AMRUTVAHINI COLLEGE OF ENGINEERING, SANGAMNER

Department of Electronics and Telecommunication Engineering

A

PROJECT BASED LEARNING (PBL) REPORT

ON

"CONTACTLESS DISTANCE MEASUREMENT SYSTEM"

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Year: 2021-22

Department of Electronics & Telecommunication Engineering

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CERTIFICATE

This is to certify that the PBL report entitled

"CONTACTLESS DISTANCE MEASUREMENT SYSTEM"

has satisfactorily completed by,

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In partial fulfillment of term work for Second year of E&TC engineering
In Savitribai Phule Pune University for academic year 2021-2022.

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CHAPTER 1
INTRODUCTION

1.1 ABSTRACT

Distance measurement of an object in the path of a person, equipment, or a vehicle, stationary or moving is used in a large number of applications such as robotic movement control, vehicle control, blind man's walking stick, medical applications, etc. Measurement using ultrasonic sensors is one of the cheapest among various options. In this project distance measurement of an obstacle by using ultrasonic sensor and a microcontroller is presented.

The current methods of blockage detection are based on manual visual inspection and inspection through CCD camera-based equipment's. In such systems first pictures of obstacle can be obtained and then they are observed and analyzed. The main limitation of these systems is that they cannot tell you the exact distance or location of the obstacle.

1.2 INTRODUCTION

Distance measurement of an object in front or by the side of a moving entity is required in a large number of devices. These devices may be small or large and also quite simple or complicated. Such distance measurement systems are available. These uses various kinds of sensors and systems. Low cost and accuracy as well as speed is important in most of the applications.

Among the various techniques of noncontact measurement, ultrasonic technique is the best when we need stable and accurate distance of obstacle, no matter what colour it is. It is also usable outside in the sun. As the human ear's audible range is 20 Hz to 20 kHz, it is insensitive to ultrasonic waves, and hence the ultrasound waves can be used for applications in industries or vehicles without hindering human/other activity. In this project, we are going implement such a measurement system which uses ultrasonic sensor unit and an Arduino Uno based system. The Arduino Uno is easily available at low cost. An error correction is applied to minimize the error in the measured distance. Ultrasound sensors are very versatile in distance measurement. They are also providing the cheapest solutions.

Ultrasound waves are useful for both the air and underwater. Ultrasonic sensors are also quite fast for most of the common applications. The working of this system is to take input from ultrasonic sensor about the obstacle and send it for processing to Arduino, then display the results on the lcd screen

1.3 NEED OF PROJECT

- The main need of this project is to provide a useful system to measure the distance which will be easy to configure and handle.

1.4 AIM OF THE PROJECT

- The aim of this project is to design and develop contactless distance measurement system which uses ultrasonic waves to detect obstacle.

1.5 OBJECTIVES OF THE PROJECT

- To study the working of ultrasonic sensor, Arduino uno, lcd display.
- To study the behavior of ultrasonic waves i.e., reflection of ultrasound.
- To measure distance without direct contact with the object.
- To measure the distance with accuracy. 5) The main objective of this system is to measure the distance between system and the object without any physical contact with the object.

1.6 LITERATURE SURVEY:

Obstacle detecting sensors are one of the most basic type of sensors that electronic hobbyists use. There are several methods to make cheap obstacle sensors. These simple sensors are made using an IR Rx/Tx pair or Normal LED and LDR pair(this design is most basic and is heavily affected by environment lighting conditions). This sensor may be useful for simple requirement but they have following drawbacks :

1. Can't say anything about the real distance of obstacle.
2. Give different result for different coloured obstacles.
3. Need calibration (like setting up a variable resistor).

To solve these problems initially IR Range Finder Modules(like one made by Sharp) were used but they have small range. [2]

1. 1 Sharp GP2D12 Distance Measurement Sensor has a maximum range of 80cm
2. Sharp GP2D120 Distance Measurement Sensor has a maximum range of 30cm only.

To solve all these problems, we can use an Ultrasonic Range Finder Module. An Ultrasonic Range Finder Module uses ultrasonic waves (inaudible to humans) to measure distance. These modules consist of an Ultrasonic Transmitter (Tx) that emits the ultrasonic wave, the waves after striking any obstacle bounces back and reach the Ultrasonic Receiver (Rx). By measuring the time, it takes for the whole process to complete and using simple arithmetic we can measure the distance to the obstacle[3]. The Ultrasonic Range Finder Modules has a wide operating range of 1cm to 400cm with an accuracy of 1cm. These specifications make it ideal for distance measurement application. These can be used for:

1. Contact less measurement of liquid level in tanks (even 4m deep tank).
2. Radars for robot.
3. Obstacle sensing in Robotics.
4. Speed check in roads.
5. Handheld units that can be pointed on vehicles to measure their speed.
6. Fixed unit installed in check booths that can click pictures of over speeding vehicles.

The reason for using ultrasonic wave is

1. The speed of Ultra Sonic waves is 343m/s (Speed of Sound) which is not too fast for MCUs to measure accurately. Compare this with speed of electromagnetic waves (like light or radio waves) which is 30,00,00,000 m/s! So, it takes only 20ns (nano second) to go and bounce back from an obstacle which is 3m away! An AVR running at 16MIPS(maximum for most AVRs) takes 62ns to execute a single instruction.
2. Ultrasonic waves travels narrower, like a beam than normal sound wave. This property helps the sensor detect the obstacles that are exactly in line with it only. The sensors can be rotated with steppers or servo motors to get a ”image” of obstacle in the surrounding area (like a radar). 3. Finally the wave does not disturb any humans nearby.

1.6.1 COMPARISON TABLE:

Table 1: Comparison of Existing Systems

Sr. No	Authors	Paper Title	Publisher	Year	Method Used	Drawbacks
1	Arefin Shamsul MD., & Mollick Tajrian	Design of an Ultrasonic Distance Meter	International Journal of Scientific & Engineering Research Volume 4	2013	Based on ultrasonic technology	But the range of measurement is 2.5 m
2.	Suleiman Khayal, Osama	Obstacle Detection Using the Concept of Ultrasound	IEEE	2016	It can detect obstacles in its path	It can only detect obstacle not the distance
3.	K. Ramasubramanian, R. A. Chandini and V. Mallapragada	Optical Sensor for Noncontact Measurement of Lignin Content in High-Speed Moving Paper Surfaces	IEEE	2014	Based on Arduino based control unit	The system includes only tracking

4.	Ahman, Emmanuel & Maryam Oluwadamilola, Abdusalaam & Lukman, Ajao	Embedded System Based Radio Detection and Ranging (RADAR) System Using Arduino and Ultra-Sonic Sensor	American Journal of Embedded Systems and Applications	2017	Based on radar subunit device	The system includes only the direct object detection
5	H. Bhuyan, M. A. Rabby, M. A. Parvez and M. M. G. Tarik	Microcontroller Based Display System Design using LED Array	Proceedings of the Conference on Engineering Research, Innovation and Education	2018	Based on radar system	System doesn't respond to greater power
6	Jetzt, J. J.	Critical distance measurement of rooms from the sound energy spectral response	The Journal of the Acoustical Society of America	1979	Based on sound optimization technique	No implementation of tracking

1.6.2 PLANNING

Table 2: Planning

Sr. no.	Month	Task
1	February 2022	• Formed the group. • Did the survey on problems related to renewable energy sources. • Found out the problems faced by the people. • Discussed different ideas with Guide related to Agriculture, Robotics, and Embedded.
2	February 2022	• Final topic was selected: “Contactless distance measurement system.” • Gave presentation on final topic. • Suggestions are given by the teachers.

3	March 2022	• Literature survey • Block diagram implementation • Finalization of components, downloading of datasheet of each component used for the project.
4	March 2022	• Circuit diagram design. • Designed the Flowchart. • Simulation on Tinkercad
5	April 2022	• Testing • Real time programming. • Faults finding
6	April 2022	• Troubleshooting and modifications if necessary. • Preparation of report.

CHAPTER 2
HARDWARE DESIGN

2.1 BLOCK DIAGRAM

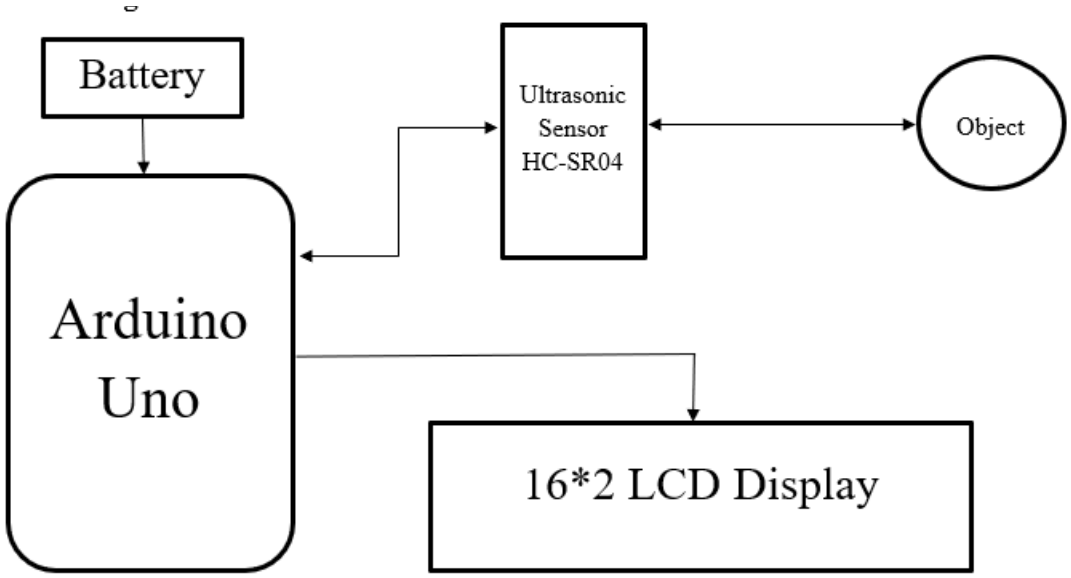

Fig.1: Block Diagram

2.1.1 BLOCK DIAGRAM DESCRIPTION:

First of all, we provide power to the Arduino uno. After that Arduino sends signal to the ultrasonic sensor which further converts it into ultrasound and propagates it in perpendicular direction to the ultrasonic sensor. After some time, the reflected waves from object are detected by receiver of ultrasonic sensor.

This data is further sent to the Arduino uno, after that Arduino calculates the distance travelled by ultrasound and stores the result into a variable distance.

After that this data is send to the lcd display. The lcd display displays the counted distance on the display

2.2 COMPONENTS REQUIRED:

2.2.1 Arduino Uno R3

The **Arduino Uno** is a microcontroller board based on the ATmega328. Arduino is an open-source, prototyping platform and its simplicity makes it ideal for hobbyists to use as well as professionals. The Arduino Uno has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller,

simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started.

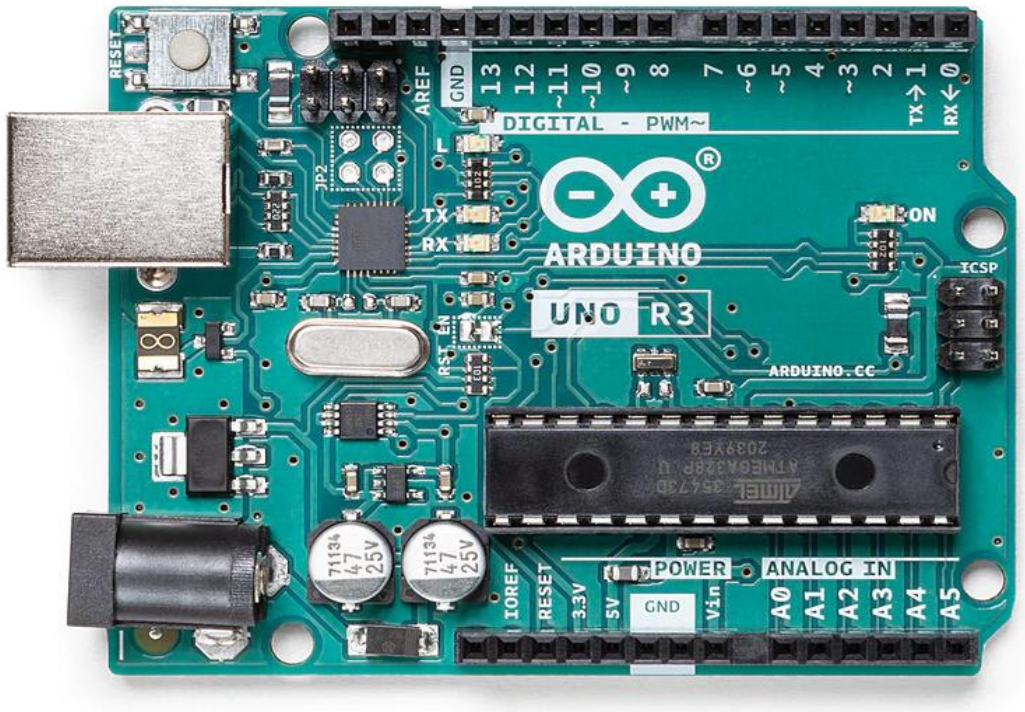

Fig.2: Arduino Uno R3

Features:

- Microcontroller: ATmega328P
- Operating Voltage: 5V
- Input Voltage (recommended): 7-12V
- Input Voltage (limits): 6-20V
- Digital I/O Pins: 14 (of which 6 provide PWM output)
- Analog Input Pins: 6
- DC Current per I/O Pin: 40 mA
- DC Current for 3.3V Pin: 50 mA
- Flash Memory: 32 KB of which 0.5 KB used by bootloader
- SRAM: 2 KB (ATmega328)
- EEPROM: 1 KB (ATmega328)
- Clock Speed: 16 MHz

2.2.2 Ultrasonic sensor (HC SR-04):

The HC-SR04 Ultrasonic distance sensor consists of two ultrasonic transducers. The one acts as a transmitter which converts electrical signal into 40 kHz ultrasonic sound pulses. The receiver listens for the transmitted pulses. If it receives them, it produces an output pulse whose width can be used to determine the distance the pulse travelled. The sensor is small, easy to use in any robotics project and offers excellent non-contact range detection between 2 cm to 400 cm (that's about an inch to 13 feet) with an accuracy of 3mm. Since it operates on 5 volts, it can be hooked directly to an Arduino or any other 5V logic microcontrollers.

Fig.3 Ultrasonic sensor (HC SR-04)

Operating Voltage	DC 5V
Operating Current	15mA
Operating Frequency	40KHz
Max Range	4m
Min Range	2cm
Ranging Accuracy	3mm
Measuring Angle	15 degree
Trigger Input Signal	10µS TTL pulse
Dimension	45 x 20 x 15mm

2.2.3 16X2 LCD:

LCD (Liquid Crystal Display) screen is an electronic display module and find a wide range of applications. A 16x2 LCD display is very basic module and is very commonly used in various devices and circuits. These modules are preferred over seven segments and other multi segment LEDs.

This LCD has two registers, namely, Command and Data. The command register stores the command instructions given to the LCD. A command is an instruction given to LCD to do a predefined task like initializing it, clearing its screen, setting the cursor position, controlling display etc. The data register stores the data to be displayed on the LCD. The data is the ASCII value of the character to be displayed on the LCD. Click to learn more about internal structure of a LCD.

No	Symbol	Function
1	VSS	Ground
2	VDD	5V +
3	V0	Contrast
4	RS	Register
5	RW	Read/Write
6	E	Enable
7	D0	Data bus
8	D1	Data bus
9	D2	Data bus
10	D3	Data bus
11	D4	Data bus
12	D5	Data bus
13	D6	Data bus
14	D7	Data bus
15	A	Anode (5V+)
16	K	Cathode (GND)

Fig.4: 16x2 LCD

Interface Pin Description:

- The operating voltage of this display ranges from 4.7V to 5.3V
- The display bezel is 72 x 25mm
- The operating current is 1mA without a backlight
- PCB size of the module is 80L x 36W x 10H mm
- HD47780 controller
- LED colour for backlight is green or blue
- Number of columns – 16
- Number of rows – 2
- Number of LCD pins – 16
- Characters – 32
- It works in 4-bit and 8-bit modes
- Pixel box of each character is 5×8 pixel
- Font size of character is 0.125Width x 0.200height

2.2.4 Battery(9V):

The 9V battery is an extremely common battery that was first used in transistor radios. It features a rectangular prism shape that utilizes a pair of snap connectors which are located at the top of the battery. This battery is very efficient and provides power for more time.

Fig.5: Battery(9V)

Features:

9V Battery Nominal Voltage:	9 Volts
Capacity (Alkaline) ≈	550 mAh
Capacity (Carbon-Zinc) ≈	400 mAh
Capacity (Lithium Primary) ≈	1200 mAh
Capacity (NiMH) ≈	175-300mAh
Operating Temperature:	0°C – 60°C
Length:	17.5 mm
Height:	48.5 mm
Width:	26.5 mm
Chemistry:	Alkaline, Lithium, Carbon-Zinc, NiCd, NiMH, Lithium-Ion

2.2.5 Battery snap(9V) with DC jack:

A 9v Battery Snap Connector with DC Jack with Battery Connector Cap is an adapter which transfers the 9 volts from a battery to a DC power plug- which then can be plugged in and power a DC power barrel jack with 9 volts. The 9V Battery Snap Connector with Power Plug provides the ability to conveniently use a 9V battery to power many common boards and modules such as the popular Arduino and compatible microcontrollers.

Fig.6: Battery snap(9V) with DC jack

2.2.6 SPST switch:

A Single Pole Single Throw (SPST) switch is a switch that only has a single input and can connect only to one output. This means it only has one input terminal and only one output terminal.

A Single Pole Single Throw switch serves in circuits as on-off switches. When the switch is closed, the circuit is on. When the switch is open, the circuit is off.

SPST switches are, thus, very simple in nature.

Fig.7: SPST switch

2.2.7 Male to Female jumper wires:

Jumper wires are simply wires that have connector pins at each end, allowing them to be used to connect two points to each other without soldering. Jumper wires are typically used with breadboards and other prototyping tools in order to make it easy to change a circuit as needed.

Jumper wires typically come in three versions: male-to-male, male-to-female and female-to-female. The difference between each is in the end point of the wire. Male ends have a pin protruding and can plug into things, while female ends do not and are used to plug things into.

Fig.8: Male to Female jumper wires

2.3 CIRCUIT DIAGRAM:

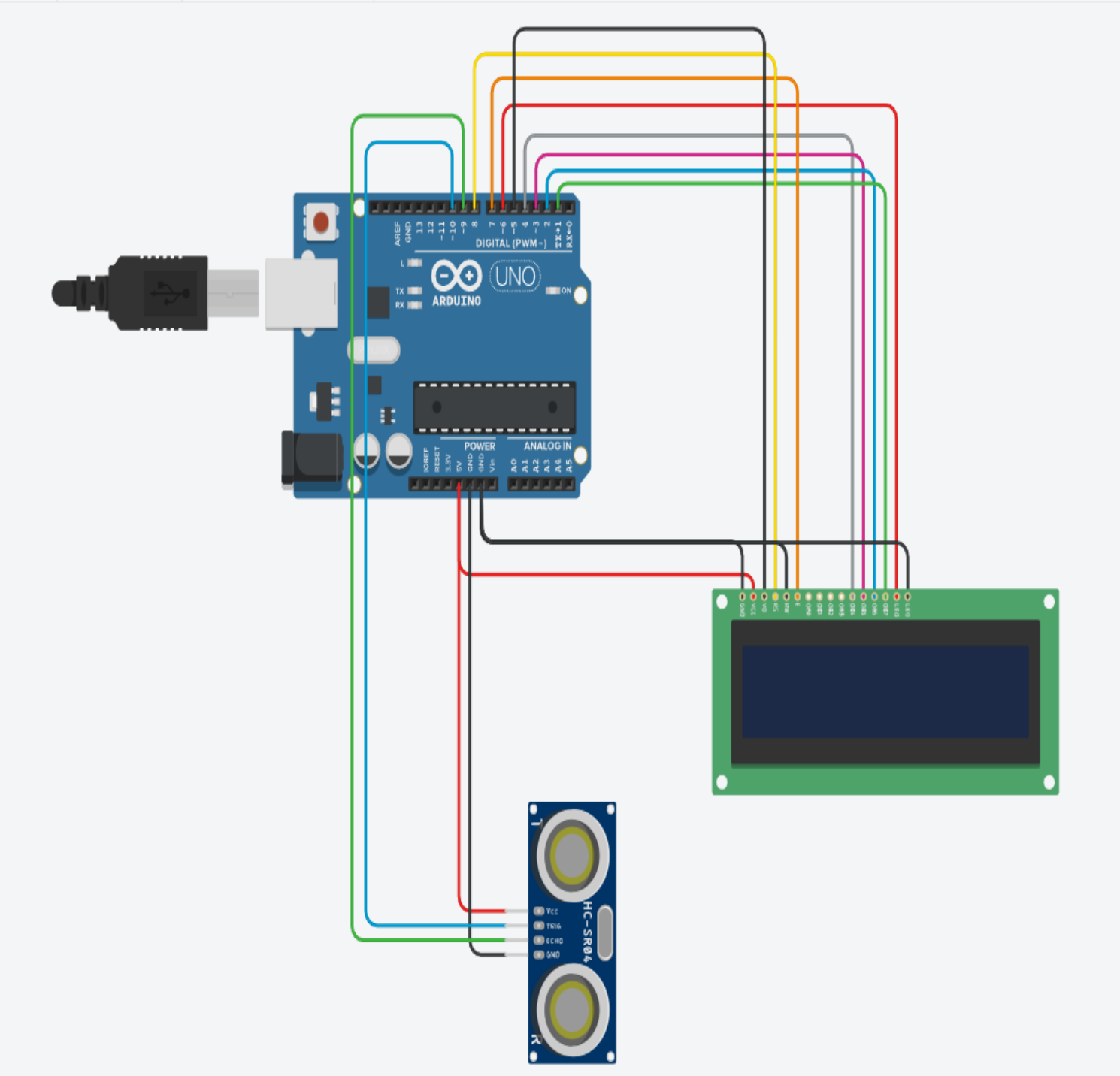

Fig.9: Circuit Diagram of system

2.4 WORKING MODEL (PROTOTYPE):

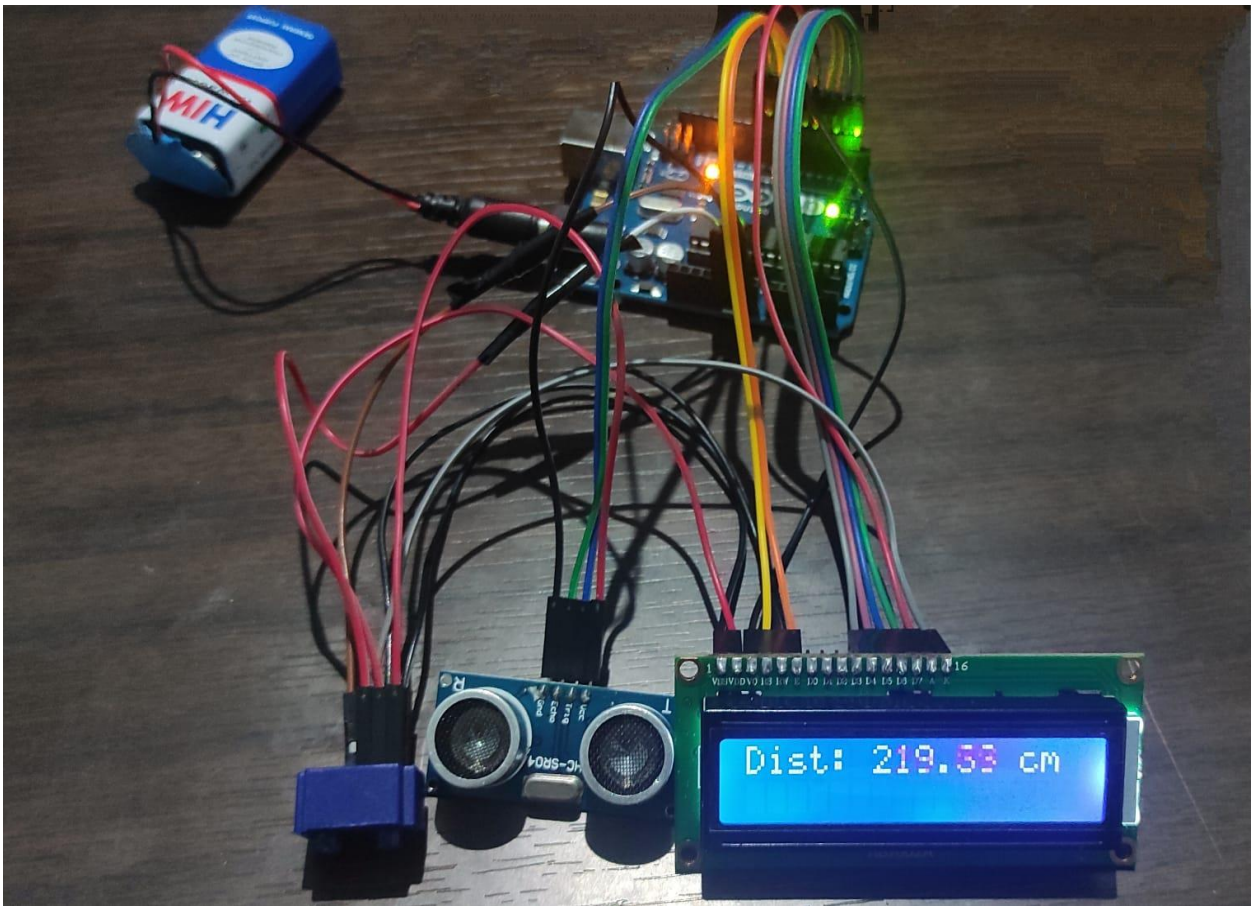

Fig.10: Working model (prototype)

CHAPTER 3

3.1 ALGORITHM:

Step 1: Start
Step 2: Transmit pulse and initialize the timer
Step 3: Count time until getting reflected pulse
Step 4: If get reflected pulse then stop the timer, else wait until getting reflected pulse
Step 5: Then send counted time to MCU for calculations
Step 6: After calculation send the results to display them on lcd screen
Step 7: End

3.2 FLOWCHART:

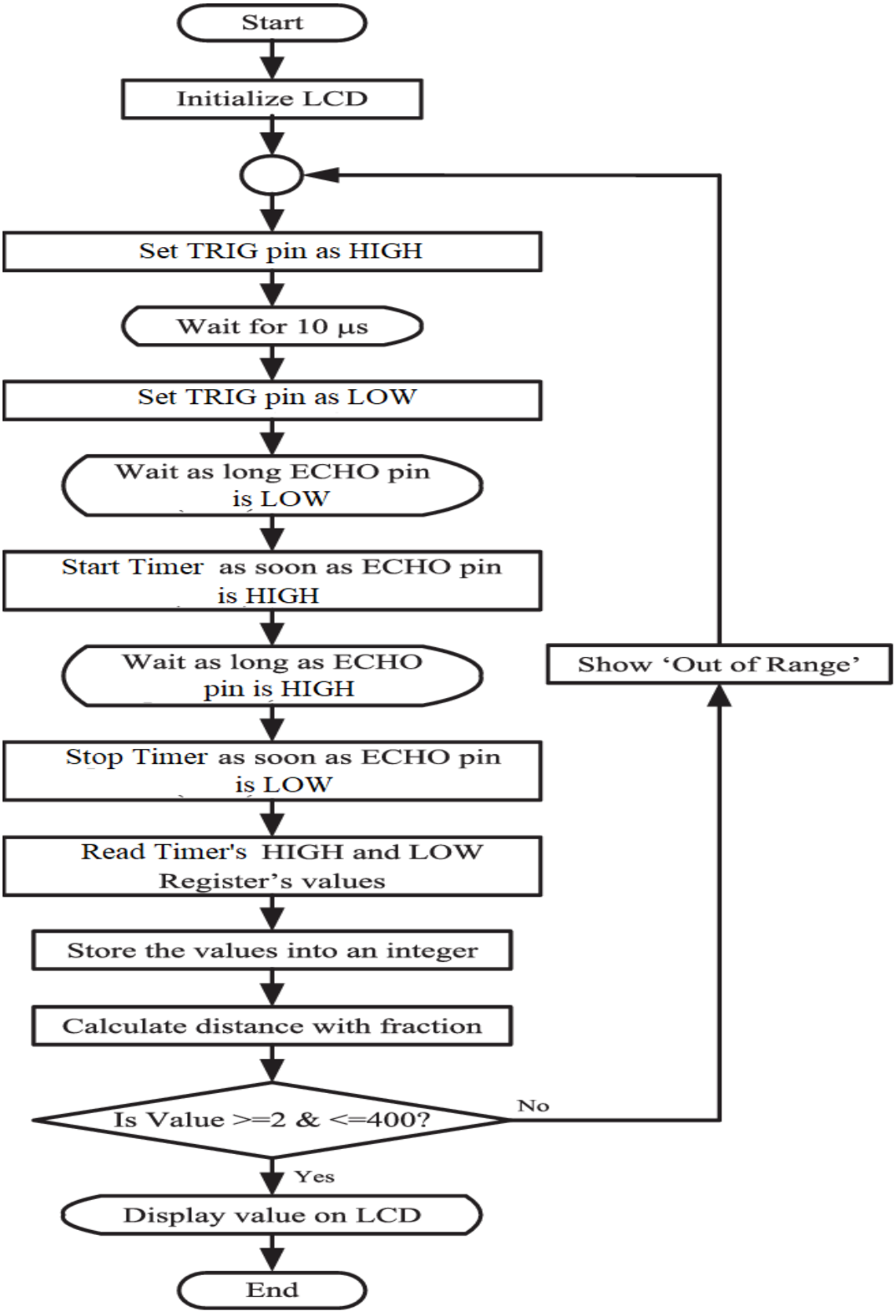

Fig.11: Flowchart of the system

3.3 SOFTWARE REQUIREMENTS:

3.3.1 Arduino IDE:

The Arduino Integrated Development Environment - or Arduino Software (IDE) - contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions and a series of menus. It connects to the Arduino hardware to upload programs and communicate with them.

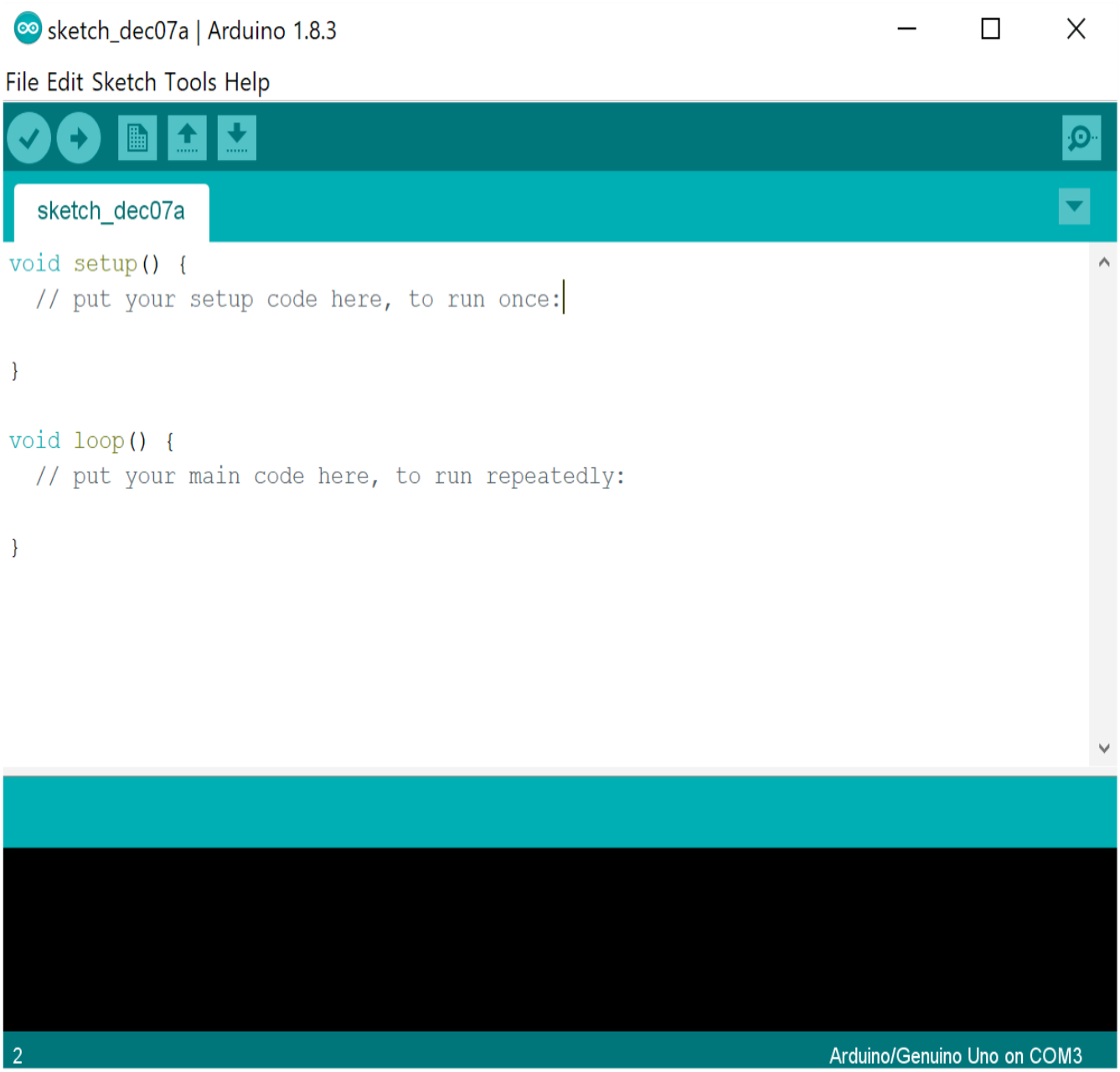

Fig.12: Arduino IDE

3.3.2 Code:

```
// includes the LiquidCrystal Library
#include <LiquidCrystal.h>

// Creates an LCD object. Parameters: (rs, enable, d4, d5, d6, d7)
LiquidCrystal lcd(8, 7, 4, 3, 2, 1);

const int trigPin = 10;
const int echoPin = 9;
long duration;
float distance;

int contrast=100; /*It is the contrast of display,
                    always keep it 100 for best contrast ratio*/

/*out of all pwm pins only pin 5&6 gives 980 Hz frequency hence
   used pin 5 for contrast and pin 6 for backlight brightness*/

int backlight=10; /*It is the brightness of backlight of display, always keep it in range 0 to 60,
                    if increased more than 60, the display will burn out.*/


void setup()
{
  pinMode(6,OUTPUT);
  analogWrite(6, backlight); // analogWrite(pin,value)

  pinMode(5,OUTPUT);
  analogWrite(5, contrast); // analogWrite(pin,value)*/

  lcd.begin(16,2); // Initializes the interface to the LCD screen
  pinMode(trigPin, OUTPUT);
  pinMode(echoPin, INPUT);
  lcd.clear();
  lcd.setCursor(4,0);
  delay(500);
  lcd.print("WELCOME");
  delay(2000);
  lcd.clear();
  delay(500);
}

void loop()
{
  // Write a pulse to the HC-SR04 Trigger Pin
```

```
  digitalWrite(trigPin, LOW);
  delayMicroseconds(2);
  digitalWrite(trigPin, HIGH);
  delayMicroseconds(10);
  digitalWrite(trigPin, LOW);

  // Measure the response from the HC-SR04 Echo Pin
  duration = pulseIn(echoPin, HIGH);

  // Determine distance from duration
  // Use 0.03433 centi-metres per second as speed of sound
  distance= duration*0.03433/2;

  // Set cursor to 0th column and 0th row
  lcd.setCursor(0,0);  //lcd.setCursor(column,row)

  if(distance>=2 && distance<=9){
    lcd.print("Dist: ");
  lcd.print(distance);
    lcd.print(" cm  ");
  }
  else if(distance>=10 && distance<=99){
    lcd.print("Dist: ");
  lcd.print(distance);
    lcd.print(" cm ");
  }
  else if(distance>=100 && distance<=400){
    lcd.print("Dist: ");
  lcd.print(distance);
    lcd.print(" cm");
  }
  else{
    lcd.print("Out of range");
  }
  delay(1000);
  lcd.clear();
}
```

CHAPTER 4

SYSTEM OVERVIEW

4.1 ADVANTAGES

- To reduce human efforts, distance can be measured without any physical contact with particular object.
- Can be used to measure depth of water resources such as well, river, etc.
- Instant and fast calculation of distance.
- Very high accuracy: 1 mm

4.2 DISADVANTAGES:

- Maximum range is 400 cm and minimum range is 2 cm.
- Cannot be used on porous surfaces like cloth.
- Speed of sound changes with room temperature, hence there may be error in measurement with change in temperature.

4.3 APPLICATIONS:

- Radar
- Self-driving cars
- Drones
- Reverse parking system of cars

CHAPTER 5

CONCLUSION:

The objective of this project was to design and implement an Ultrasonic Distance Measurement device. As described in this report a system is developed that can calculate the distance of the tracked object. With respect to the requirements for an ultrasonic rangefinder the followings can be concluded:

1. The system can calculate the distance of the obstruction with sufficient accuracy.
2. This device has the capability to interact with other peripheral if used as a secondary device.
3. This can also communicate with PC through its serial port.
4. This offers a low cost and efficient solution for contactless distance measurements.

CHAPTER 6

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YouTube:

[17] Ultrasonic Sensor HC-SR04 and Arduino Tutorial

https://youtu.be/ZejQOX69K5M

GitHub (code):

The full information of project is available on following GitHub repository

https://github.com/OnkarWaman/Contactless-Distance-Measurement-System.git