR04 ultrasonic module has 4 pins: Ground, VCC , Trig, Echo.

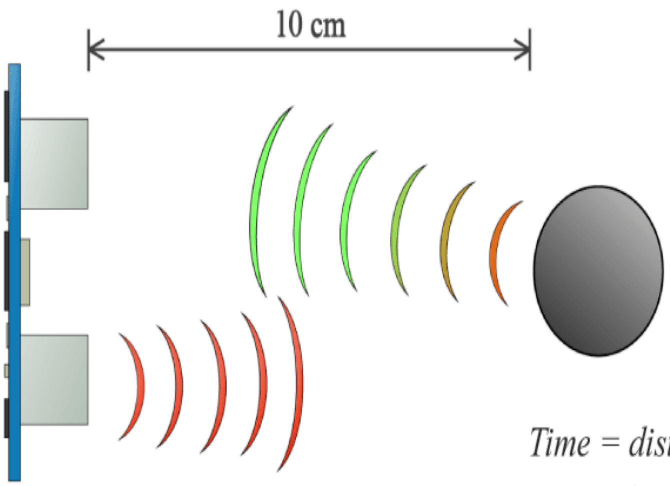
The Ground and VCC pins of the module needs to be connected to the ground and the 5 volts pins on the Arduino Board respectively and the Trig and Echo pins to any Digital I/O pin on the arduino board.



In order to generate ultrasound we need to set the trig on a high state for 10 micro seconds. That will send out an 8 cycle sonic burst which will travel at the speed sound and it will be received in the echo pin. The echo pin will output the time in microseconds the sound the wave travelled.



For example, if the object is 10cm away from the sensor, and the speed of the sound is 340 m/s or 0.034cm/micro second, the sound wave will need to travel about 294 micro seconds. But what we will get from the echo pin will be double that number because the sound wave needs to travel forward and bounce backward. So in order to get the distance in cm we need to multiply the received travel time value from the echo pin by 0.034 and divide it by 2.



speed of sound:

$v = 340\ m/s$

$v = 0{,}034\ cm/\mu s$

Time = distance / speed:

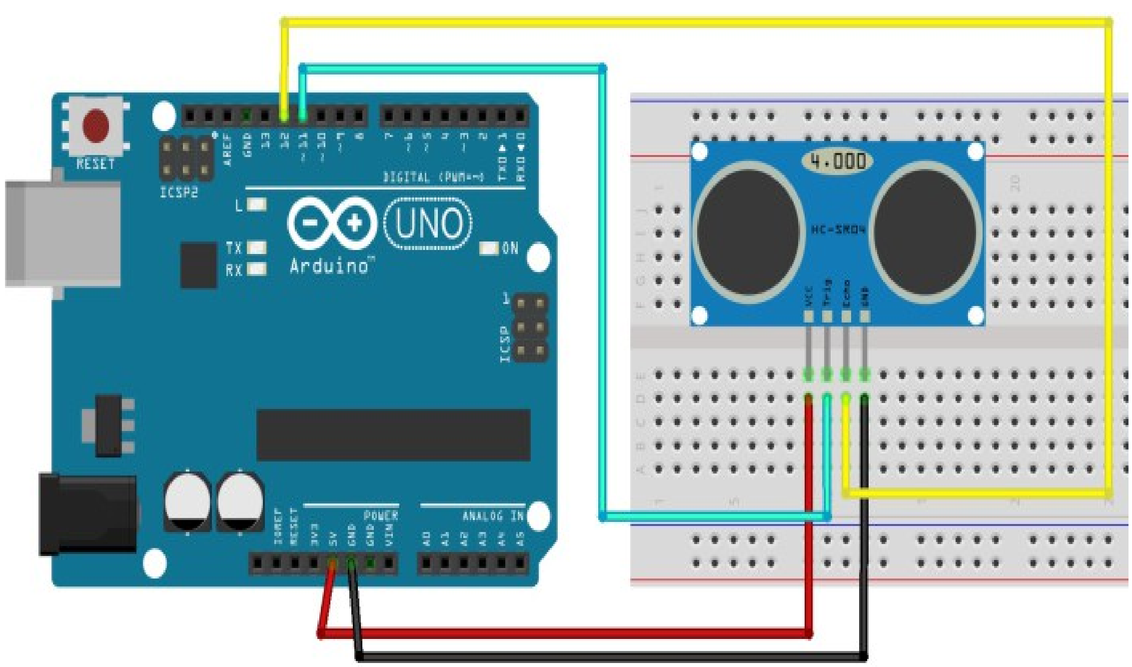
$t = s / v = 10 / 0{,}034 = 294\ \mu s$

Distance:

$s = t \cdot 0{,}034 / 2$

SCHEMATICS

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

Source code

the following code is uploaded to arduino

```
  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);
}
```

HOW THE CODE WORKS

First, you create variables for the trigger and echo pin called *trig Pin* and *echo Pin*, respectively. The trigger pin is connected to digital pin 11, and the echo pins is connected to digital pin 12:

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

You also create three variables of type long: *duration*, *cm* and *inch*. 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 *inch* variable will save the distance in inches.

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

In the *setup(),* we 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()*, we trigger the sensor by sendind a HIGH pulse of 10 microseconds. But, before that, we give a short LOW pulse to ensure we’ll get a clean HIGH pulse:

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

digitalWrite(trigPin, LOW);
Then, we read the signal from the sensor – a HIGH pulse whose duration is the time in microseconds from the sending of the signal to the reception of its echo to an object.

duration = pulseIn(echoPin, HIGH);
Finally, we just need to convert the duration to a distance. We can calculate the distance by using the following formula:

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 *traveltime* by 2 because we have to take into account that the wave was sent, hit the object, and then returned back 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();

WHY USE AN ULRASONIC SENSOR?

Ultrasound is reliable in any lighting environment and can be used inside or outside. Ultrasonic sensors can handle collision avoidance for a robot, and being moved often, as long as it isn't too fast.

Ultrasonics are so widely used, they can be reliably implemented in grain bin sensing applications, water level sensing, drone applications and sensing cars at your local drive-thru restaurant or bank.

Ultrasonic rangefinders are commonly used as devices to detect a collision.

Ultrasonic Sensors are best used in the non-contact detection of:

- Presence
- Level
- Position
- Distance

*Non-contact sensors are also referred to as **proximity sensors.***

Ultrasonics are Independent of:

- Light
- Smoke
- Dust
- Color
- Material (except for soft surfaces, i.e. wool, because the surface absorbs the ultrasonic sound wave and doesn't reflect sound.)

***Long range detection** of targets with varied surface properties.*

ultrasonic sensors are superior to infrared sensors because they aren't affected by smoke or black materials, however, soft materials which don't reflect the sonar (ultrasonic) waves very well may cause issues. It's not a perfect system, but it's good and reliable.

Applications Involving Ultrasonic Detection

- Ultrasonic Distance Measurement
    - *Ex. Distance measurement would be applied in a garage parking application, sensing when a vehicle is pulled completely into a garage.*

- ultrasonic sensors for water level detection
    - *Tank level measurement, Fuel gauging, irrigation control.*

- Ultrasonic Obstacle Detection
    - *Our UAV sensors for drones as well as our proximity sensors that are used for robots are for obstacle detection.*

Ultrasonic sensors are a reliable, cost-effective solution for distance sensing, level, and obstacle detection.

Once you understand ***how ultrasonic sensors work*** and what ultrasonics are perfect for and not so good for, you can make a more educated decision on the right sensor system for our application.

FUTURE SCOPE

I. New prototyping hardware & capatibility & interfacing with other consumer elatrone/tv/smartphones & flooding of shields.

II. Mining equepments may require where entail.

III. Acready compatible with many major simulation software like MATLAB & lab view, we may see even move flexible programming environment & development option

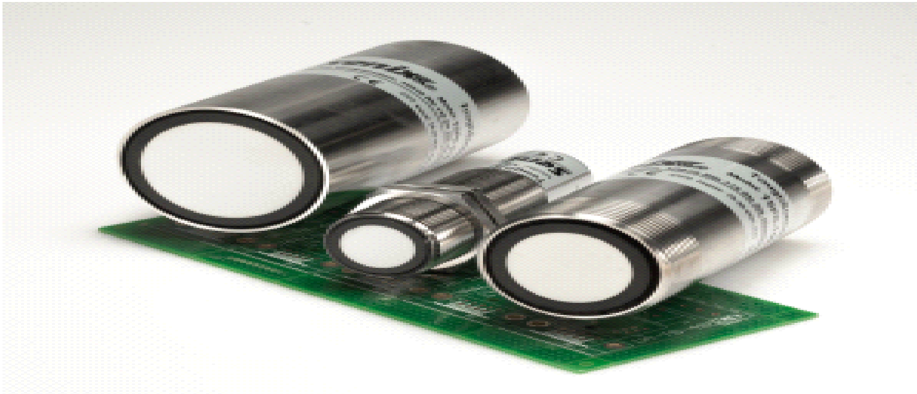
IV. Using temp. Compensation, it can be used over wide temp range.

V. Height meausrment, agriculture velide, collision /protection can be other application.

Ultrasonic sensors measure the distance to or presence of a target object or material through air without touching it. The measured distance is provided as acompatible with displays, machinery, PLC's, computers and most electronic or electrical machinery.

Non-contact ultrasonic sensors have distinct advantages in challenging environments where corrosive, scaling, coating, or dirty materials are likely to negatively impact the performance and maintenance costs of contact sensors. Non-contact ultrasonic sensors are also desirable where the material being measured cannot be corrupted by contact with any measuring device.

Ultrasonic Sensors measure the distance of target objects or materials through the air using "non-contact" technology. They measure distance without damage and are easy to use and reliable.



Whether used indoors or out, ToughSonic® sensors can take abuse. Solid state electronic components are epoxy potted into stainless steel housings, and there are no mechanical parts to break. IEC compliant electrical interfaces are protected from reversed connections and over-voltages.

These distance measurement sensors connect with all common types of automation and telemetry equipment. Applications range from simple analog connections to sophisticated multi-sensor data networks.

What types of targets can sensors detect?

A wide range of materials can be measured, including hard or soft, colored or transparent, flat or curved.

Tough

- Type 316 stainless steel housings
- Sealed epoxy potted construction
- Ruggedized piezoelectric ultrasonic transducers, potted in place
- Liquid tight IP68 immersion rating
- IEC compliant electrical interface protection
- Hardened ToughSonic internal electronics
- UV-resistant, potted-in cable

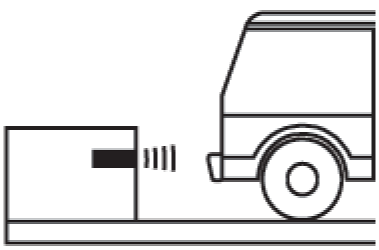
- CE compliant

Distance Ranging Applications

Machinery and processes in a wide range of industries use ToughSonic distance measurement sensors where size or position feedback is required: printing, converting, robotics, material handling, transportation and more. Here are just some of the ways they are used:

Positioning & Locating

Distance measurement sensors are used to control or indicate the position of objects and materials. A proportional analog signal is often sent to a PLC or motor drive, such as a web or cable loop control, to synchronize the material transfer between two machines. Distance feedback can be displayed to an operator to manually position a vehicle or object being handled.

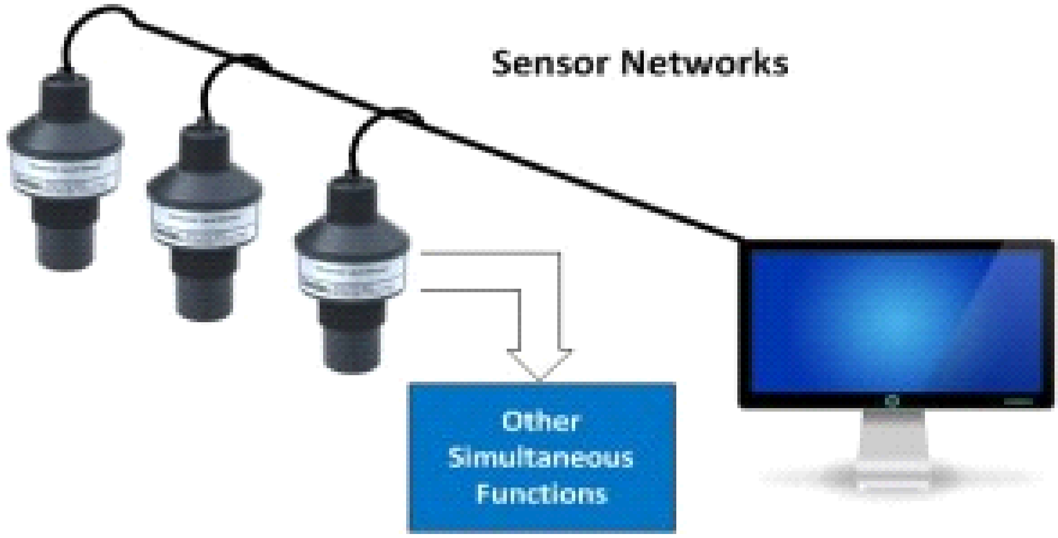


Dimensioning & Selecting

Distance measurement sensors can determine the dimensions of objects such as height, width and diameter, using one or more sensors. Items can be selected or rejected based on their dimensions or profiles, such as determining whether an object on a conveyor is upside down or not, by using the sensor’s timing and distance features.

Profiling & Multi-Sensor Systems

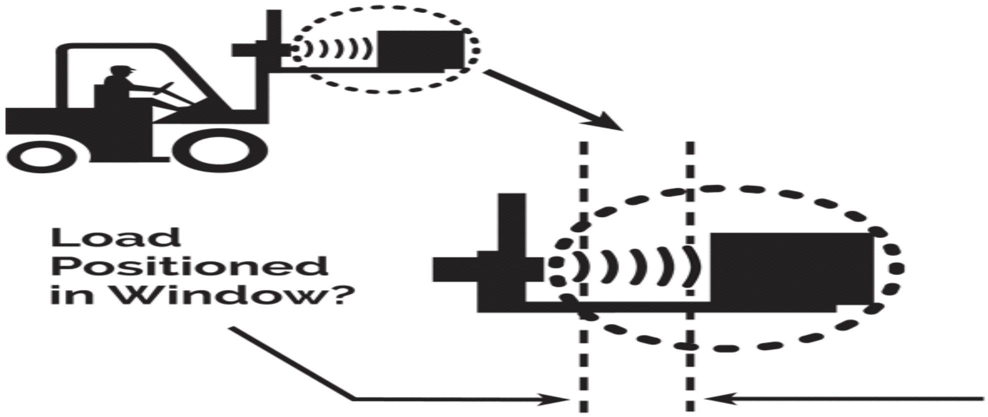
Applications requiring multiple measurements are handled by networks or groups of standard sensors. ToughSonic sensors can output both analog and serial data, to be collected and processed by a computer or PLC. Protocols are available to support high-speed data collection in applications such as conveyor bulk flows.



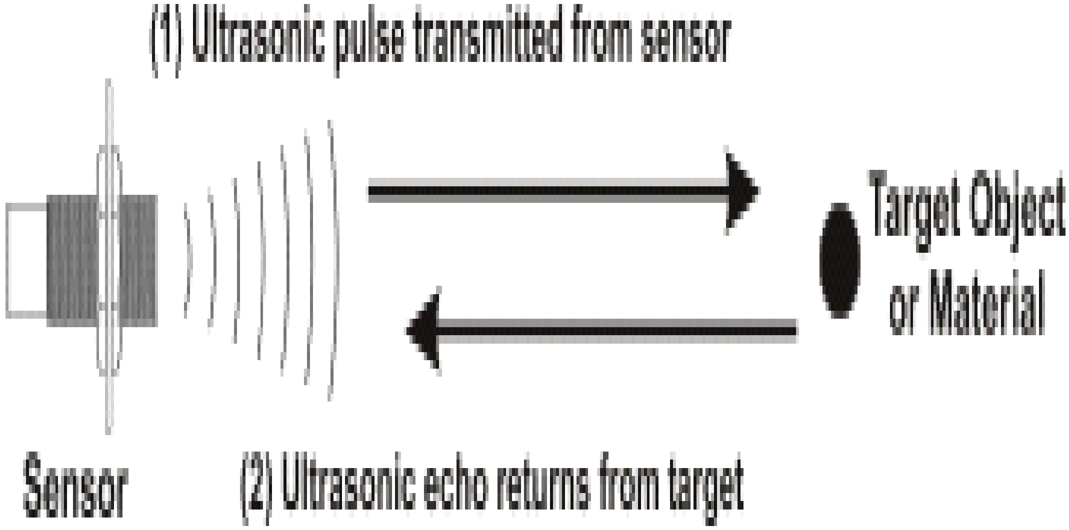
Ultrasonic Sensors detect objects or materials through the air using “non-contact” technology. They are easy to use and reliable. Most materials can be detected: hard or soft, any color or transparency, flat or curved. Unlike traditional proximity sensors, they operate over longer distances and can be set up to limit object detection within a user-specified distance band (“window”).

Distance Discrimination

Senix ultrasonic sensors can be configured to restrict object detection to a user-configurable range of distances. They can also be configured to establish a single maximum range of detection within the sensor’s maximum range. This allows the sensor to ignore further objects that may be permanently or intermittently within the sensor’s maximum range.



Ultrasonic sensors (sometimes called ultrasonic transducers), measure the distance to or the presence of a target object by sending a sound pulse, above the range of human hearing (ultrasonic), toward the target and then measuring the time it takes the sound echo to return. Knowing the speed of sound, the sensor determines the distance of the target and sets its outputs accordingly



Sensor outputs are set based on the measured distance, or under override conditions, a lack of target detection or user-selected response algorithms. Outputs can be:

• an analog voltage or current signal proportional to the measured distance

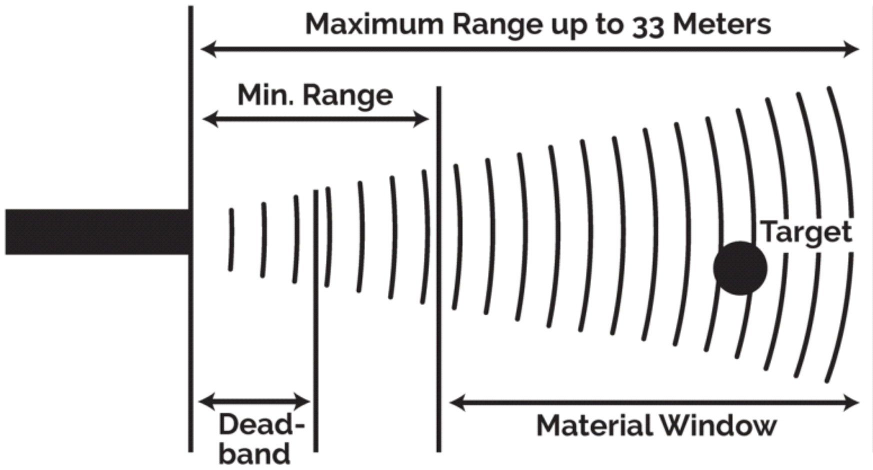
• Switches or relay contact closures that open or close at specific distances

• distance data transmitted digitally as serial data communications.

Sensors will detect both large and small targets, including liquids, solids and granular materials. The size, shape and orientation of the target will affect the maximum distance at which it can be detected. The sensor is not affected by optical characteristics such as color, reflectivity, transparency or opaqueness.

How far can Senix ultrasonic sensors measure?

The maximum range of our products is presently 20 meters (about 70 feet) and varies by model. The distance at which an object is detected depends on its size, shape and orientation. In general the target must be larger to be detected at longer distances – the object must reflect a sufficiently strong ultrasonic echo back to the sensor to be detected. Large, flat targets such as a liquid surface in a tank are detected at the maximum range. Curved objects or sound absorbing materials such as fabrics or non-wovens reflect less energy directly back to the sensor. Granular materials may absorb sound or deflect sound energy away from the sensor due to surface variation and/or angle of repose. Sensor maximum range should be de-rated for these targets.



Other factors affect how close an ultrasonic sensor can be to a target and still measure distance correctly. When too close the sensor will not detect the first echo, but may detect a second or third echo, yielding a longer than actual value. This **deadband** distance varies by model and is larger for longer range models, varying from 44 to 305 mm (1.75 to 14 inches). The **minimum range** and **maximum range** define the limits of the **material window,** which is the useful operating range of the sensor. The material window is user-adjustable with SenixVIEW software to ignore unwanted targets or optimize system performance. When used outdoors we recommend limiting the range to the sensor's "Optimum Range" specification rather than the "Maximum Range" to allow for environmental extremes

What happens if the ultrasonic beam hits other objects?

A common misunderstanding is that if the ultrasonic beam is larger than the target there is a problem. This is not true in general. It does not matter that the beam is larger or reaches other objects as long as those objects do not reflect sound back to the sensor or are farther away than the target of interest. For example, this means that a sensor can be mounted next to a wall or can measure inside a tube and the measurement will not be affected as long as the wall or tube surface is smooth because no sound energy is reflected back to the sensor from the surface. In computer configurable sensors, the detection of undesired or off-axis objects can be affected by beam width, sensitivity adjustment, range adjustment, processing filters and object masking.

Temperature

The temperature of the air between the sensor and the target can affect measurement accuracy since the speed of sound varies with temperature. If this is an issue, temperature compensation is available in all computer configurable models. At room temperature the speed of sound changes approximately 0.175%/°C, or 1% for every 5.7 °C. As the temperature increases the target will measure closer, and vice versa.

Air temperature variations or gradients between the sensor face and the target will affect accuracy because the sensor assumes a constant temperature when it calculates distance. This can be an issue in vertical measurements such as a tank level if internal heating occurs when the tank is exposed to the sun, creating a temperature gradient inside the tank.

Some customers have had success with hot applications. Very hot environments above the sensor's operating range are not recommended. In general, the readings become less reliable in a non-homogeneous environment. Severe temperature gradients, however, such as measuring red-hot metal cause the echo to reflect off the gradient rather than the intended target, making the measurement invalid.

Humidity

Humidity change is generally not a significant factor (0.036% / 10% RH change).

Pressure/Vacuum

Normal atmospheric pressure changes or small pressure changes in vessels will not affect ultrasonic sensor operation. Ultrasonic sensors are not designed for high pressure applications. Sound does not travel in a vacuum.

Audible Noise

Loud audible noises produced by machinery do not affect the sensor.

Ultrasonic Noise

Locally generated ultrasonic noise at the sensor operating frequency can interfere with measurements. Some potential sources are high pressure air releases near the sensor caused by air nozzles, pneumatic valves or solenoids, and ultrasonic welders. In computer programmable sensors, processing options can be selected to ignore the effects of noise bursts. Higher frequency sensors are less susceptible since there is less high frequency noise due to sound absorption in the air. Air paths are usually rearranged, blocked or eliminated to prevent this. Senix sensors are designed to allow several ultrasonic sensors in the same vicinity without mutual interference.