DISTANCE MEASUREMENT USING ULTRASONIC SENSOR AND ARDUINO IN VEHICLE APPLICATIONS

Submitted in partial fulfillment of the requirements for the award of

Bachelor of Engineering Degree in

Electrical and Electronics Engineering

by

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SATHYABAMA
INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)
Accredited with Grade "A" by NAAC
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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **D.KAMALEESWARI – 40140017 AND B.PRABAVATHI – 40140026- EEE** who carried out the project entitled **"DISTANCE MEASUREMENT USING ULTRASONIC SENSOR AND ARDUINO IN VEHICLE APPLICATIONS "** under our supervision from January 2023 to April 2023.

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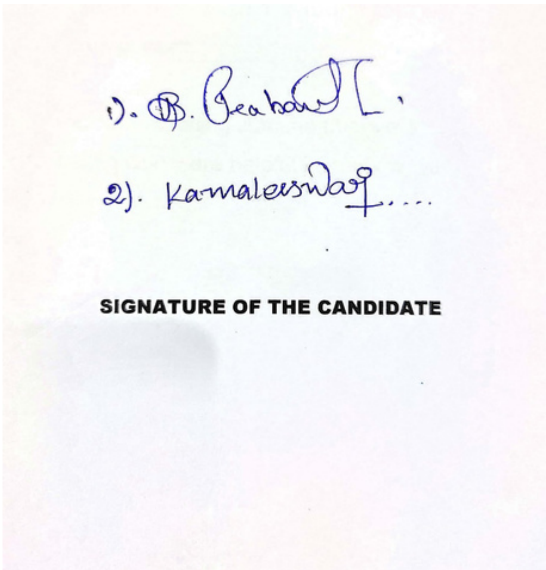
SENSOR AND ARDUINO IN VEHICLE APPLICATIONS" done by us under the guidance of

MRS.D.RAMYA is submitted in partial fulfillment of the requirements for the award of Bachelor of Engineering degree in Electrical and Electronics Engineering.



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Abstract

- The News reports estimates that 1 in 5 car accidents occur in the parking lot. It may be a head-on, rear-end, or T-bone crash. Since these occur in the parking lot, the vehicle's speed is low, and possibly the passengers remain safe.But in some circumstances, they could be fatal.
- Studies say parking accidents are mostly due to drivers' distractions caused by using mobile phones.
- In a parking lot, pedestrians move freely, and the driver has to remain alert even about their blind spots.
- We designed a system using the ultrasonic sensor that could be deployed in an Vehicle. The ultrasonic sensor is used to detect objects in blind spots.
- A blind spot is an area in close proximity to the vehicle where the driver has low or zero visibility.
- The ultrasonic sensor works similarly to bats. Like bats, the ultrasonic sensor transmits ultra-frequency waves and measures the distance of the obstacle from the vehicle.
- These sensors can accurately detect objects and don't require any lighting. When the object is very close, it could signal the driver to become alert. Thus, it assists drivers in moving safely in a parking lot.

TABLE OF CONTENT

CHAPTER NO.	TITLE	PAGE NO
	Certificate	
	Abstract	
	List of tables	
	List of figures	
1	**INTRODUCTION**	
	1.1 General Background	10
	1.2 Global Scenario	11
	1.3 Problem Statement	12
	1.4 Motivation of the project	13
2	**Literature Survey**	**14**
3	**PROJECT DESCRIPTION**	
	3.1 Existing Methodology	17
	3.2 Proposed Methodology	18
	3.3 Block Diagram	19
4	**Simulation and Hardware**	
	4.1 List of the components	20
	4.1.1 Jumper Wires	20
	4.1.2 Arduino Uno R3	21

4.1.3 Ultrasonic sensor(HC-SR04) 23
4.1.3.1 Ultrasonic sensor module 24
4.1.3.2 Timing Diagram 24
4.1.4 16x2 LCD 12C display 26
4.1.5 10K potentiometer 27
4.1.6 Servomotor 28
4.1.7 Resistor(220ohm) 29
4.1.8 Bread board 29
4.2 Hardware Connection 30
4.3 Simulation Model 31
4.4 Arduino Program 32
4.5 Simulation Output using tinkercad software 36
4.6 Arduino IDE program Execution 37

5 CONCLUSION AND FUTURE SCOPE 38

List of figures

Figure No .	TITLE	PAGE NO.
4.1.1	Jumper wires	20
4.1.2	Aurdino UNO R3 Board	21
4.1.3	Ultrasonic Sensors	21
4.1.3.2	Timing Diagram	25
4.1.4	16x2 LCD Display	26
4.1.5	10K Potentiometer	27
4.1.6	Servomotor	28
4.1.7	220 Ohm Resister	29
4.1.8	Breadboard	29
4.3 a	Circuit Diagram	31
4.3 b	Simulation Model	31
4.5	Simulation Output	37

List of tables

TABLE NO	TITLE	PAGE NO
4.1.2.1	Pin details – aurdino UNO	22
4.1.2.2	Technical deatails aurdino UNO	22
4.1.5	Specifications of Potentiometer	20

CHAPTER 1

INTRODUCTION

1.1 General Background

During the 18th century, the electro-optical distance meter's development has evolved through the techniques of determining the velocity of light. Fizeau, who determined the velocity of light in 1840s, and a lot more inventions; E. Bergstrand was then inspired to design the first "Geodimeter" in 1940s. This works has developed and evolved throughout the history by aspiring Scientists. Moreover, recent scientists first patent application for an electromagnetic distance meter, this was made by Löwy in 1923.The use of this ultrasonic distance measuring device is useful in measuring the distance between two objects. Instead of using devices such as a measuring tape, an ultrasonic device can determine the length between two points of up to 4 meters. The researchers have decided to conduct this study to create a prototype of an ultrasonic distance measuring device and study and understand the basic concepts of using ultrasonic as a method of measuring distance. The concepts on how coding works when using Arduino UNO, ultrasonic distance measurement, Sonar, etc., This project will be useful in measuring two points; this device uses the concept of a sonar to determine the distance of an object.

Distance measurement is a crucial aspect of science and technology, enabling us to determine the distance between two points or objects. It plays a vital role in various fields such as astronomy, geodesy, navigation, surveying, and many more.

The concept of distance measurement has been around for centuries, with early civilizations using primitive methods such as pacing, ropes, and sticks. However, with the advancements in technology, we now have access to sophisticated instruments that can measure distances with high precision and accuracy.

Today's the developing world shows various adventures in every field. In each field the small requirements are very essential to develop big calculations. By using different sources we can modify it as our requirements and implement in various field. In **earlier days the measurements are generally occur through measuring devices**. But now a day's digitalization as is on height. Therefore we use a proper display unit for measurement of distance. We can use sources such as sound waves which are known as ultrasonic waves using ultrasonic sensors and convert this sound wave for the measurement of various units such as distance, speed. This technique of distance measurement using ultrasonic in air includes continuous pulse echo method, a burst of pulse is sent for transmission medium and is reflected by an object kept at specific distance. The time taken for the sound wave to propogate from transmitter to receiver is proportional to the distance of the object.

1.2 Global Scenario:

Distance measurement using Arduino and ultrasonic sensors are vast and diverse. They can be used in autonomous vehicles for obstacle detection and collision avoidance, in industrial settings for object detection and positioning, in healthcare for monitoring patient distances, and in home automation for smart lighting and security systems.

Moreover, this technology can also be used in agriculture for crop monitoring, in sports for measuring ball speed and trajectory, and in education for teaching basic principles of physics and electronic

The development of smart cars requires new sensors that areable to measure distances in the range of a few centimeters to a few meters. Parking aids, as well as intelligent suspensions and headlight leveling, are some examples of features that require a distance measurement to be performed with contactless sensors. Several different physical principles can be employed to measure the distance but price limits greatly restrict the actual choices.

1.3 Problem Statement:

This study aims to create a simple, effective and efficient ultrasonic distance measuring device

To be specific, these are the questions that the researchers seek to answer:

1. Is it possible to create an effective and efficient ultrasonic distance measuring device with a relatively low budget?

2. How much distance can the ultrasonic distance measuring device achieve?

a. Is it comparable to any of the measuring devices that are widely available and used?

b. Does it do a better job of taking measurements than the ones that

already exist?

3. Can the device take measurements with minimal to no errors?

4. Is it not too complicated to adapt the device?

1.4 Motivation of the project:

- Our main moto is to reduce the blindspot accidents.
- Blind spots exist in a wide range of vehicles: aircraft, cars, buses, trucks, agricultural equipments, heavy equipments, boats, ships, trams, and trains.
- Blind spots may occur in the front of the driver when the A-pillar (also called the windshield pillar), side-view mirror, or interior rear-view mirror block a driver's view of the road.
- Behind the driver, cargo, headrests, and additional pillars may reduce visibility.
- Proper adjustment of mirrors and the use of other technical solutions can eliminate or alleviate vehicle blind spots.
- A no zone is one of several areas around a large truck, where the truck driver cannot see. Collisions frequently occur in no zones.
- A blind zone is one of several areas around heavier rolling stocks
- So, we decided to implement a project called distance measurement using ultrasonic sensor in vehicle application.
- Starting from the base, we have chosen a vehicle parking areas to implement this project.
- In Future, we can find a efficient solution to implement the project in various scenario like roads.

CHAPTER 2

2.1 Literature Survey:

The researchers wanted to create an ultrasonic distance measuring device because of the advantages it can have over the ones that are widely available today. As described by Zakari and Aliyu (2014), “The advent of EDM equipment has completely revolutionaries all surveying procedures and resulted in a change of emphasis and techniques, by reason of the fact that distance can now be measured quickly and accurately”. The researchers have examined that if a reliable ultrasonic measuring device would be introduced in the market, a lot of fields involving the importance of distance measurement would benefit from it.According to Sharma and Abrol (2014), when measuring distance, there are two methods: contact and non-contact. The researchers will be using a non-contact method because the ultrasonic sensor to be used does not have to be in physical contact with the object to be measured. In order to do so, the sensor uses the propagation of ultrasonic sound waves.The ultrasonic sensor that will be used by the researchers is the HC-SRO4. The sensor has a transmitter that vibrates short, high-frequency sound pulses that reach a surface then bounces back to the receiver. This method of electronically measuring distance is known as the Pulse Method. According to Rüeger (2012), the way which the Pulse Method works is that, “A short, intensive signal is transmitted by an instrument. It travels to a target point and back and thus covers twice the distance. Measuring the so-called flight time between transmission and reception of the same pulse, the distance may be calculated.To expound on how the ultrasonic sensor works, the study of Mehta and Tiwari (2018) describes the major part of the sensor, the transducer. An ultrasonic sensor usually has the transducer to convert sound energy into electrical energy and vice-versa. These sound waves are in the frequency range of 20000hz which is beyond the hearing range of humans therefore only the sensor can detect them. First, they identified that signal processing is easier because the speed of sound is slower than the speed of light in the presence of air. Second, the relatively short ultrasonic wavelengths allow for a “more highly accurate distance measurement , therefore measuring the distance from such objects does not affect the measurements. Finally, ultrasonic is not affected by the effects of light and airborne dusts, allowing it to perform measurements of distance in outdoor environments. To elaborate, another paper on the use of ultrasonic sensor with the inclusion of Arduino by Soni et al. (2017) explains the theory of sound waves. According to the authors, “Sound waves are defined as longitudinal pressure waves in the medium in which they are travelling. Subjects whose dimensions are larger than the wavelength of the impinging sound waves reflects them, the reflected waves are called the echo. If the speed of sound in the medium is known and the time taken for the sound waves to travel the distance from the source to the subject and back to the source is measured, the distance from the source to the subject can be computed accurately”.A similar study on the use of ultrasonic sensor for distance measurement was also done by Ratan and Luthra (2015). They also applied the use of an ultrasonic sensor for distance measuring due to its versatility and applicability in so many fields. Their objective was to create a low cost simple device with acceptable accuracy. Although they have met the objective of the project, the limitations they found on their project was the need to orient the device perpendicularly to the “plane of propagation of the ultrasonic waves .Another similar study of an ultrasonic sensor for distance measurement was also done by Abdullah (2015). They used an ultrasonic sensor (particularly the HC-SRO4) for their study, it is because they found out that this material is to be the “most reliable and inexpensive method for distance measurement". But in their case, a temperature compensator was added to their system to compensate for the errors that may possibly occur due to the ambient temperature. The is because the speed of ultrasonic wave is affected by the "type of medium and the temperature".The researchers may consider the addition of a temperature compensator if temperature has a substantial effect on the device's capabilities and if it restricts its effectivity in the places where it is expected to be used.Carullo, A., & Parvis, M. (2001). An ultrasonic sensor for distance measurement in automotive applications. IEEE Sensors journal, 1(2), 143. As ultrasonic sensors have a wide application in the field, in a paper published by Carullo and Parvis (2001), they mounted an ultrasonic sensor to measure the distance between the ground and the bottom of the car. Their purpose was to get the height of the car from its bottom surface to the ground with goal of satisfying the requirements in the automotive field. Their experiment was a success and it exemplifies the versatility of an ultrasonic sensor in various fields.With regards to distance measurement, another electromagnetic device patented by Woo and Lien (1979) works similarly to that of the researchers' device. Although the major difference is that they are using an optical sensor for distance

measurement and not an ultrasonic sensor. But their device also has a display capable of showing the resulting measurements. The display can show the measurements according to the preference of the user: in centimeters, inches, or meters. The researchers would like to include something similar by providing two units of measurements in the display. A combination of centimeters and inches which are both the most widely used units in measuring distance worldwide.

CHAPTER 3

PROJECT DESCRIPTION

3.1 EXISTING METHODOLOGY

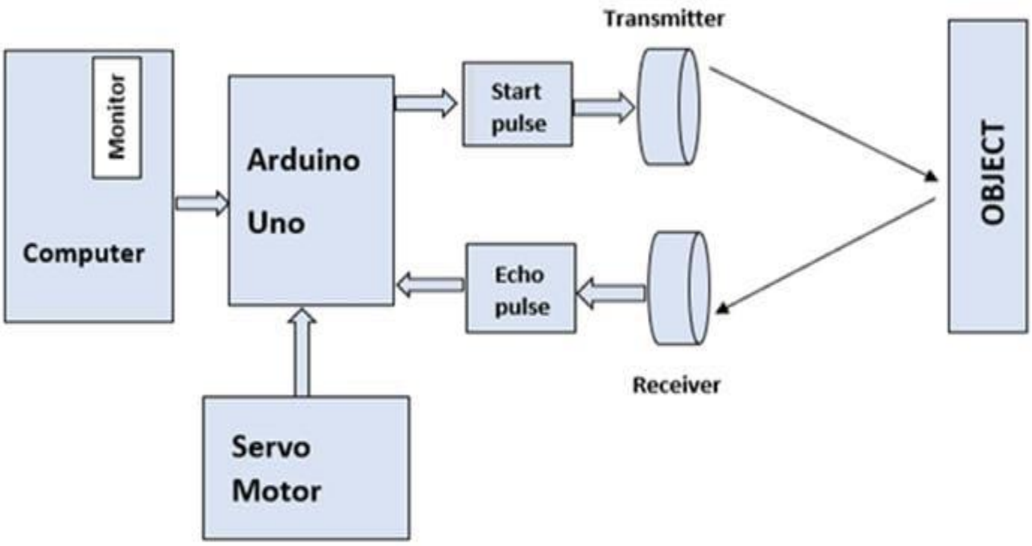
Ultrasonic sensors are commonly used as affordable methods to measure distance in industry. However, the accuracy of their measurements is often low, especially when inexpensive sensors and reasonably low-priced equipment are used. In this article, a low-cost ultrasonic-sensor module which is used for threshold-detection techniques is examined. Several numerical techniques, such as the least square method (LSM), piecewise LSM, and the Vandermonde method were applied to the sensor data to increase the accuracy of the distance measurement. Eventually, the smart filter signal detection algorithm was applied to the sensor data and the results were compared. The smart-filter-signal-detection algorithm provides 0.4-millimeter accuracy. In order to achieve this accuracy, the environment temperature is taken into account.

3.2 PROPOSED METHODOLOGY

The distance measurement system will consist of the HC-SR04 ultrasonic sensor, Arduino board, and various output devices. The ultrasonic sensor will be mounted on the front of the vehicle, facing forward to detect any obstacles in its path. When an obstacle is detected, the sensor will send a signal to the Arduino board, which will then process the data and provide feedback to the driver through the output devices. The feedback may include visual cues such as LED lights or auditory cues such as warning sounds.

- To implement this project, we will need an Arduino board, ultrasonic sensors, jumper wires, and a power source. The ultrasonic sensors will be mounted on the front and back bumpers of the vehicle, and connected to the Arduino board through jumper wires. Once the hardware is set up, we will write a program code that controls the sensors and processes the distarice the measurements. The program will use algorithms to calculate the distance between the vehicle and nearby objects, and display the results on a screen or through audio feedback.The use of ultrasonic sensors and Arduino boards in vehicle applications has a wide range of potential applications beyond just parking and collision avoidance.
- For example, it could be used in autonomous vehicles to provide real-time feedback on the surrounding environment and adjust the vehicle's direction accordingly.
- It could also be used in logistics and transportation applications to monitor the distance between vehicles in a convoy or track the position of goods being transported.
- With the increasing demand for smart transportation solutions, the use of ultrasonic sensors and Arduino boards is likely to become more widespread in the coming years.

3.3 BLOCK DIAGRAM :



. Fig:3.3.1

The ultrasonic sensors will be mounted on the front and back bumpers of the vehicle, and connected to the Arduino board through jumper wires..

Arduino will receive the data from the ultrasonic sensor and process it to calculate the distance between the vehicle and the obstacle. In addition to processing the data, the Arduino board will also be responsible for providing feedback to the driver through various output devices such as speakers or LED lights. In this project we have used buzzer to alert the driver.

CHAPTER 4

HARDWARE AND SIMULATION

4.1 COMPONENTS REQUIRED:

- Jumper wires
- Arduino UNO R3
- Ultrasonic sensor (HC-SR04)
- 16×2 LCD I2C Display
- 10K Potentiometer
- Servo motor
- Resistor (220 ohms)
- Breadboard

4.1.1 JUMPER WIRE:

A jump wire (also known as jumper, jumper wire, DuPont wire) is an electrical wire, or group of them in a cable, with a connector or pin at each end (or sometimes without them – simply "tinned"), which is normally used to interconnect the components of a breadboard or other prototype or test circuit, internally or with other equipment or components, without soldering.

Fig: 4.1.1

4.1.2 ARDUINO UNO R3 BOARD:

Arduino Uno is a microcontroller board based on the ATmega328P (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator (CSTCE16M0V53-R0), a USB connection, a power jack, an ICSP header and a reset button.

The Arduino UNO is the best board to get started with electronics and coding. If this is your first experience tinkering with the platform, the UNO is the most robust board you can start playing with. The UNO is the most used and documented board of the whole Arduino family.

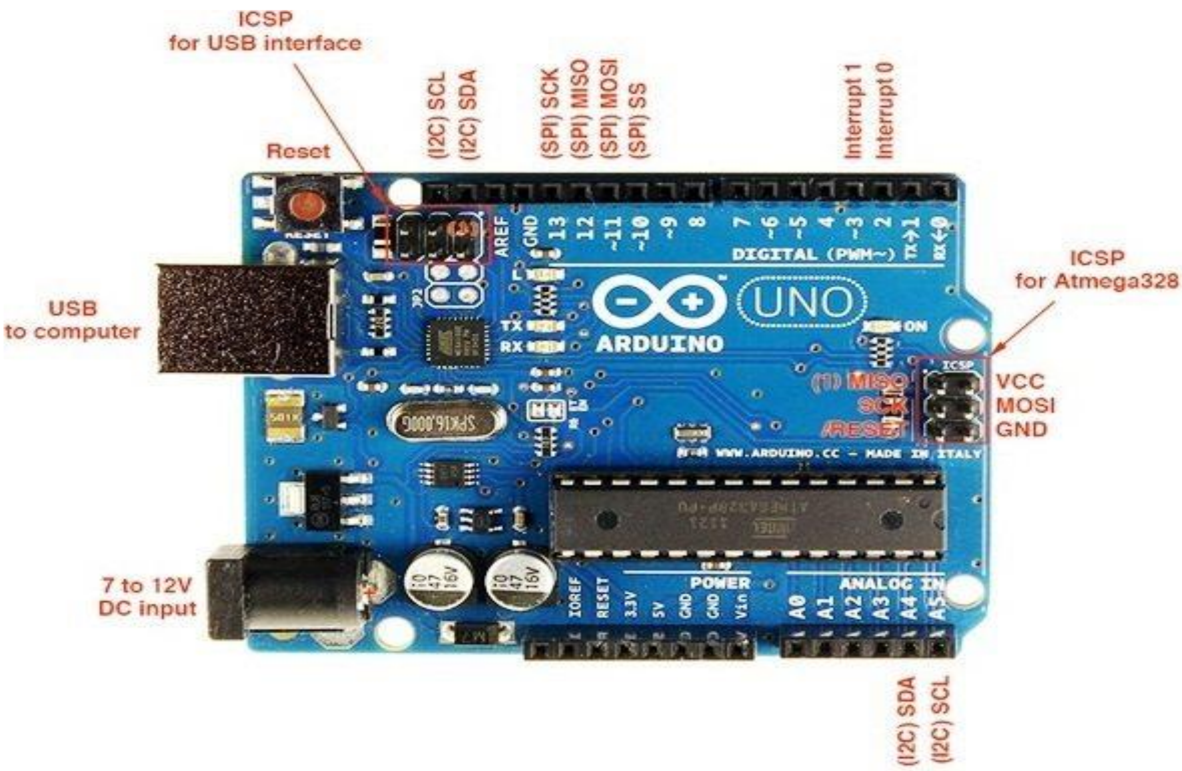


Fig:4.1.2

4.1.2.1 PIN DETAILS – ARDUINO UNO

IOREF (only in R3)	Input Output voltage reference pin, it is internally connected to 5V. Arduino Shields can read this pin to see the board is running at 3.3V or 5V. This allows it to select proper power source or enable input output voltage translators for proper working.
RESET	This pin can be used to RESET arduino. LOW voltage level at this pin resets arduino which is similar to pressing RESET button.
3.3V	3.3V Output
5V	5V Output
GND	Reference Ground
Vin	External Power Input. You may connect +ive of the battery to this pin and -ive of the battery to GND.
A0 – A5	Analog Voltage Input Pins
AREF	Analog Voltage Reference Input. By default analog to digital converter reference voltages are 0 and 5V. We can change the higher reference voltage 5V using AREF pin and analogReference() function.
0 – 13	Digital Input Output Pins
~	Indicated PWM Outputs
TX & RX	Transmit and Receive pins of UART.

4.1.2.2 TECHNICAL DETAILS – ARDUINO UNO

Microcontroller	ATmega328
Operating Voltage	5V
Clock Speed	16MHz
Input Voltage Range (On-Board Regulator)	6 – 20V
Recommended Input Voltage Range	7 – 12V
Digital Input Output Pins	14 (6 can provide PWM output)
Max. Current per IO pin	40mA
Max. Current for 3.3V pin	50mA
Analog Input Pins	6
Flash Program Memory	32KB (of which 0.5KB is used by bootloader)
SRAM	2KB
EEPROM Data Memory	1KB

4.1.3 ULTRASONIC SENSORS

Ultrasonic sensors are great tools to measure distance and detect objects without any actual contact with the physical world. It is used in several applications, like in measuring liquid level, checking proximity and even more popularly in automobiles to assist in self-parking or anti-collision systems.

Fig:4.1.3

In this project, we have used the HC-SR04 UltrasonicSensor with Arduino to determine the distance of an obstacle from the sensor. The basic principle of ultrasonic distance measurement is based on ECHO. When sound waves are transmitted in the environment then waves return back to the origin as ECHO after striking on the obstacle. So we only need to calculate the traveling time of both sounds means outgoing time and returning time to origin after striking on the obstacle.

The speed of the sound is known to us, after some calculation we can calculate the distance. We are going to use this same technique for this Arduino distance measurement project.

4.1.3.1.Ultrasonic Sensor Module:

There are many types of Arduino distance sensors, but in this project we have used the HC-SR04 to measure distance in range of 2cm-400cm with an accuracy of 3mm. The sensor module consists of an ultrasonic transmitter, receiver and control circuit. The working principle of ultrasonic sensor is as follows:

- ❖ High level signal is sent for 10us using Trigger.
- ❖ The module sends eight 40 KHz signals automatically, and then detects whether pulse is received or not.
- ❖ If the signal is received, then it is through high level. The time of high duration is the time gap between sending and receiving the signal.

Distance= (Time x Speed of Sound in Air (340 m/s))/2

4.1.3.2 Timing Diagram:

The module works on the natural phenomenon of ECHO of sound. A pulse is sent for about 10us to trigger the module. After which the module automatically sends 8 cycles of 40 KHz ultrasound signal and checks its echo. The signal after striking with an obstacle returns back and is captured by the receiver. Thus the distance of the obstacle from the sensor is simply calculated by the formula given a

Distance= (time x speed)/2.

Here we have divided the product of speed and time by 2 because the time is the total time it took to reach the obstacle and return back. Thus the time to reach obstacle is just half the total time taken.

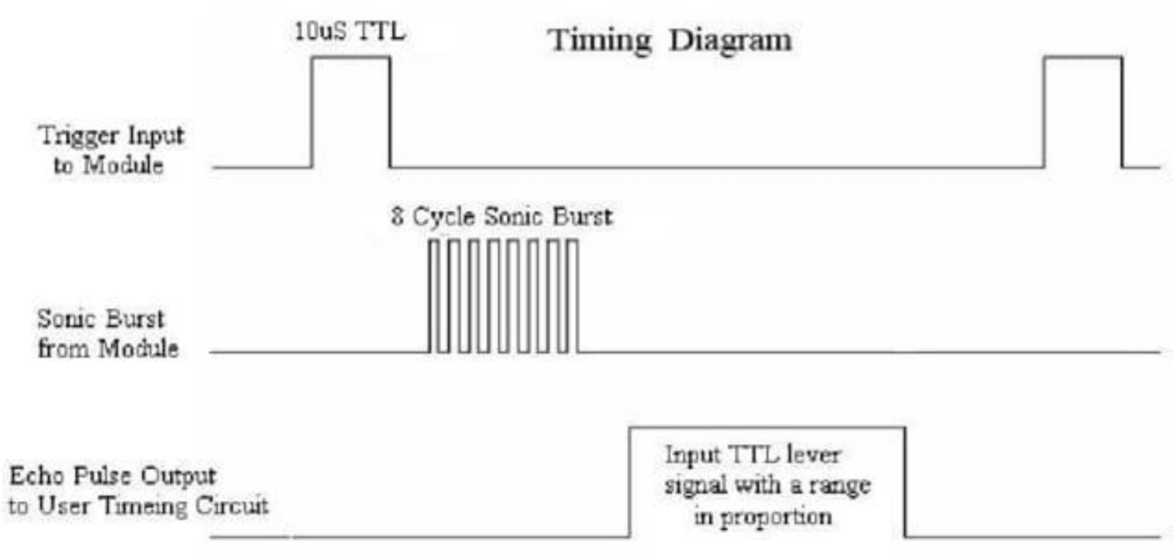


Fig:4.1.3.2

4.1.4 16X2 LCD DISPLAY

This is a 16x2 LCD display screen with I2C interface. It is able to display 16x2 characters on 2 lines, white characters on blue background. These displays are mainly preferred for multi-segment light-emitting diodes and seven segments. The main benefits of using this module are inexpensive; simply programmable, animations, and there are no limitations for displaying custom characters, special and even animations, etc.

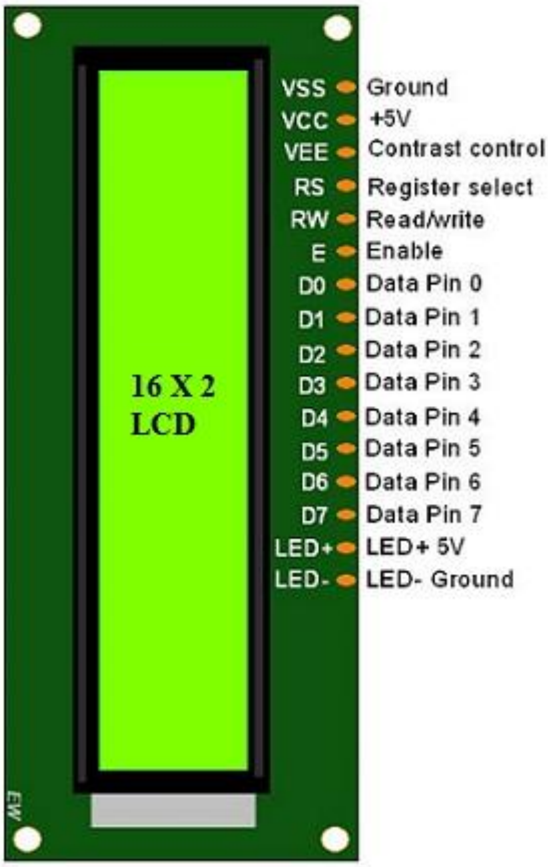


Fig:4.1.4

Usually, Arduino LCD display projects will run out of pin resources easily, especially with Arduino Uno. And it is also very complicated with the wire soldering and connection. This I2C 16x2 Arduino LCD Screen is using an I2C communication interface. It means it only needs 4 pins for the LCD display: VCC, GND, SDA, SCL. It will save at least 4 digital/analog pins on Arduino. All connectors are standard XH2.54 (Breadboard type). You can connect with the jumper wire directly.

4.1.5 10K POTENTIOMETER

The 10K Potentiometer is used for **adjusting various parameters like voltage, current, etc in an electronic circuit**. The POT Potentiometer is a passive electronic component that has two end terminals with a resistive element and the sliding contact called the wiper acts as the third terminal.It is mostly used in application where a single turn can provide enough control resolution.

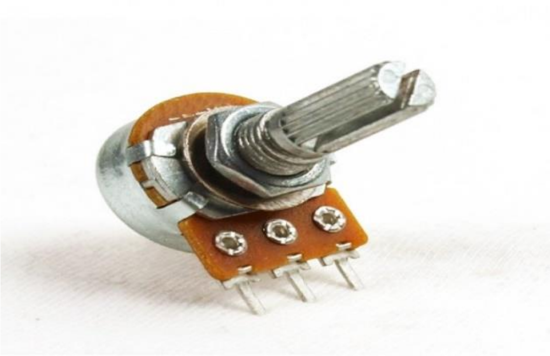


Fig:4.1.5

SPECIFICATIONS:

Resistance	10K Ohm
Potentiometer Type	Pot Potentiometer
Material	Carbon Film and Metal
Interface	3 Pin
Shaft Length	15mm
Dimensions	1 x 1 x 1cms
Weight	15 grams

Table:4.1.5

4.1.6 Servo motor

Servo motors are electronic devices and rotary or linear actuators that rotate and push parts of a machine with precision. Servos are **mainly used on angular or linear position and for specific velocity, and acceleration.**

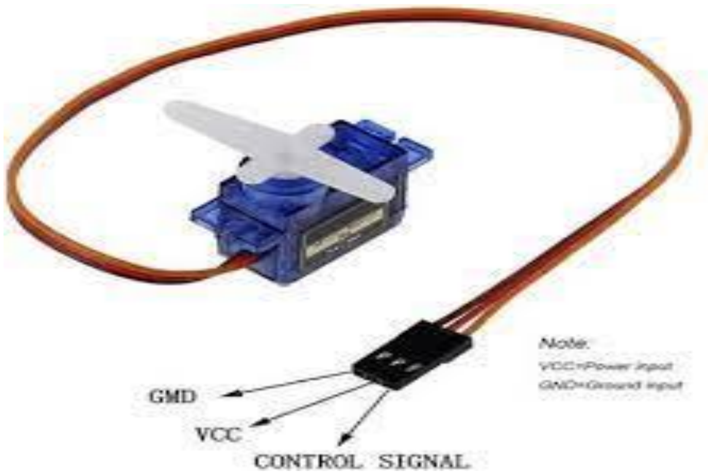


Fig:4.1.6

In this project, an ultrasonic sensor is tied to a servo motor. The servo motor rotates continuously between 0 and 180 degrees, performing the function of a radar.

When an object comes in the range of the sensor, the sensor tracks it and raises an alarm. The corresponding distance of the object from the sensor gets displayed on the LCD screen.

4.1.7 220 Ohm resistor

The 220 Ohm resistor can be identified via resistor color codes of Red-Red-Brown-Gold or Red-Red-Black-Black-Gold

Fig:4.1.7

In this project we used resistors to limit the amount of current going to certain components in the circuit, such as LEDs and integrated circuits.

4.1.8 Breadboard

A breadboard is a solderless construction base used for developing an electronic circuit and wiring for projects with microcontroller boards like Arduino. As common as it seems, it may be daunting when first getting started with using one.

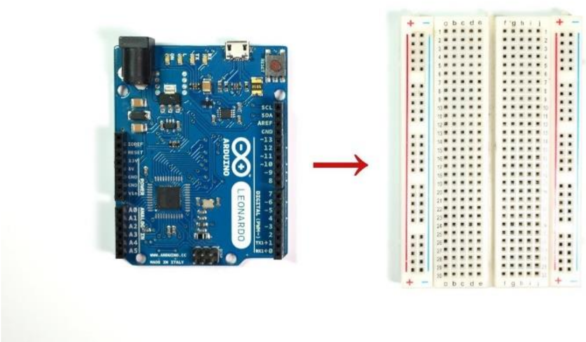


Fig:4.1.8

4.2 HARDWARE CONNECTIONS:

The circuit diagram for arduino and ultrasonic sensor is shown above to measure the distance. In circuit connections Ultrasonic sensor module's "trigger" and "echo" pins are directly connected to pin 18(A4) and 19(A5) of arduino. A 16x2 LCD is connected with arduino in 4-bit mode. Control pin RS, RW and En are directly connected to arduino pin 2, GND and 3. And data pin D4-D7 is connected to 4, 5, 6 and 7 of arduino.

First of all we need to trigger the ultrasonic sensor module to transmit signal by using arduino and then wait for receive ECHO.This technique of distance measurement using ultrasonic in air includes continuous pulse echo method, a burst of pulse is sent for transmission medium and is reflected by an object kept at specific distance.

The time taken for the sound wave to propogate from transmitter to receiver is proportional to the distance of the object. In this distance measurement system we had ultrasonic sensor HC-SR04 interfaced with Arduino UnoR3. Programming and hardware part of ultrasonic sensor interfacing with Arduino UnoR3.servo motors are used to control the position of objects, rotate objects, move legs, arms or hands of robots, move sensors etc. with high precision. Servo motors are small in size, and because they have built-in circuitry to control their movement, they can be connected directly to an Arduino.

Arduino reads the time between triggering and Received ECHO. We know that speed of sound is around 340m/s. so we can calculate distance by using given formula:

Distance= (travel time/2) * speed of sound

Where speed of sound around 340m per second. A 16x2 LCD displaying distance

4.3 Simulation Model :-

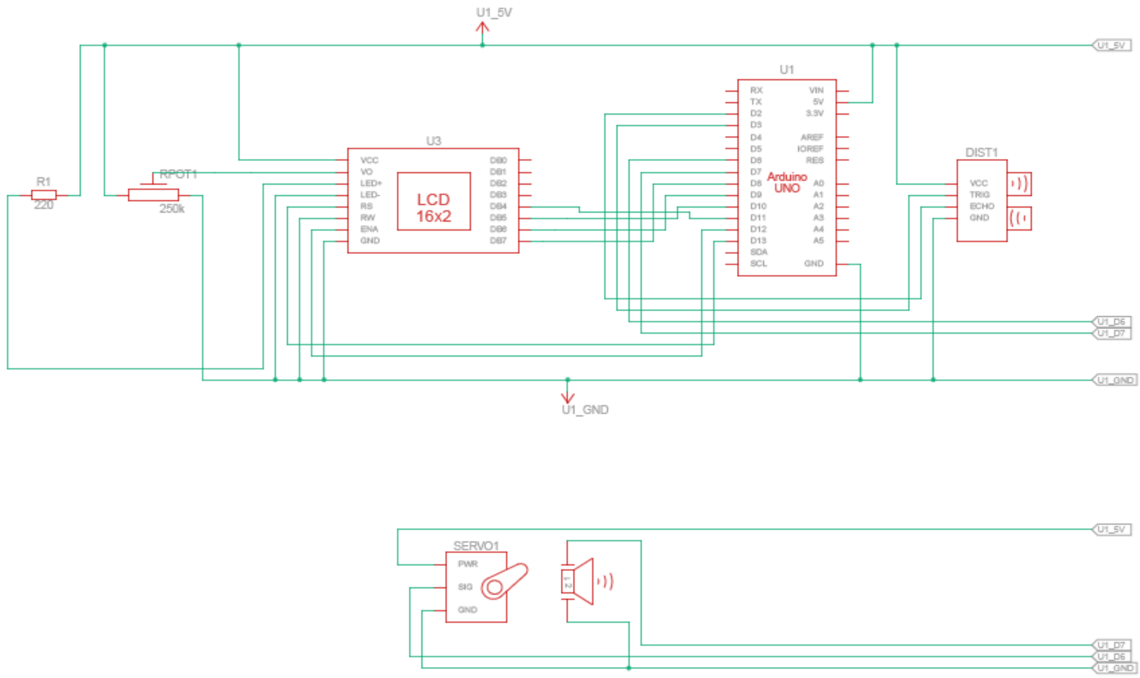


Fig: 4.3a

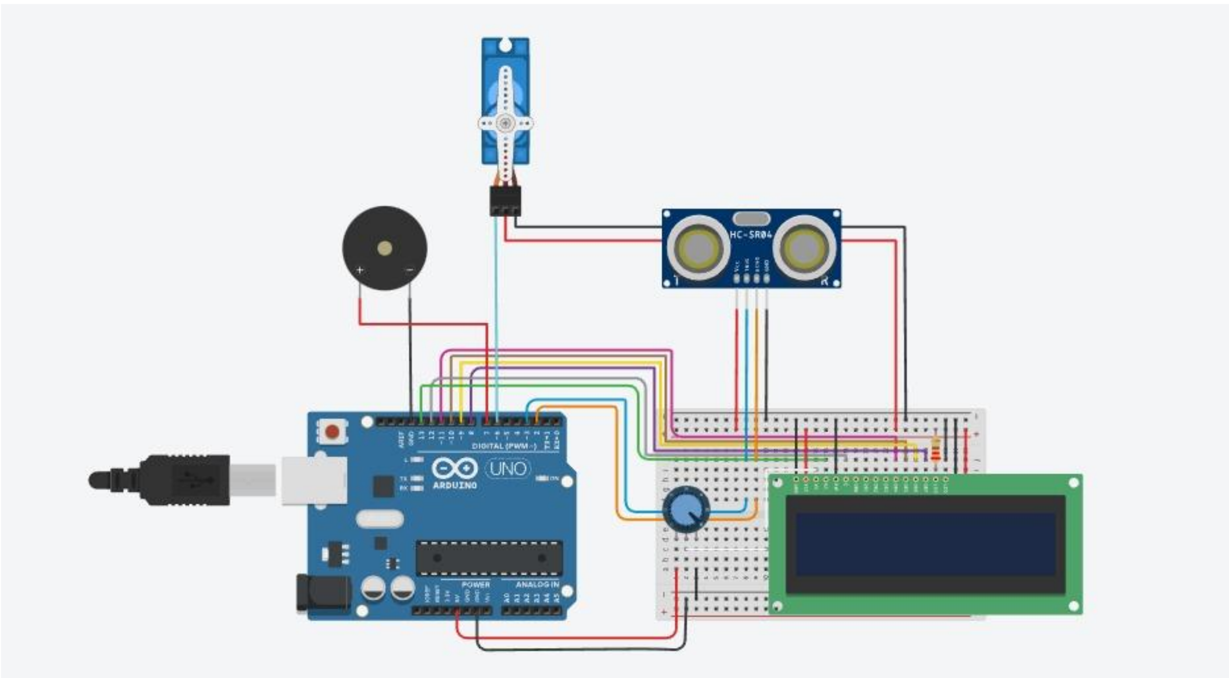


Fig:4.3 b

4.4 ARDUINO PROGRAM:

```
#include <LiquidCrystal.h> //LCD library
 #include<Servo.h> //Servo library

  #define echo   2
  #define trig   3
  #define Buzzer 7

const int scan_Distance = 100;//distance upto which the sensor should
scan
float  duration; // time taken by the pulse to return back
float distance;  // oneway distance travelled by the pulse
Servo myservo ;

  LiquidCrystal lcd(13, 12, 11, 10, 9, 8);//lcd(RS,EN,D4,D5,D6,D7)

  void setup() {
    myservo.attach(6); // Servo is connected to Digital pin 6

    pinMode(trig, OUTPUT);
    pinMode(echo, INPUT);
    pinMode(Buzzer,OUTPUT);
    Serial.begin(9600);
    lcd.begin(16, 2);

  }
```

```
void loop() {
  for (int i = 0; i <= 180; i++) {
    myservo.write(i);
    time_Measurement();
    distance = duration * (0.0343) / 2;
    if (distance <= scan_Distance) {
      intruder_detected();
    }
    else {
      lcd.clear();
      lcd.print("Scanning...... ");
    }
    delay(100);
  }
  for (int i = 180; i >= 0; i--) {
    myservo.write(i);
    time_Measurement();
    distance = (float)duration * (0.0343) / 2;
    if (distance <= scan_Distance) {
      intruder_detected();
    }
    else {
      lcd.clear();
      lcd.print("Scanning...... ");
    }
    delay(100);
```

```
  }
}

void time_Measurement()
{
  digitalWrite(trig, LOW);
  delayMicroseconds(2);

  digitalWrite(trig, HIGH);
  delayMicroseconds(10);
  digitalWrite(trig, LOW);

  duration = pulseIn(echo, HIGH);
}

void intruder_detected()
{
  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print("  Intruder at ");
  lcd.setCursor(0, 1);
  lcd.print("    ");
  lcd.print(distance);
  lcd.print(" cm");
  digitalWrite(Buzzer, HIGH);
  delay(3000);
  digitalWrite(Buzzer, LOW);}
```

4.5 Simulation Output using Tinkercad software:

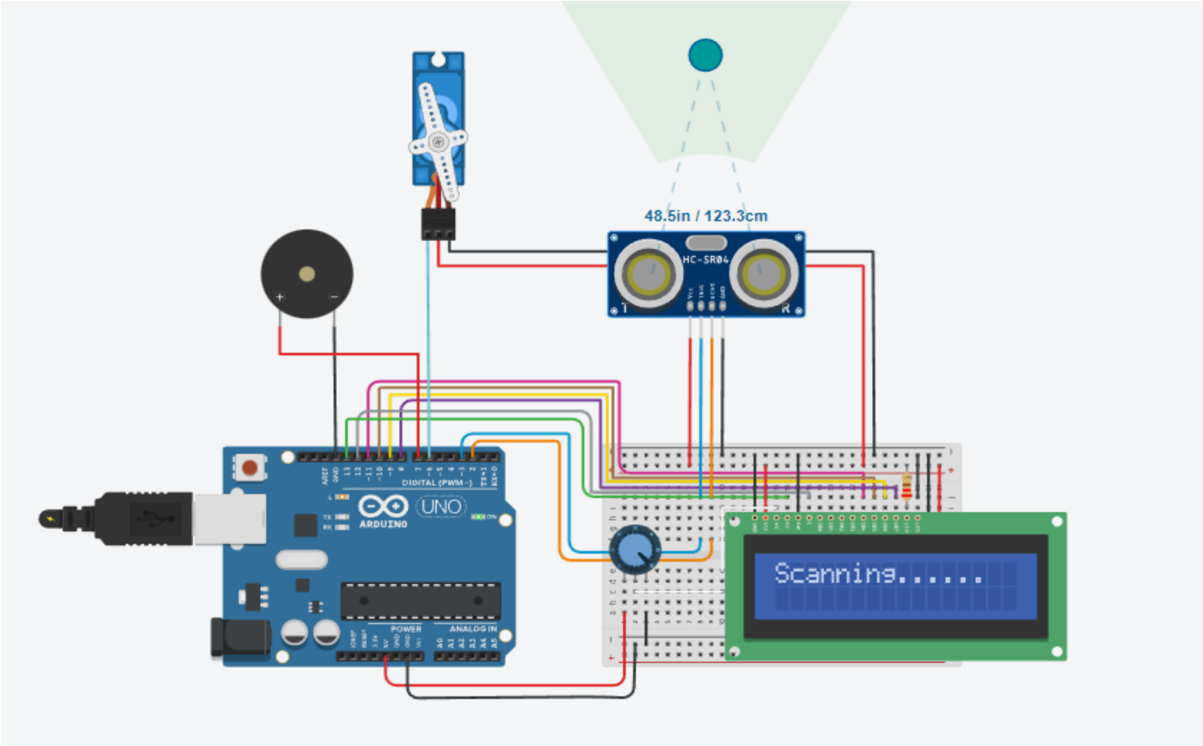


Fig: 4.5 a

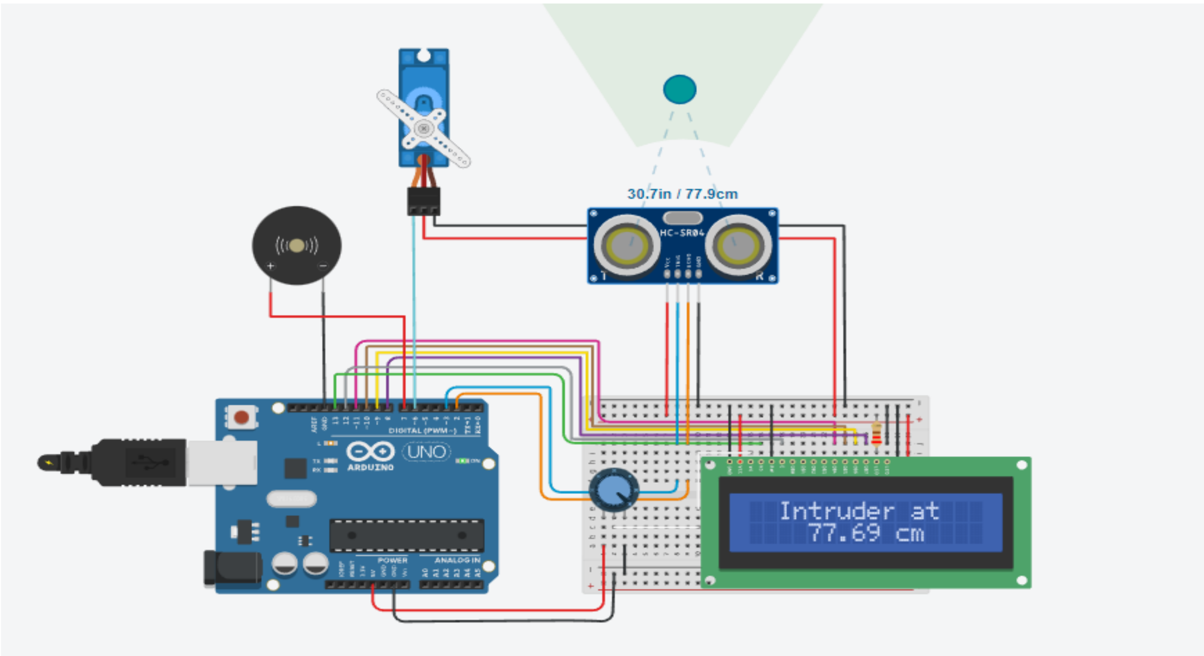
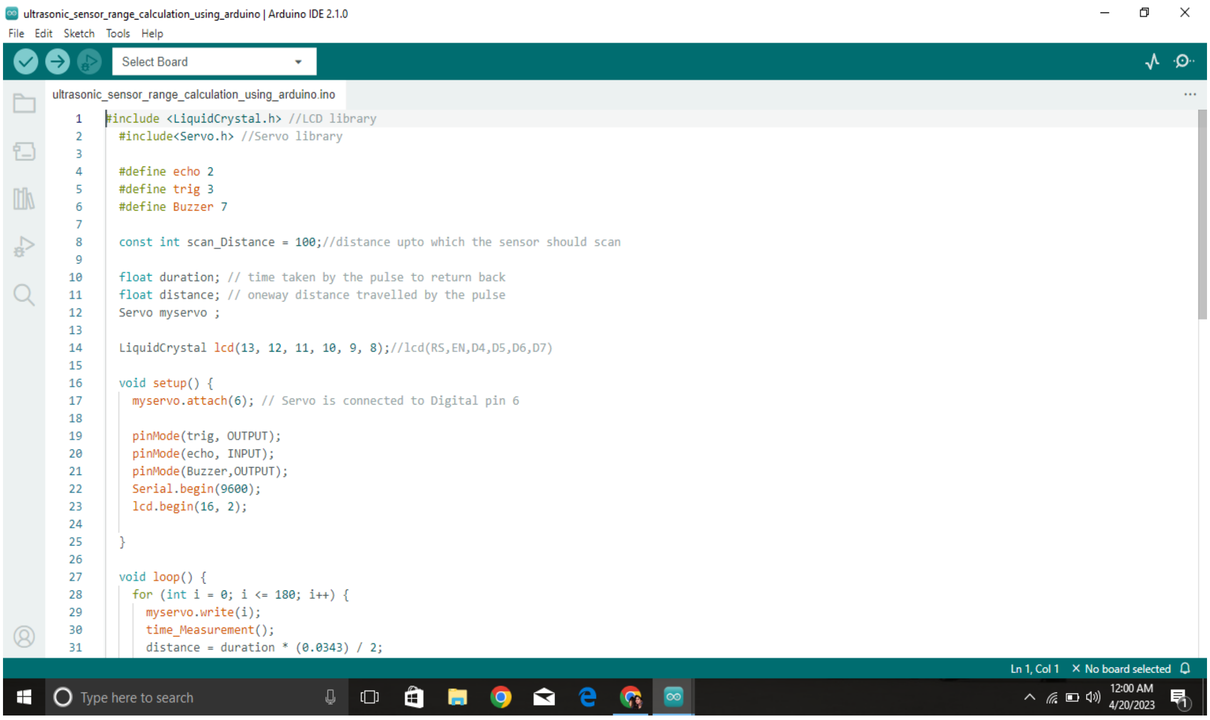
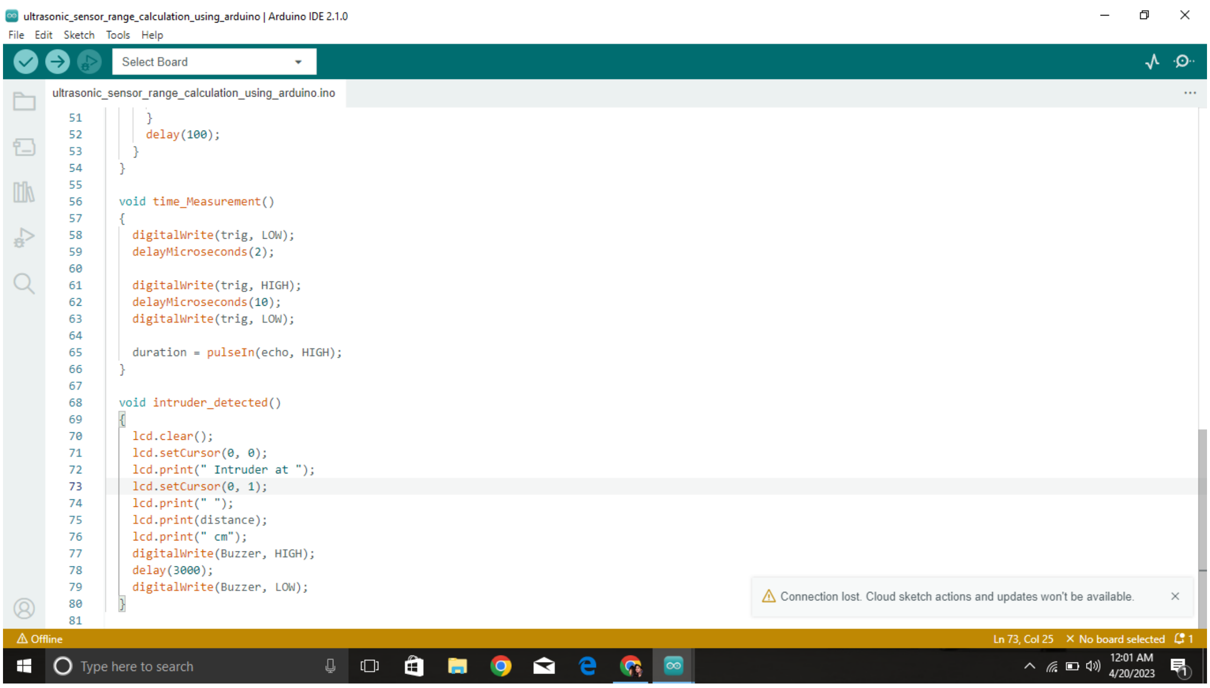


Fig: 4.5 b

4.6 AURDINO IDE PROGRAM EXECUTION:





CHAPTER 5

CONCLUSION AND FUTURE SCOPE

Distance measurement using ultrasonic sensors and Arduino is a popular research area with various applications. The results of this review indicate that ultrasonic sensors and Arduino are widely used in the development of electronic projects related to distance measurement. Further research is needed to explore the potential of these technologies in various other applications

Distance =speed*time

The human audible range can be converted measure the distance precisely manner

FUTURE SCOPE

The range can be improved by:
1.Using temperature adjustable devices, it can be used over wide temperature range.
2. Using High Range Ultrasonic sensors to extend the range of distance measurement.

References

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