DISTANCE MEASUREMENT USING ULTRASONIC SENSOR

A Mini Project Report Submitted
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in

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by

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DECLARATION

We hereby declare that the work presented in this report entitled "DISTANCE MEASUREMENT USING ULTRASONIC SENSOR", was carried out by us. We have not submitted the matter embodied in this report for the award of any other University or Institute. We have given due credit to the original authors/sources for all the words, ideas, diagrams, graphics, computer programs, experiments, results, that are not our original contribution. We have used quotation marks to identify verbatim sentences and given credit to the original authors/sources.

We affirm that no portion of our work is plagiarized, and the experiments and the results reported in the report are not manipulated. In the event of a complaint of plagiarism and the manipulation of the experiments and results, we shall be fully responsible and answerable.

Mohd Tabish Husain
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(Signature)

CERTIFICATE

Certified that **Mohd Tabish Husain,** has carried out the project work presented in this report entitled **"Distance Measurement Using Ultrasonic Sensor"** for the requirement of mini project (KEC-354) in 3rd semester of Electronics and Communication Engineering branch for the award of **Bachelor of Technology** from Feroze Gandhi institute of Engineering and Technology, Raebareli under my supervision. The report embodies results of original work, and studies are carried out by the student himself.

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ABSTRACT

The project is designed to develop distance measurement system using ultrasonic waves and interfaced with arduino. We know that human audible range is 20 Hz to 20 kHz. We can utilize these frequency range waves through ultrasonic sensor HC-SR04. As large amounts are spent for hundreds of inflexible circuit boards, the arduino will allow business to bring many more unique devices. This distance measurement system can be widely used as range meters and as proximity detectors in industries. The hardware part of ultrasonic sensor is interfaced with arduino. This method of measurement is efficient way to measure small distances precisely. The distance of an obstacle from the sensor is measured through ultrasonic sensor. After knowing the speed of sound the distance can be calculated.

Nowadays, we have some difficulties in obtaining the distance that we want to measure. Even though, measuring tape is an easy option, but this kind of tool will have a limitation of manual error. Before this, engineers have produced a range finder module but in the end, they find out the module have many disadvantages like limitation for distance, different result for different colored obstacles, and need a calibration for every time before starts using it. Manual distance measuring is always done at the expense of human error. Precise and fix measurement of low range distance, is the main objective for this project. This device can measure distance in the range of 1cm up to 4m with the accuracy of 1cm. It works by transmitting ultrasonic waves at 40 kHz. Then, the transducers will measure the amount of time taken for a pulse of sound travel to a particular surfaces and return as the reflected echo. After that, the circuit that have been programmed with arduino nano will calculate the distance based on the speed of sound at 25°C which an ambient temperature and also the time taken. The distance then will be display on a LCD module. The importance of the project is calculating accurate distance from any obstacle that we want to measure. The device can be used in many different fields and categories like distance calculation in construction field, robots, car sensor to avoid obstacles and many other applications. The building process of the device was based on using as much as possible from the courses taken in the university, like Basic Electrical Engineering, Multimedia and systems and Electronics Devices and also practical work in the laboratories.

There are several ways to measure distance without contact. One way is to use ultrasonic waves at 40 kHz for distance measurement. Ultrasonic transducers measure amount of time taken for a pulse of sound to travel to a particular surface and return as the reflected echo. This circuit calculates the distance based on the speed of sound at 25°C ambient temperature and shows it on LCD display. Using it, we can measure distance up to 4 meters. In this circuit, a 40 kHz ultrasonic sensor is used for measurement. In this project, we excite the ultrasonic transmitter unit with a 40 kHz pulse burst and expect an echo from the object whose distance we want to measure. It travels to the object in the air and the echo signal is picked up by another ultrasonic transducer unit (receiver), also a 40 kHz pre-tuned unit.

Distance measurement of an object in front or by the side of the moving entity is required in large number of devices. These devices may be small or large and can be quite simple or complicated. Distance measurement has important applications in automotive and industrial applications. The distance measurement through sensors is useful in detecting obstacles. It is this distance measurement feature that allowed to imagine about self-driving cars and robots. The distance measurement application is also used in industries to check fuel levels in aircrafts and commercial transport vehicles .These uses various kinds of sensors and systems. In this project we have implemented such a measurement system which uses an ultrasonic sensor and arduino nano. Ultrasonic means of distance measurement is a convenient method compared to traditional one using measurement scales. Ultrasonic sound waves are useful both the air and underwater. Ultrasonic sensors are versatile for the distance measurement and it is quite fast for the common application. The transmitted waves are reflected back from the object and received by the sensor again. This provide for cheapest solution. Any distance measurement application has a sensor circuit and an actuator or display circuit (to perform path change according to the obstacle detection or display the distance reading respectively).

Today's 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 is on its heights. 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 propagate 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 nano. Distance measurement plays a vital role in engineering, science, business. The distance is always measured between two points. Generally distance measurement is possible only by making contact with the target whose distance is to be measured, but this paper discusses the measurement of distance without making contact with the target. This is done by generating 40 kHz ultrasonic waves using ultrasonic transducers. Here the distance is calculated on the basis on time taken by the pulse generated by the ultrasonic transducer to travel to the target and return as reflected echo. This device also makes the use of arduino for calculating the distance and displaying it on a seven segment display. The distance up to 4m is calculated in air medium at ambient temperature.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1
INTRODUCTION

1.1 INTRODUCTION

Measurement has always been essential to humans. We use it to interpret certain phenomena that can be quantified into numbers such as time which can be measured through seconds, mass through kilograms, or distance through meters. Although these measurements can be done unaided, it is much more effective to use devices that can provide accurate information. This is especially true in the field of engineering or science where any error can be consequential.

That is why experts in these fields require special devices. They use measuring tapes, thermometers, or even weighing scales to obtain precise measurements. Through these devices, they can effectively do tasks that require as such while preventing any error to occur as much as possible.

Although the measurement devices that are used today are very effective, we believe that we can take this a step further in terms of efficiency. Devices such as a measuring tape or a ruler are very convenient, yet they still do require a few menial tasks to accomplish. Thus, we want to come up with a device that will be relatively simple to use and can acquire the measurements accurately in a very short time.

Nowadays, length measurement is used in every sphere of life to enable fair trading conditions and to develop new and improved products and processes that enhance our standard of living. This ranges from the production of microscopic electronic devices with circuit dimensions made the accuracies of some ten thousand millionths of a meter, and millimeter accuracy in distance measurement in construction over many kilometers. But this also extends to everyday life where we rely on accurate length measurement to ensure, for example, that our clothes fit or our self-assembly furniture goes together. There are several ways to measure distance without contact. One way is to use the laser and the other is to use ultrasonic waves.

A laser distance meter sends out a finely focused pulse of light to the target and detects the reflection. The meter measures the time between those two events, and converts this to a distance. The formula is simple: Distance = ½ (Speed x Time). However the speed of light is 300,000 km per second, so to resolve differences of 1 cm, the meter must measure time intervals of the order of billionths of a second. A laser distance meter can measure distances of up to 30m with an accuracy of ±3 mm.

An ultrasonic distance meter works on a similar principle, but instead of light, it uses sound with a pitch too high for the human ear to hear. The speed of sound is only about ⅓ of a km per second, so the time measurement is easier. In this method 40 kHz ultrasonic signal is used for distance measurement. Ultrasonic transducers measure the amount of time taken for a pulse of sound to travel to a particular surface and return as the reflected echo.

The main component of the distance meter is the HC SR04 ultrasonic sensor module. This type of sensor module consists of ultrasonic transmitter and receiver pairs. The ultrasonic transmitter produces the ultrasonic signals with the frequency of about 40 kHz and an echo signal from the target is received by the receiver. The time between transmitting the signal and receiving the signal is measured by the help of the microcontroller (arduino nano). The velocity of the ultrasonic signal (or wave) is the same as that of the sound velocity. The distance can be calculated from the measured time and known velocity. The calculated distance is sent to the 16 x 2 lines LCD module. The LCD displays the measured distance in both “cm” and “inches”. The block diagram of the ultrasonic distance meter is shown in Fig. 1.1.

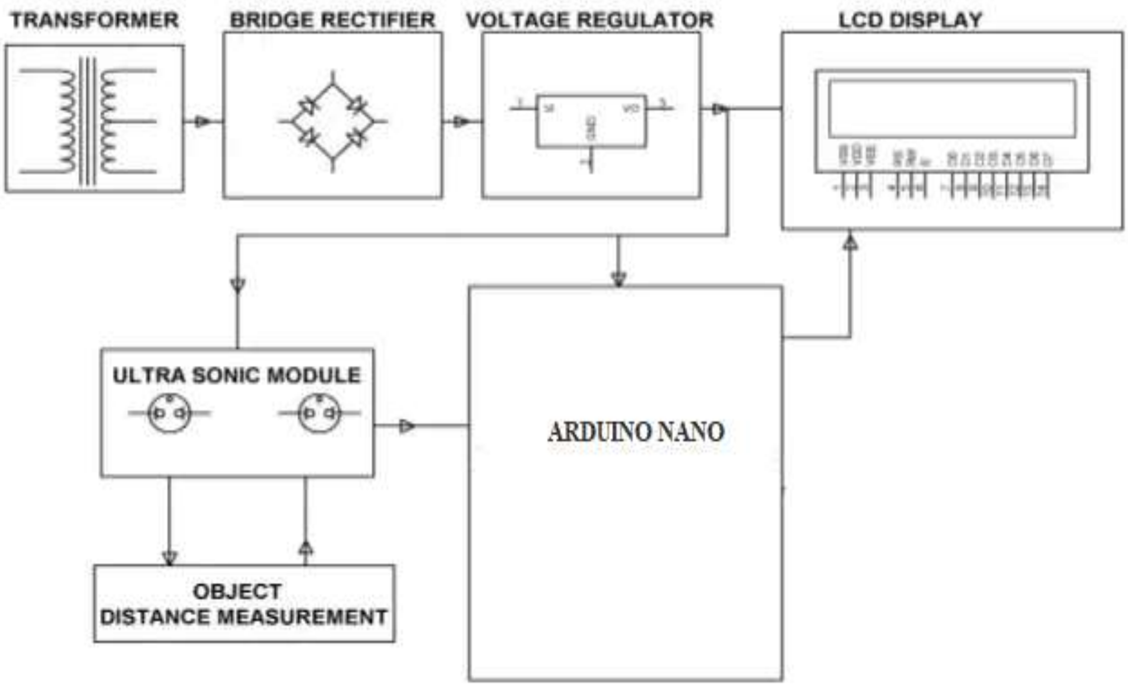

FIGURE 1: THE FUNCTIONAL BLOCK DIAGRAM OF THE CONSTRUCTED DEVICE

1.2 PROJECT 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.
We 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.

The system consists of only one main component, a microcontroller unit which acts as the brain of the system. Input and output components such as transmitter unit, receiver circuit, temperature control and LCD modules are connected to the system brain. Fig. 1.1 shows the components of the system and how they are connected. The transmitter generates a 40 kHz signals and begin the transmission time together with the process of sending signals. While the signals begin to transmit through ultrasonic transducer, the microcontroller will capture the starting point of transmission time and hold it until the receiver gets the echo signal back. The signal will contact with any obstacle ahead and will bounce back to the receiver circuit. When the signal is back, the receiver must detect the echo signal, process & send to the microcontroller. The microcontroller will stop the transmission time immediately and will calculate the range using the transmission time and display the range on LCD modules. If the transmit signal cannot touch any obstacle in front it, or the time is very fast, the system will display error message on the LCD modules, indicate the range is not suitable for the system.

Ultrasonic sensors are often used in automation tasks to measure distance, position changes, level measurement, such as presence detectors or in special applications, for example, when measuring the purity of transparent material. They are based on the principle of measuring the propagation time of ultrasonic waves. This principle ensures reliable detection is independent of the color rendering of the object or to the design and the type of its surface. It is possible to reliably detect even such materials as liquids, bulk materials, transparent objects, glass etc. Another argument for their use is them using in aggressive environments, not very great sensitivity to dirt and also the possibility of measuring a distance. Ultrasonic sensors are manufactured in many mechanical designs. For laboratory use, the simple housing used for transmitter and receiver separately or in a single housing, for industrial use are often constructed robust metal housing. Some types allow you to adjust the sensitivity using a potentiometer or digitally. Also, the output may be in the unified version or the analog signal directly in digital form. In the case of sensors that can be connected via the communication interface to the PC, it is possible to set detailed parameters of all the sensor's operating range and measured distances.

Ultrasound has similar propagation characteristics in the environment as audible sound. This is mechanical vibration particle environment. Ultrasound propagation may be in gaseous, liquid and solids. For ultrasound is generally regarded as a sound of a frequency higher than 20 kHz.

According to the use the ultrasound can be divided into two groups:

1.2.1 **Active ultrasound:** When applied exhibits physical or chemical effects. The generated output reaches higher values. The ultrasound is used for cleaning, welding, drilling and the like.

1.2.2 **Passive ultrasound:** Output is contrast generated at much lower (usually small) values. His main area of application is then measuring distance, detecting defects in materials and thickness of the materials, measuring the flow of liquids and gases and also diagnostics in healthcare. Speed of sound is dependent on the type of environment in which it moves, and the current temperature of the environment.

Velocity of sound in some materials is showed in Table 1.1

Gases		Solids		Liquids	
(m/s)		(m/s)		(m/s)	
Air (0°C)	331	Al	5100	Water (20°C)	1481
Air (20ºC)	343	Steel	5000	Water (25°C)	1497
He (25°C)	965	Concrete	1700	Gasoline (20°C)	1170
H (25°C)	1284	Cu	3500	Hg (25°C)	1450
He – Helium H – Hydrogen Al – Aluminium			Cu – Cuprum Hg - Quicksilver		

TABLE 1: THE SPEED OF SOUND PROPAGATION IN MATERIALS

1.3 OBJECTIVE

The objective of the project is to replace the old traditional range detector, used in several applications. In present project the object position is measured electronically by using seven segment displays by replacing the heavy and bulky circuits with the compact circuits using intelligent Microcontroller. The bulky pressing switch is replaced by the small and one touch tactile switch. It saves electric consumption, saves the no. of man power, through seven segment display and one microcontroller as well as ultrasonic receiver & transmitter sensors.

1.4 AIM OF PROJECT

- To make up students mind, not only to work individually but also to work in team.
- To get the knowledge of each student in various subjects which he has studied before
- To prepare a team, not only to make project but, also to decide design, cost of

raw material and advantages and limitations of them.

- The students can know that which and what kind of difficulties and constrains they have to face and find the right solution.

1.5 LITERATURE REVIEW

Distance measurement is the activity of obtaining and comparing in our real world. It is one of the important functions in science, engineering and astronomy to business activities. There are many types of distance measurement systems we use in our environment from normal rulers to Interferometer. In applications, basic concept of electronic distance measure system is adopted in many areas like aviation, navigation and many more. In aviation, direct feedback system is required for linear positioning and motion control application. One of the good examples for distance measurement in navigation is GPS system using satellites. So there is no doubt about the usefulness of distance measurement technology in our environment. Reviews of available literature of this project have been performed to ensure more understanding to construct ultrasonic distance meter. The areas that were focused are on behavior of ultrasound through journals, books, and internet. Although many different type of ranging systems available in market, there are only three major type of ranging systems used in technology which are Ultrasonic Ranging System.

We 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". We 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. We 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 us 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.

In the paper published by Ishihara, Shiina, and Suzuki (2009). They studied the characteristics of an ultrasonic sensor. 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”. Third, ultrasonic is not affected by the transparency or color of a surface, 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”. Additionally, the ultrasonic detection range depends on the target’s size and position, “The bigger is the target, stronger will be the reflected signal and more accurate will be the distance calculated”.

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”.

We 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.

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. We 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 2

SELECTION OF PROJECT

Before selection of the project, a discussion was done between the team members and their requirement in routing activities. We think on a similar product whether it is available I marked or not thinking by different kinds of it features.

We can make modified product having more advantages at economics cost. Also we have to consider the feasibility as well as suitability for available resources and facilities to carry out the project work.

2.1 MARKET SURVEY

The study of the spending characteristics and purchasing power of the consumer who are within your business's geographic area of operation; a research method for defining the market parameters of a business.

We can with stand in the market but, we should have two things one thing is that the project we have chosen never face any problem regarding its working. On the basis of concept of products the market survey and group discussion we had find that the project we will select can be used in stunts in the sky.

The following projects were under consideration:

2.2 SMART STICK FOR BLIND BASED ON ULTRASONIC SENSOR:

2.2.1 What is smart stick for blind?

The smart stick for the blind as the name suggests is a device for the visually impaired to guide the user to respective destination and avoiding to collide with the obstacles. It uses two ultrasonic sensors HC SR 04 to detect the depth below or the obstacles in between. Along with that it uses Arduino as the main controller. And 1sheeld as the Bluetooth interface between the controller and smartphone. Whenever there is any obstacle in front. The sensor will detect the distance from the obstacle and send to the controller. The controller will then convert in audio format.

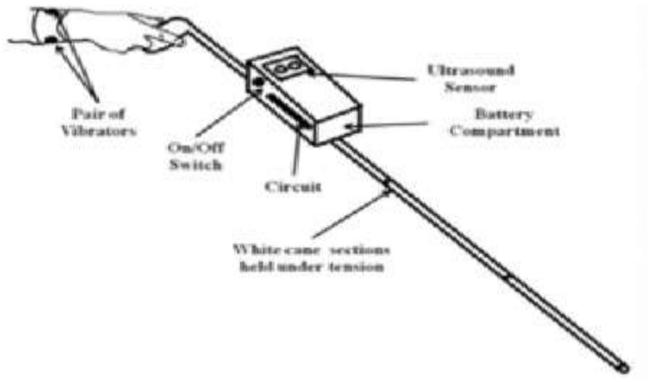

FIGURE 2: PROTOTYPE MODEL OF OBSTRUCTION DETECTION SYSTEM

2.2.2 How do Smart Stick for Blind works?

The smart blind stick automatically detects the obstacle in front of the person and give him a response to the person by vibrating the stick and also with a warning sound. Through this, the blind person can aware about the obstacles in front of him. An Ultrasonic sensor is used for detecting the obstacles. The system starts by powering the microcontroller and runs in a continuous loop. In the loop, the ultrasonic sensors continuously sense the surrounding objects using the ultrasonic transceivers and the signals are fed into the microcontroller. Next, the distance of the object is computed and compared to the predetermined feedback ranges. If the computed distance falls within the ranges, the user is alerted. Otherwise, the next distance is computed and compared.

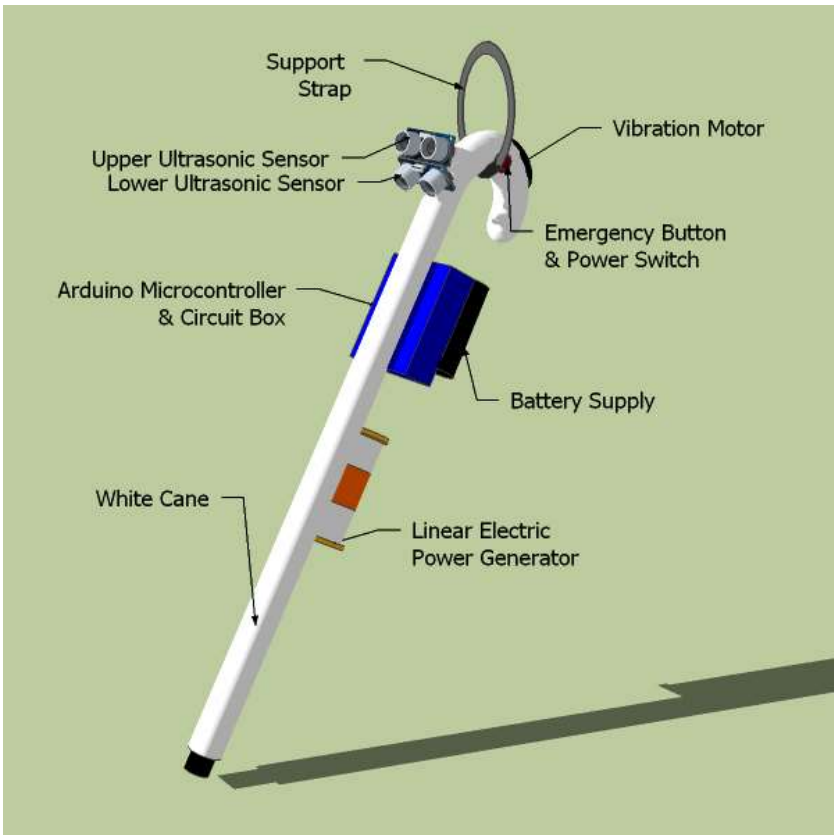

FIGURE 3: ARCHITECTURAL DESIGN OF SMART STICK FOR THE BLIND

2.3 SMART BLOOD OXYGEN AND HEART RATE MONITOR WITH MAX301000 & ARDUINO

2.3.1 What is Smart Blood Oxygen and Heart Rate Monitor?

Smart Blood Oxygen and Heart Rate Monitor is a device that can measure Blood Oxygen & Heart Rate using MAX30100 Pulse Oximeter & Arduino. The blood Oxygen Concentration termed as SpO2 is measured in Percentage and Heart Beat/Pulse Rate is measured in BPM. The MAX30100 is a Pulse Oximetry and heart rate monitor sensor solution. The SpO2 and BPM value is displayed in 0.96″ OLED Display. With each beat, the display value is changed in the OLED screen. By using Bluetooth module HC-

05/HC-06 (operating in a slave mode), the data is send to the android app wirelessly and the data on the app is monitored as well as a track record of the data is kept in text format. In this way, we can send the data read from the device to another device or to the Internet. This wearable device can be used by athletes to monitor their heart rate and blood oxygen levels during a workout.

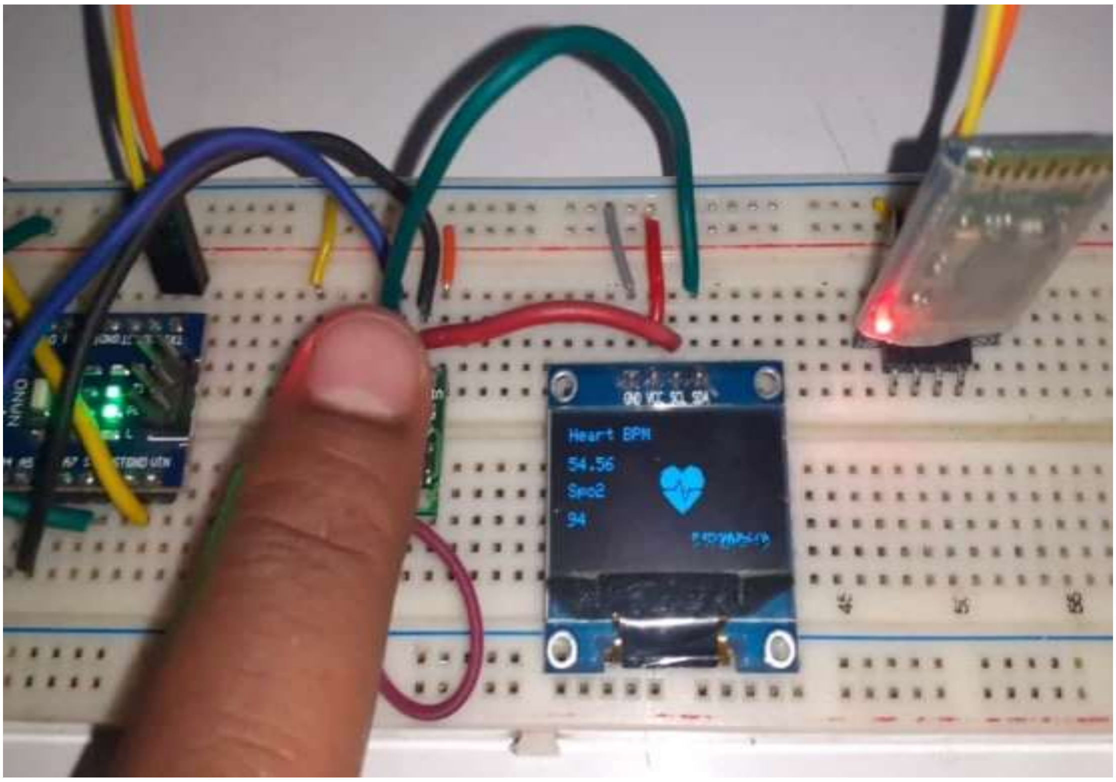

FIGURE 4: PROTOTYPE OF BLOOD OXYGEN AND HEART RATE MONITOR

2.3.2 How does Smart Blood Oxygen and Heart Rate Monitor works?

Oxygen enters the lungs and then is passed on into blood. The blood carries oxygen to the various organs in our body. The main way oxygen is carried in our blood is by means of hemoglobin. During a pulse oximetry reading, a small clamp-like device is placed on a finger, earlobe, or toe. Small beams of light pass through the blood in the finger, measuring the amount of oxygen. It does this by measuring changes in light absorption in oxygenated or deoxygenated blood. The device has two LEDs, one emitting red light, another emitting infrared light. For pulse rate, only the infrared light is needed. Both the red light and infrared light is used to measure oxygen levels in the blood.

When the heart pumps blood, there is an increase in oxygenated blood as a result of having more blood. As the heart relaxes, the volume of oxygenated blood also decreases. By knowing the time between the increase and decrease of oxygenated blood, the pulse rate is determined.

It turns out, oxygenated blood absorbs more infrared light and passes more red light while deoxygenated blood absorbs red light and passes more infrared light. This is the main function of the MAX30100: it reads the absorption levels for both light sources and stored them in a buffer that can be read via I2C.

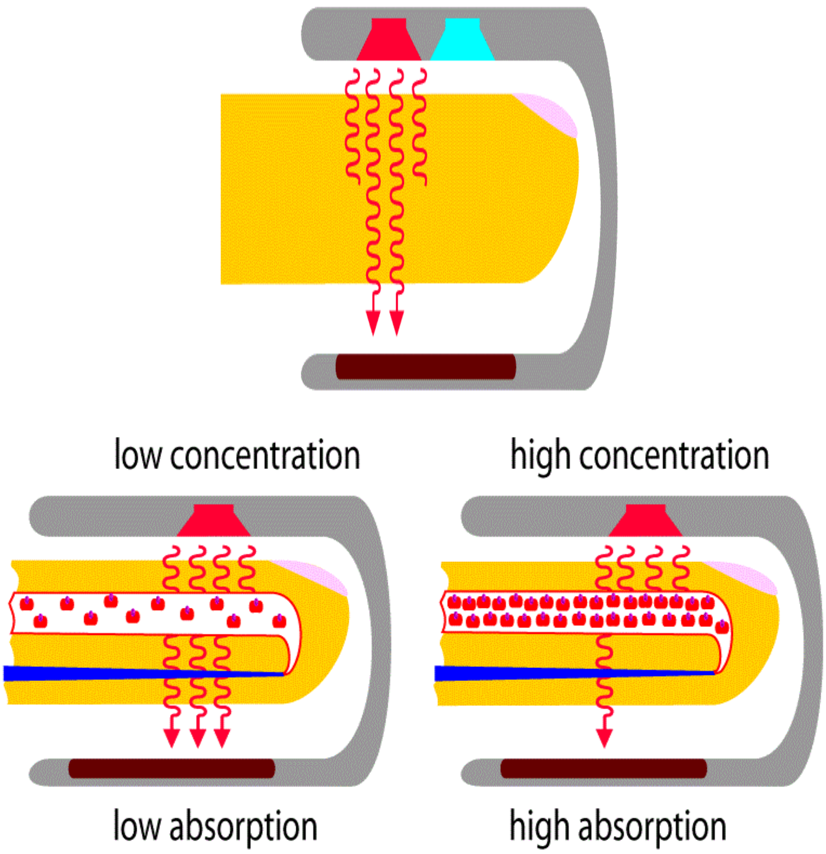

FIGURE 5: WORKING OF BLOOD OXYGEN AND HEART RATE MONITOR

2.4 FIRE & SMOKE ALARM SYSTEM

2.4.1 What is Fire & Smoke Alarm System?

A smoke detector is a device that detects smoke, typically as an indicator of fire. Commercial, industrial, and mass residential devices issue a signal to a fire alarm system, while household detectors, known as smoke alarms, generally issue a local audible or visual alarm from the detector itself.

A smoke detector's purpose is a simple one, to give you ample notification in case of a fire in your house. Without a smoke detector, by the time you realize that there is a fire, your house could be so badly engulfed that you cannot find a safe exit or the smoke can be so overwhelming that you suffocate trying to get out.

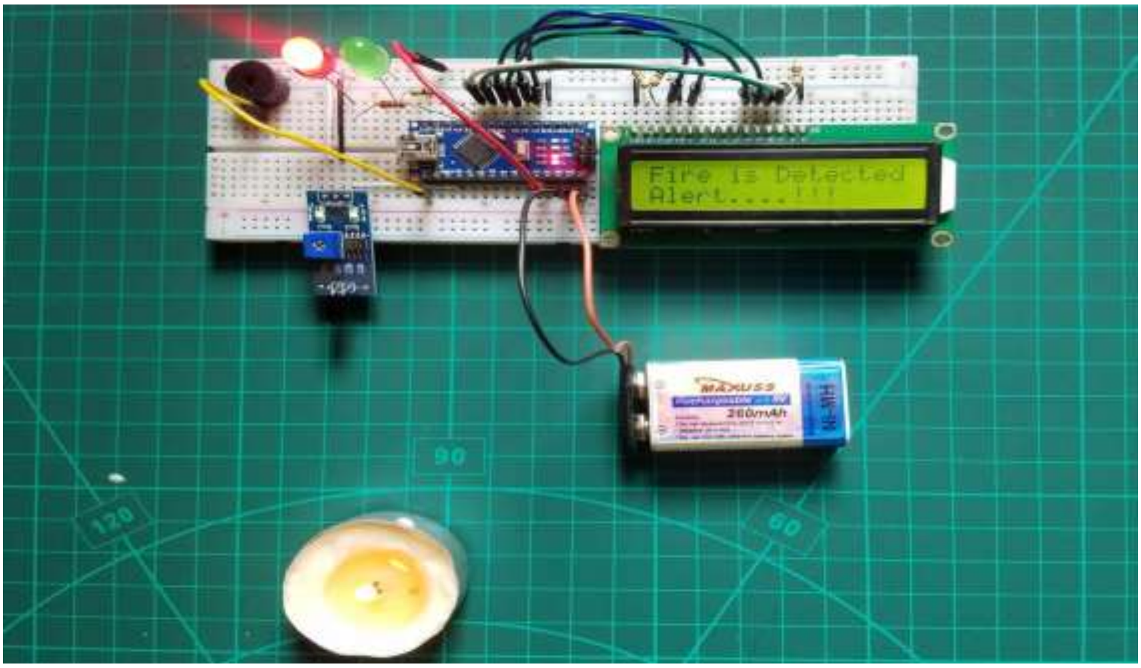

FIGURE 6: PROTOTYPE OF FIRE & SMOKE ALARM SYSTEM

2.4.2 How does Fire & Smoke Alarm System works?

Photoelectric sensors generate a beam of light focused on a light-sensitive cell, enclosed in the alarm. If the light beam is interrupted from smoke entering the detector, the alarm goes off. Ionization sensors work by having a small piece of radioactive material create an electric current between two plates. If smoke or hot air enters the chamber, the reaction is changed and the current is disrupted, causing the alarm to go off. Photoelectric smoke detectors work best with slow, smoky fires and ionization detectors work best with quick, hot fires.

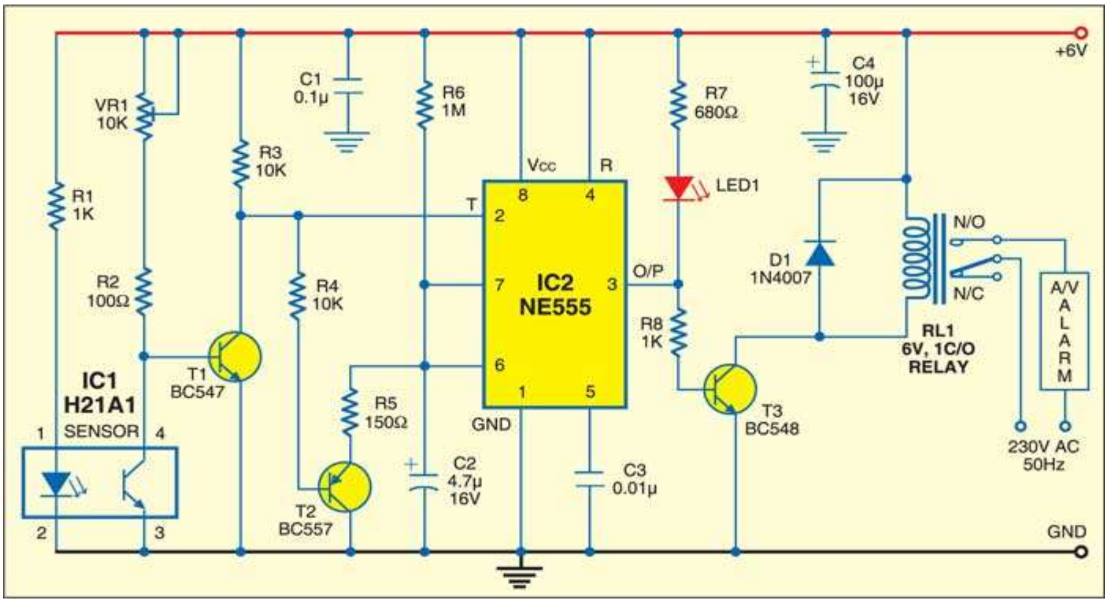

FIGURE 7: CIRCUIT DIAGRAM OF FIRE & SMOKE ALARM SYSTEM

2.5 DISTANCE MEASUREMENT USING ULTRASONIC SENSOR

2.5.1 What is Distance Measurement using Ultrasonic Sensor?

Distance Measurement using Ultrasonic Sensor, is a device based on the use of ultrasonic sensor for the purpose measuring the distance from a particular object in place the traditional or conventional measurement devices like measurement tape to avoid the maximum chances of errors while measuring. The contactless measurement also aids in minimizing the work done by the humans and requires less human effort.

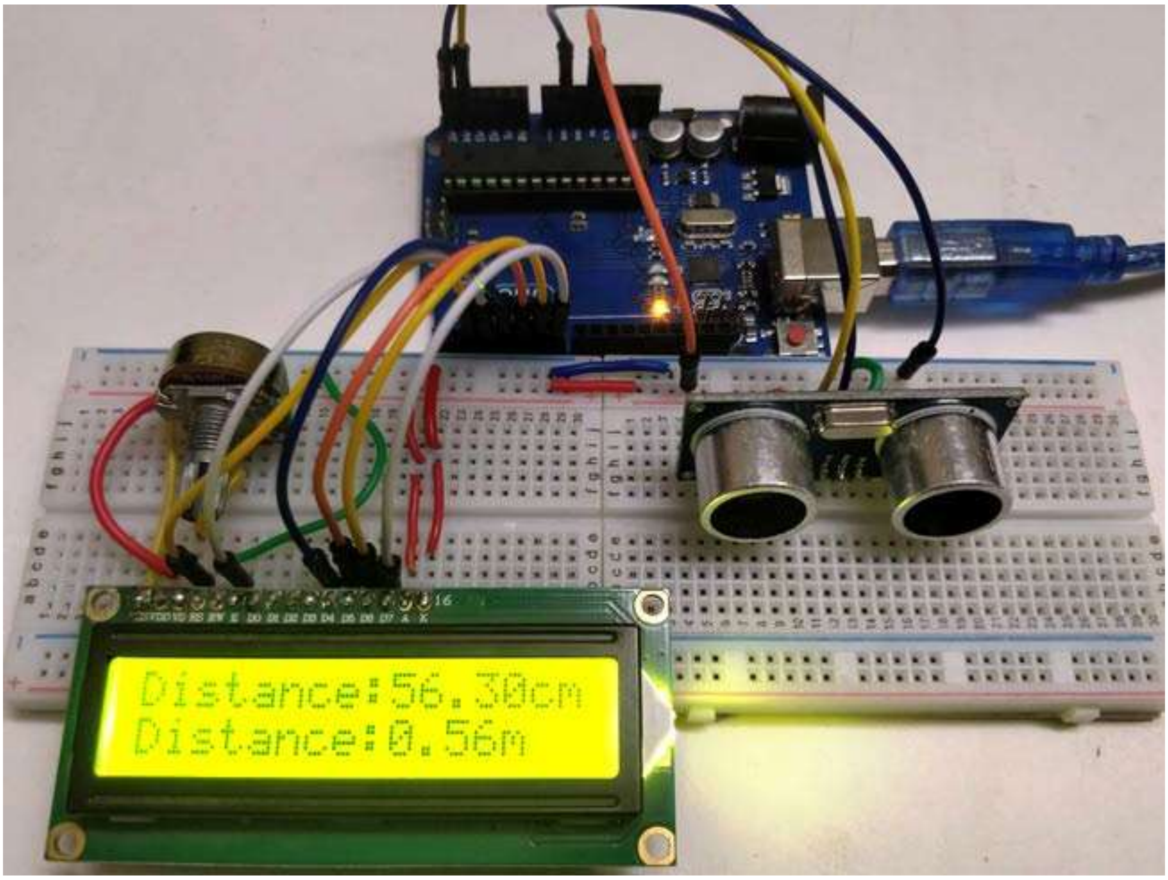

FIGURE 8: PROTOTYPE OF DISTANCE MEASUREMENT DEVICE

2.5.2 How does Distance Measurement using Ultrasonic Sensor works?

The basic principle of ultrasonic distance measurement is based on ECHO. When sound waves are transmitted in the environment then waves are returned 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. As the speed of the sound is known to us, after some calculation we can calculate the distance. The high-level signal is sent to 10 microseconds using Trigger. The module sends 40 KHz signals automatically and then detects whether the pulse is received or not through Echo. If the signal is received, then it is through the high level. The time of high duration is the time gap between sending and receiving the signal is calculated. Ultrasonic sensor distance measurement formula is Distance = $\{\text{Time x Sound speed in Air } (340\ ^{m}/_{s})\}/_{2}$

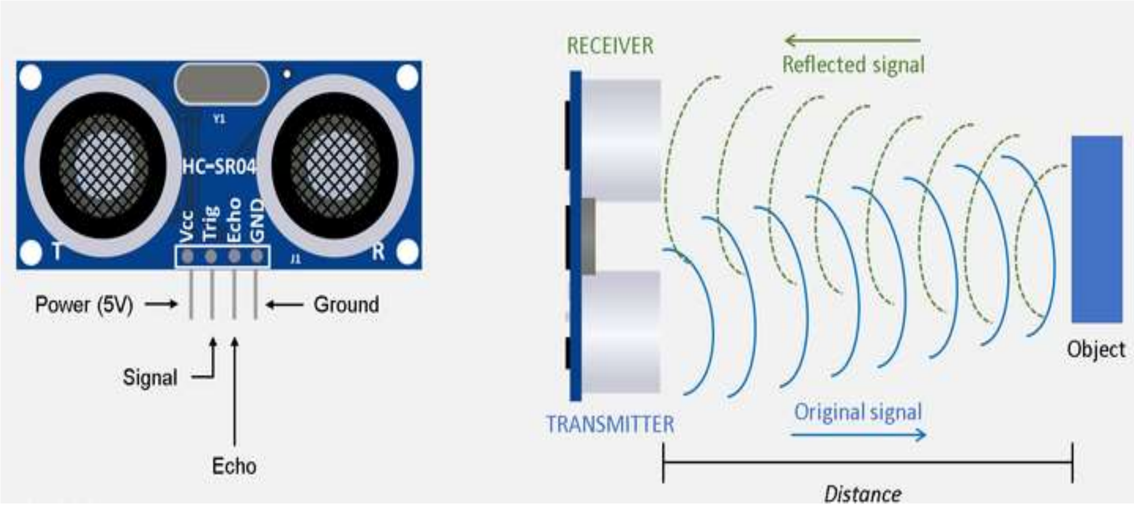

FIGURE 9: ULTRASONIC SENSOR AND ITS WORKING

2.6 SELECTION OF PROJECT

After considering all the projects mentioned in this chapter, we had a detailed discussion about the choice of our project. We discussed about the cost, preparation, interface, design and working of project that led us to a conclusion that the project we are going to work on should be cost efficient, easy to design, must be easy to use and must work in stable condition. After evaluating all the pros and cons we have selected the “DISTANCE MEASUREMENT USING ULTRASONIC SENSOR” as our project.

The goal of the project is to make a distance measuring device that is effective, efficient, yet simple. In order to do so, we have decided to make an ultrasonic distance measuring device using an ultrasonic sensor, specifically, the HC-SRO4.

First off, the use of an ultrasonic sensor indicates that the device will measure distance through a non-contact method. Additionally, in order for it do so, it will be done through what is known as the pulse method evident by the presence of a transmitter and receiver on the HC-SRO4. The device won’t have any alarming effect on humans, specifically on the hearing sense, as the sensor transmits sound waves in the frequency of 20000 Hz, which is outside the limits of the hearing range of humans. Therefore, there will be no issues on its long-term use. Moreover, we chose to use an ultrasonic sensor because it is relatively more inexpensive while proving to be versatile in use. But there are a few things worth noting when using an ultrasonic sensor for distance measurement

The sensor has a few limitations because of its nature, specifically, the method it uses to measure the device and how it executes it. First of all, in order for it to measure the distance of a certain object, it has to be oriented in perpendicular to the surface of the object. Second, the target surface must be wide enough in order for the ultrasonic waves to echo back to the receiver and obtain precise measurements. Third, the ultrasonic sensor can only measure a distance of up to 400 cm. Fourth, the speed of ultrasonic sound waves is affected by the type of medium and temperature so the device may not perform well in poor conditions.

But we have considered the sensor despite the drawbacks. First, unlike other types of sensors such as laser, the use of ultrasonic will allow for a more accurate distance measurement. Second, signal processing is easier because the speed of sound is slower than light in the presence of air. Third, ultrasonic sound waves are not affected by the transparency or color of a surface. Fourth, the waves are also not affected by the effects of light and airborne dusts. And most of all, the price of the sensor justifies its drawbacks.

In conclusion, we have determined that in order to achieve their goal of creating an effective, efficient, and simple electromagnetic distance measuring device, the best option is to use the HC-SRO4 ultrasonic sensor. Despite its drawbacks and limitations, its relatively low price and versatility in various scenarios justifies its use.

We will study about the methodology and construction of the project in the upcoming chapters

CHAPTER 3

PROJECT REQUIRMENTS

3.1 INTRODUCTION

In this chapter we shall discuss about the requirements of the project and the equipments that we are going to use for the device.

Following equipments mentioned below are used in our project:

3.2 ARDUINO NANO

3.2.1 What is Arduino Nano?

The Arduino Nano is a small, complete, and breadboard-friendly board based on the ATmega328 (Arduino Nano 3.x). It offers the same connectivity and specs of the Arduino Uno board in a smaller form factor. It lacks only a DC power jack, and works with a Mini-B USB cable instead of a standard one.

The Arduino Nano is equipped with 30 male I/O headers, in a DIP30-like configuration, which can be programmed using the Arduino Software integrated development environment (IDE), which is common to all Arduino boards and running both online and offline. The board can be powered through a type-B micro-USB cable or from a 9 V battery.

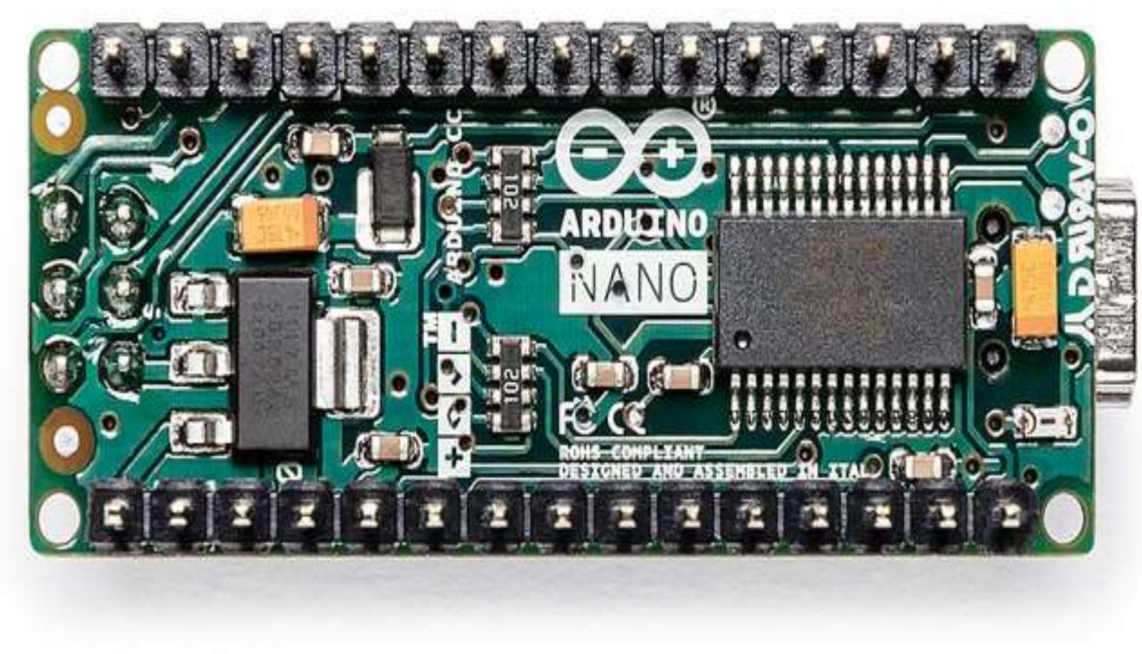

FIGURE 10: THE ARDUINO NANO

3.2.2 How is Arduino Nano Powered?

The Arduino Nano can be powered via the Mini-B USB connection, 6-20V unregulated external power supply (pin 30), or 5V regulated external power supply (pin 27). The power source is automatically selected to the highest voltage source.

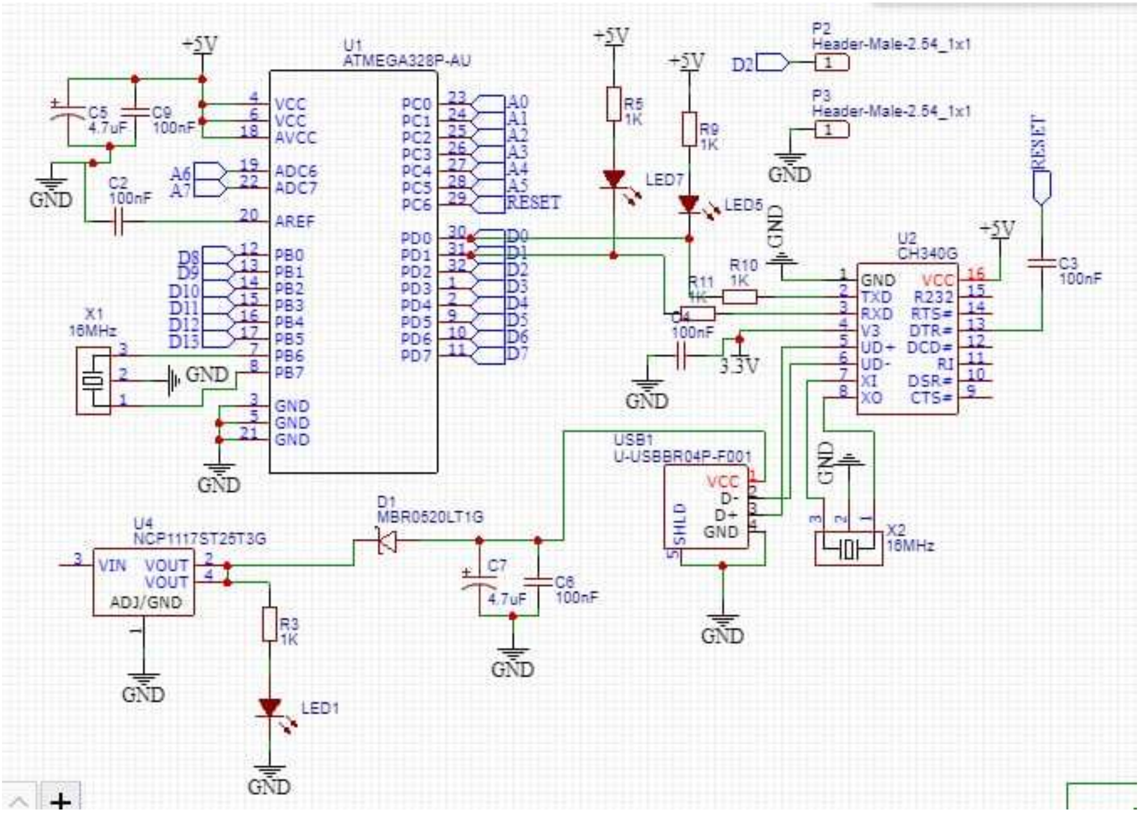

FIGURE 11: SCHEMATIC DIAGRAM OF ARDUINO NANO

3.2.3 Memory

The ATmega328 has 32 KB, (also with 2 KB used for the bootloader). The ATmega328 has 2 KB of SRAM and 1 KB of EEPROM.

3.2.4 Input and Output

Each of the 14 digital pins on the Nano can be used as an input or output, using pinMode(), digitalWrite(), and digitalRead() functions. They operate at 5 volts. Each pin can provide or receive a maximum of 40 mA and has an internal pull-up resistor (disconnected by default) of 20-50 kOhms. In addition, some pins have specialized functions:

- Serial: 0 (RX) and 1 (TX). Used to receive (RX) and transmit (TX) TTL serial data. These pins are connected to the corresponding pins of the FTDI USB-to-TTL Serial chip.
- External Interrupts: 2 and 3. These pins can be configured to trigger an interrupt on a low value, a rising or falling edge, or a change in value. See the attachInterrupt() function for details.
- PWM: 3, 5, 6, 9, 10, and 11. Provide 8-bit PWM output with the analogWrite() function.
- SPI: 10 (SS), 11 (MOSI), 12 (MISO), 13 (SCK). These pins support SPI communication, which, although provided by the underlying hardware, is not currently included in the Arduino language.
- LED: 13. There is a built-in LED connected to digital pin 13. When the pin is HIGH value, the LED is on, when the pin is LOW, it's off.

The Nano has 8 analog inputs, each of which provide 10 bits of resolution (i.e. 1024 different values). By default they measure from ground to 5 volts, though is it possible to change the upper end of their range using the analogReference() function. Analog pins 6 and 7 cannot be used as digital pins. Additionally, some pins have specialized functionality:

- I2C: A4 (SDA) and A5 (SCL). Support I2C (TWI) communication using the Wire library (documentation on the Wiring website).

There are a couple of other pins on the board:

- AREF. Reference voltage for the analog inputs. Used with analogReference().
- Reset. Bring this line LOW to reset the microcontroller. Typically used to add a reset button to shields which block the one on the board.

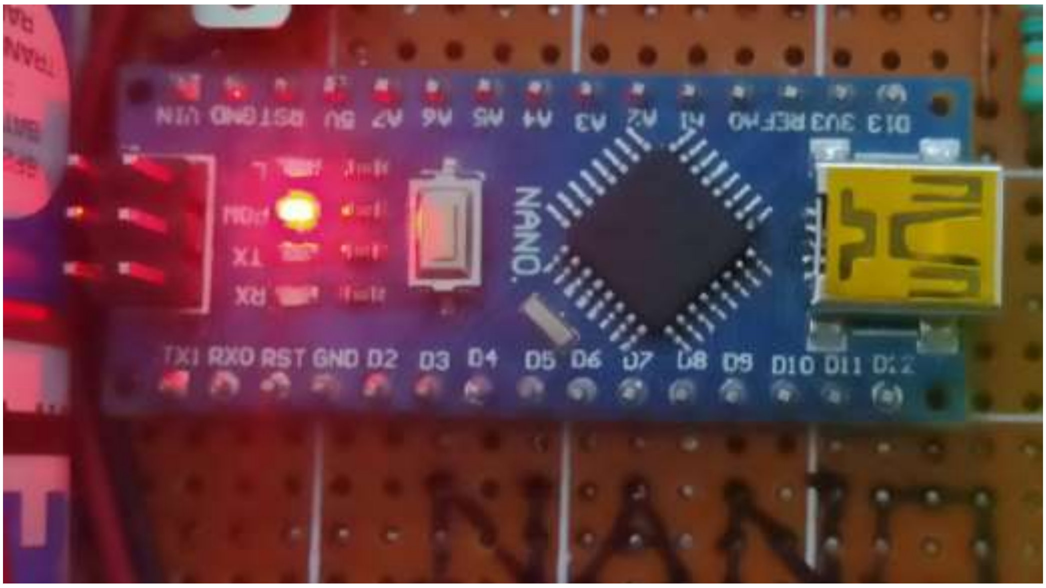

FIGURE 12: ACTUAL ARDUINO NANO USED IN PROJECT

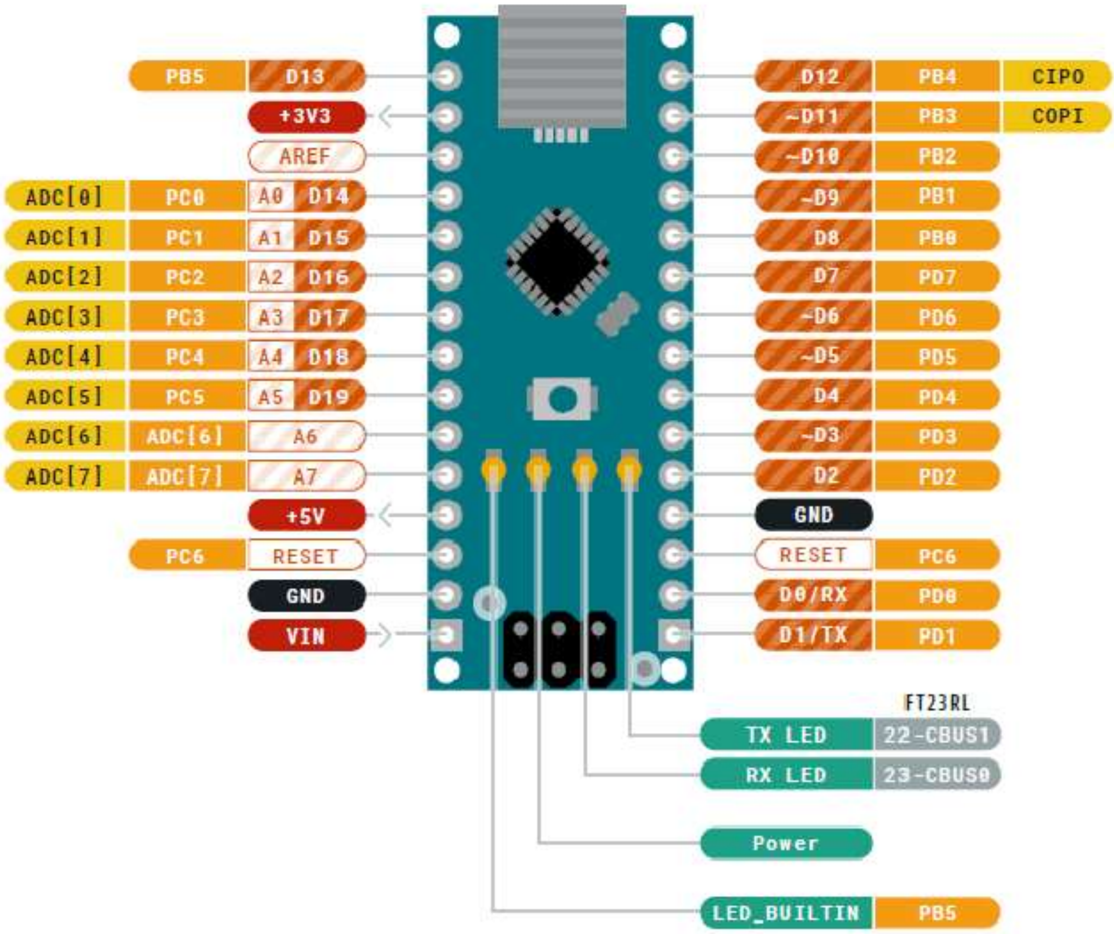

FIGURE 13: PINOUT DIAGRAM OF ARDUINO NANO

3.2.5 Communication

The Arduino Nano has a number of facilities for communicating with a computer, another Arduino, or other microcontrollers. The ATmega328 provide UART TTL (5V) serial communication, which is available on digital pins 0 (RX) and 1 (TX). An FTDI FT232RL on the board channels this serial communication over USB and the FTDI drivers (included with the Arduino software) provide a virtual com port to software on the computer. The Arduino software includes a serial monitor which allows simple textual data to be sent to and from the Arduino board. The RX and TX LEDs on the board will flash when data is being transmitted via the FTDI chip and USB connection to the computer (but not for serial communication on pins 0 and 1). A SoftwareSerial library allows for serial communication on any of the Nano's digital pins. The ATmega328 also support I2C (TWI) and SPI communication. The Arduino software includes a Wire library to simplify use of the I2C bus.

3.2.6 Automatic (software) reset

Rather than requiring a physical press of the reset button before an upload, the Arduino Nano is designed in a way that allows it to be reset by software running on a connected computer. One of the hardware flow control lines (DTR) of the FT232RL is connected to the reset line of the ATmega328 via a 100 nanofarad capacitor. When this line is asserted (taken low), the reset line drops long enough to reset the chip.

This setup has other implications. When the Nano is connected to a computer running Mac OS X or Linux, it resets each time a connection is made to it from software (via USB). For the following half-second or so, the bootloader is running on the Nano. While it is programmed to ignore malformed data (i.e. anything besides an upload of new code), it will intercept the first few bytes of data sent to the board after a connection is opened

MICROCONTROLLER	ATmega328
ARCHITECTURE	AVR
OPERATING VOLTAGE	5 V
FLASH MEMORY	32 KB of which 2 KB used by bootloader
SRAM	2 KB
CLOCK SPEED	16 MHz
ANALOG IN PINS	8
EEPROM	1 KB
DC CURRENT PER I/O PINS	40 mA (I/O Pins)
INPUT VOLTAGE	7-12V
DIGITAL I/O PINS	22 (6 of which are PWM)
PWM OUTPUT	6
POWER CONSUMPTION	19 Ma
PCB SIZE	18 x 45 mm
WEIGHT	7 g
PRODUCT CODE	A000005

TABLE 2: TECHNICAL SPECIFICATIONS OF ARDUINO NANO

3.3 ULTRASONIC SENSOR HC SR-04

3.3.1 What is an Ultrasonic Sensor?

An ultrasonic sensor is an electronic device that measures the distance of a target object by emitting ultrasonic sound waves, and converts the reflected sound into an electrical signal. Ultrasonic waves travel faster than the speed of audible sound (i.e. the sound that humans can hear). Ultrasonic sensors have two main components: the transmitter (which emits the sound using piezoelectric crystals) and the receiver (which encounters the sound after it has travelled to and from the target).

In order to calculate the distance between the sensor and the object, the sensor measures the time it takes between the emission of the sound by the transmitter to its contact with the receiver. The formula for this calculation is D = ½ T x C (where D is the distance, T is the time, and C is the speed of sound ~ 343 meters/second). For example, if a scientist set up an ultrasonic sensor aimed at a box and it took 0.025 seconds for the sound to bounce back, the distance between the ultrasonic sensor and the box would be:
D = 0.5 x 0.025 x 343 or about 4.2875 meters.

FIGURE 14: AN ULTRASONIC SENSOR

Working Voltage	DC 5 V
Working Current	15mA
Working Frequency	40Hz
Max Range	4m
Min Range	2cm
MeasuringAngle	15 degree
Trigger Input Signal	10uS TTL pulse
Echo Output Signal	Input TTL lever signal and the range in Proportion
Dimension	45*20*15mm

TABLE 3: ELECTRIC PARAMETER OF ULTRASONIC SENSOR

3.3.2 How does an Ultrasonic Sensor work?

The working principle of an ultrasonic sensor is simple. It sends an ultrasonic pulse out at 40kHz which travels through the air and if there is an obstacle or object, it will bounce back to the sensor. By calculating the travel time and the speed of sound, the distance can be calculated.

Ultrasonic sensors transmit sound waves toward a target and will determine its distance by measuring the time it took for the reflected waves to return to the receiver and then will convert the reflected sound into an electrical signal.

Moving from theory to reality, an ultrasonic sensor requires two parts, both a transmitter and a receiver. In the most standard configuration, these are placed side-by-side as close together as reasonably possible. With the receiver close to the transmitter, sound travels in a straighter line from the transmitter to the detected object and back to the receiver, yielding smaller errors in the measurements. There are also ultrasonic transceivers where the transmitter and receiver functions are integrated into a single unit, minimizing error as much as physically possible while also significantly reducing the PCB footprint.

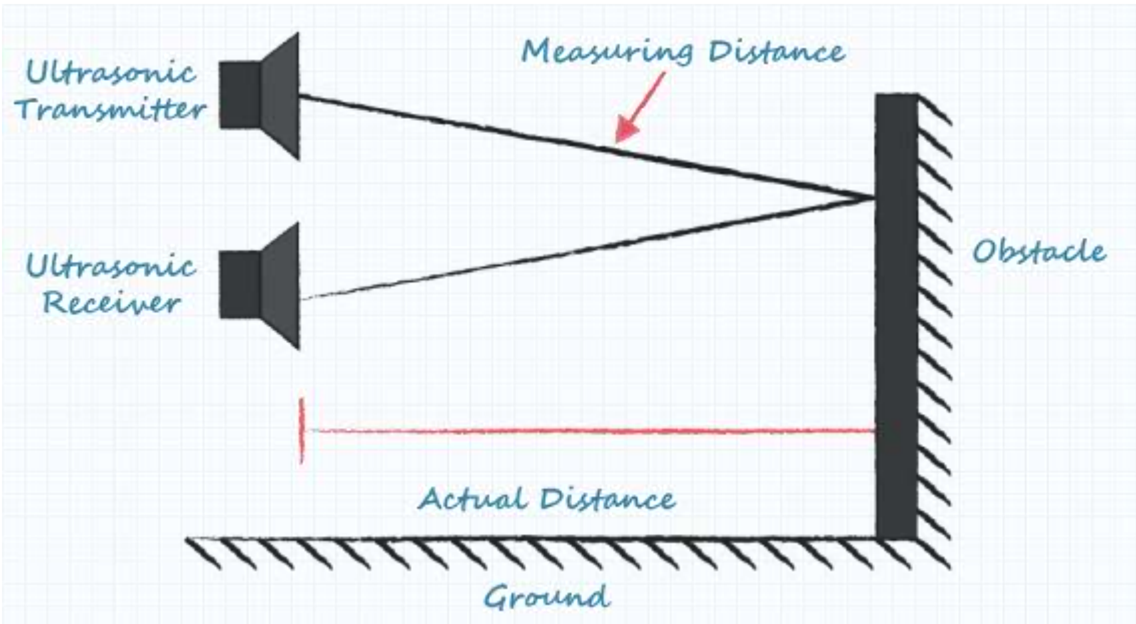

FIGURE 15: BASIC OPERATION OF AN ULTRASONIC TRANSMITTER AND RECIEVER PAIR

The acoustic waves that leave the transmitter are more similar in shape to light leaving a flashlight than a laser, so spread and beam angle must be considered. As the sound waves travel farther from the transmitter, the area of detection grows laterally and vertically. This changing area is why ultrasonic sensors give their coverage specification in either beam width or beam angle instead of a standard detection area. When comparing this beam angle between manufacturers, it is recommended to verify that the beam angle is either the full angle of the beam or the angle of variation from the straight line from a transducer.

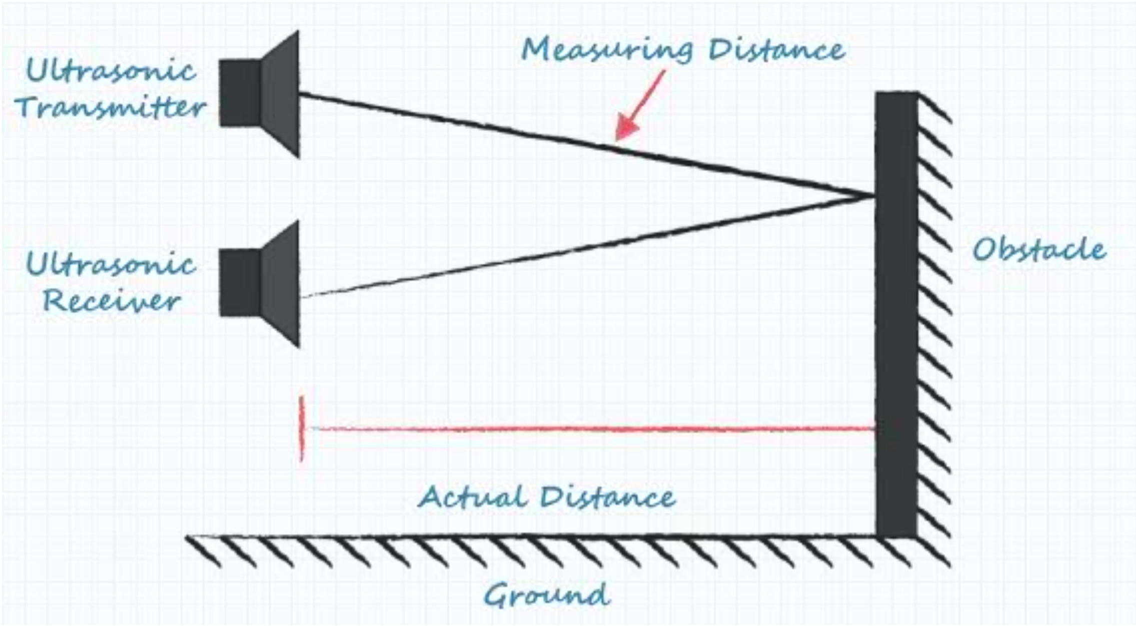

FIGURE 16: UNDERSTANDING THE BEAM ANGLE IS ESSENTIAL FOR ESTABLISHING THE DETECTION AREA

A secondary effect of the beam angle is the range of the device. In general, a narrow beam yields a greater detection range as the energy of the ultrasonic pulse is more focused and can go farther before dissipating to unusable levels. Inversely, a wider beam spreads that energy in a wider arc, reducing the expected detection range. Choosing the ideal beam width is highly dependent on the application, with wide beams better at covering larger areas and general detection, while more narrow beams avoid false positives by limiting the detection area.

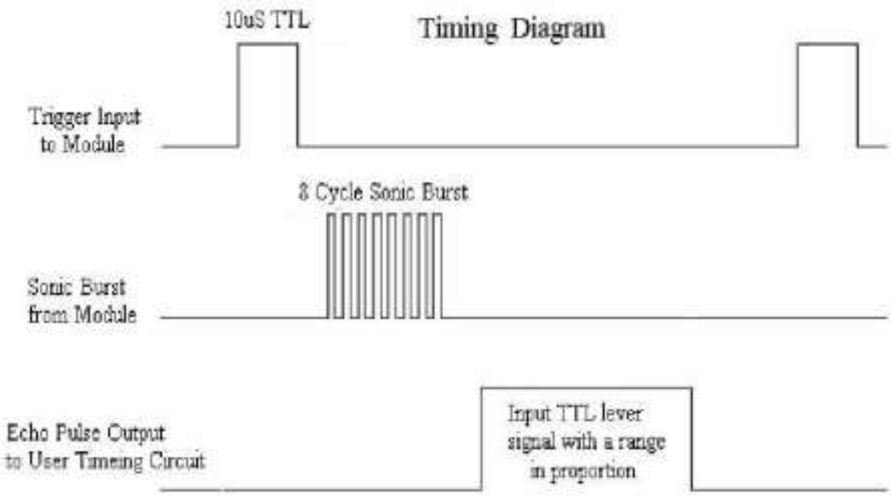

FIGURE 17: TIMING DIAGRAM OF AN ULTRASONIC SENSOR

When searching for individual components, ultrasonic sensors can be acquired as independent transmitters and receivers or as a combination of the two in a single unit, known as an ultrasonic transceiver. Most analog ultrasonic sensor options are actuated by sending a trigger signal to the transmitter with the receiver sending back a signal when the echo is detected. The length of the pulse and any encoding can be customized by the designer as needed. This process ultimately leaves the time calculation between trigger and echo, as well as the decoding, to a host controller. There are digital ultrasonic sensor modules that calculate the distance onboard and then transmit the distance to the host through the communication bus. Although ultrasonic transmitters, receivers, or transceivers are often purchased separately and assembled with custom circuitry and firmware, they are also sometimes available as a single unit, pre-mounted on a PCB in the standard range finding configuration and a simple logic board. While simpler to use, designers do give up a great deal of flexibility and customization by using these modules.

FIGURE 18: EXAMPLES OF AN ULTRASONIC TRANSMITTER, RECEIVER, AND TRANSCEIVER

3.3.3 Strengths and Weaknesses of Ultrasonic Sensors

As with any technology, ultrasonic sensors are best utilized in certain situations or applications over others. A few of their strengths include the following:

- Ultrasonic sensors are unaffected by the color of the objects being detected, including translucent or transparent objects such as water or glass.
- Their minimum and maximum ranges are quite flexible, with most ultrasonic sensors capable of detecting as near as a few centimeters up to approximately five meters. Specifically configured modules can even measure up to nearly 20 meters.
- With decades of use, this mature technology is very reliable and well

understood, yielding consistent results.

- Ultrasonic sensors provide relatively precise measurements, within 1% typically and even more precision if desired.
- They can make many measurements per second, yielding quick refresh rates.
- As there are no rare materials needed, they are usually quite inexpensive.
- Ultrasonic sensors are resistant to electrically noisy environments as well as most acoustic noise, particularly when using modules equipped with encoded chirps.

Although a versatile technology, ultrasonic sensors due have several limitations to consider before making a final sensor selection:

- As the speed of sound is dependent on temperature and humidity, environmental conditions may change the precision of the measurements.
- Although the detection zone is three dimensional, an ultrasonic sensor only detects that there is something a certain distance from the detector and cannot provide feedback on where the object is in the sensing area nor any features such as shape or color.
- While their form factor is relatively small and they can be integrated into cars or industrial applications without any concerns, ultrasonic sensors may be too large for very small, embedded projects.
- Like any sensor, they can get dirty, wet, or frozen, which will cause them to be erratic or non-functional.
- Due to their dependence on sound, which in turn depends on a medium of some sort, ultrasonic sensors do not work in a vacuum.

FIGURE 19: ACTUAL ULTRASONIC SENSOR USED IN PROJECT

3.3.4 Where are Ultrasonic Sensors Typically Used?

The first of the two most common ultrasonic sensor applications is liquid level sensing, as they can detect liquids of any color or opacity yet are also non-contact. The second is general object detection due to their low cost and simplicity. Specific object detection applications include anti-collision detection for vehicles, people detection, presence detection, box sorting, pallet detection with forklifts, bottle counting on drink filling machines, and many more.

An example of a more creative usage for ultrasonic sensors would be to use the one-way functionality of ultrasonic transmitters and receivers separately. While the ultrasonic pulses are outside of human audible ranges, they are within the hearing ranges of various animals. An ultrasonic transmitter could conceivably use its emitters to scare off animals, such as birds, while an ultrasonic receiver could be used for noise detection.

Ultrasonic sensors are a great solution for the detection of clear objects. For liquid level measurement, applications that use infrared sensors, for instance, struggle with this particular use case because of target translucence. For presence detection, ultrasonic sensors detect objects regardless of the color, surface, or material (unless the material is very soft like wool, as it would absorb sound). To detect transparent and other items where optical technologies may fail, ultrasonic sensors are a reliable choice.

3.4 LCD DISPLAY 16×2

3.4.1 What is LCD Display 16×2

An electronic device that is used to display data and the message is known as LCD 16×2. As the name suggests, it includes 16 Columns & 2 Rows so it can display 32 characters (16×2=32) in total & every character will be made with 5×8 (40) Pixel Dots. So the total pixels within this LCD can be calculated as 32 x 40 otherwise 1280 pixels.

The term LCD stands for liquid crystal display. It is one kind of electronic display module used in an extensive range of applications like various circuits & devices like mobile phones, calculators, computers, TV sets, etc. 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.

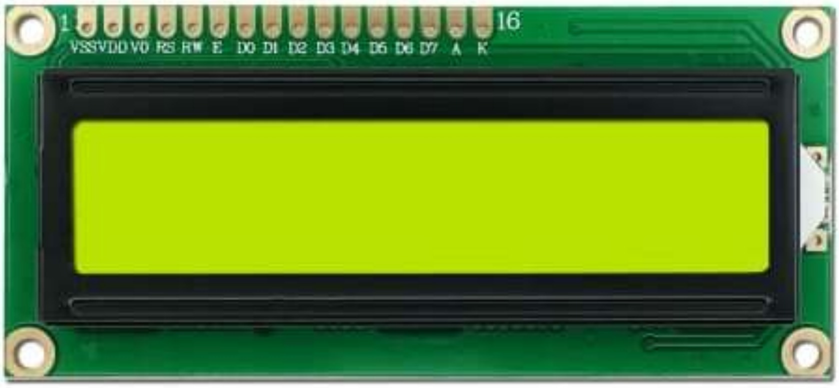

FIGURE 20: LCD DISPLAY 16×2

3.4.2 Working Principle of LCD Display 16×2

The basic working principle of LCD is passing the light from layer to layer through modules. These modules will vibrate & line up their position on 90o that permits the polarized sheet to allow the light to pass through it.

These molecules are accountable for viewing the data on every pixel. Every pixel utilizes the method of absorbing light to illustrate the digit. To display the value, the position of molecules must be changed to the angle of light.

So this light deflection will make the human eye notice the data that will be the ingredient wherever the light gets absorbed. Here, this data will supply to the molecules & will be there till they get changed
At present, LCDs are used frequently in CD/DVD players, digital watches, computers, etc. In screen industries, LCDs have replaced the CRTs (Cathode Ray Tubes) because these displays use more power as compared to LCD, heavier & larger.

The displays of LCDs are thinner as compared to CRTs. As compared to LED screens, LCD has less power consumption because it functions on the fundamental principle of blocking light instead of dissipating.

FIGURE 21: ACTUAL 16×2 LCD DISPLAY USED IN PROJECT

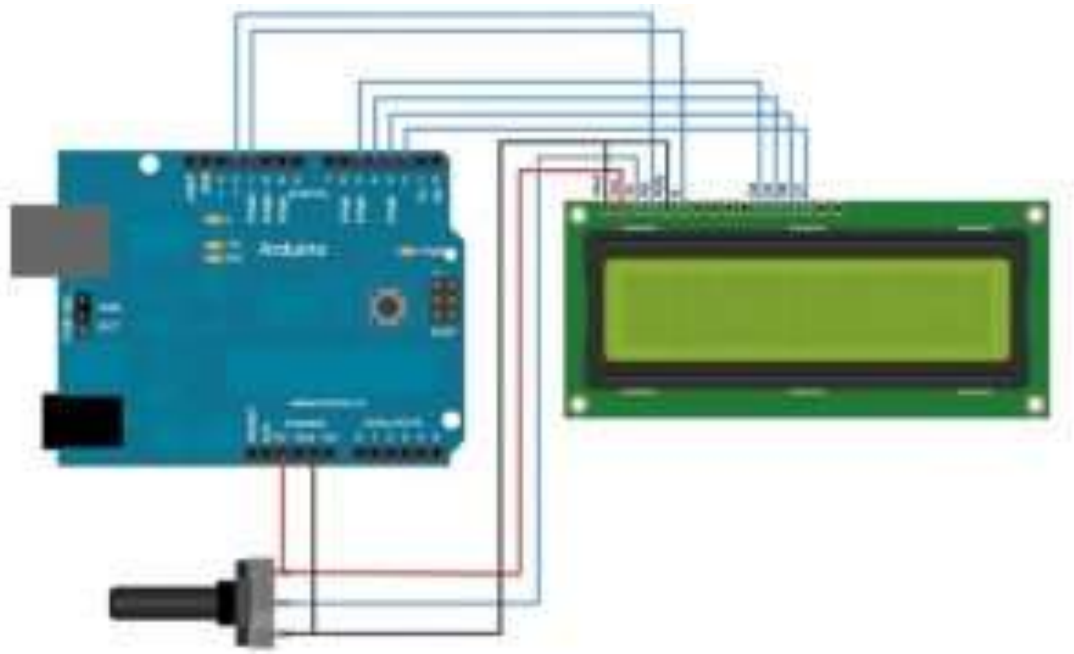

FIGURE 22: INTERFACING LCD WITH ARDUINO BOARD

3.4.3 LCD Display 16×2 Pin Diagram

The 16×2 LCD pinout is shown below.

- Pin1 (Ground/Source Pin): This is a GND pin of display, used to connect the GND terminal of the microcontroller unit or power source.
- Pin2 (VCC/Source Pin): This is the voltage supply pin of the display, used to connect the supply pin of the power source.
- Pin3 (V0/VEE/Control Pin): This pin regulates the difference of the display, used to connect a changeable POT that can supply 0 to 5V.
- Pin4 (Register Select/Control Pin): This pin toggles among command or data register, used to connect a microcontroller unit pin and obtains either 0 or 1(0 = data mode, and 1 = command mode).
- Pin5 (Read/Write/Control Pin): This pin toggles the display among the read or writes operation, and it is connected to a microcontroller unit pin to get either 0 or 1 (0 = Write Operation, and 1 = Read Operation).
- Pin 6 (Enable/Control Pin): This pin should be held high to execute Read/Write process, and it is connected to the microcontroller unit & constantly held high.
- Pins 7-14 (Data Pins): These pins are used to send data to the display. These pins are connected in two-wire modes like 4-wire mode and 8-wire mode. In 4-wire mode, only four pins are connected to the microcontroller unit like 0 to 3, whereas in 8-wire mode, 8-pins are connected to microcontroller unit like 0 to 7.
- Pin15 (+ve pin of the LED): This pin is connected to +5V
- Pin 16 (-ve pin of the LED): This pin is connected to GND.

Pin No:	Pin Name:	Description
1	Vss (Ground)	Ground pin connected to system ground
2	Vdd (+5 Volt)	Powers the LCD with +5V (4.7V – 5.3V)
3	VE (Contrast V)	Decides the contrast level of display. Grounded to get maximum contrast.
4	Register Select	Connected to Microcontroller to shift between command/data register
5	Read/Write	Used to read or write data. Normally grounded to write data to LCD
6	Enable	Connected to Microcontroller Pin and toggled between 1 and 0 for data acknowledgement
7	Data Pin 0	Data pins 0 to 7 forms a 8-bit data line. They can be connected to Microcontroller to send 8-bit data. These LCD's can also operate on 4-bit mode in such case Data pin 4,5,6 and 7 will be left free.
8	Data Pin 1	
9	Data Pin 2	
10	Data Pin 3	
11	Data Pin 4	
12	Data Pin 5	
13	Data Pin 6	
14	Data Pin 7	
15	LED Positive	Backlight LED pin positive terminal
16	LED Negative	Backlight LED pin negative terminal

TABLE 4: 16×2 LCD PINOUT CONFIGURATION

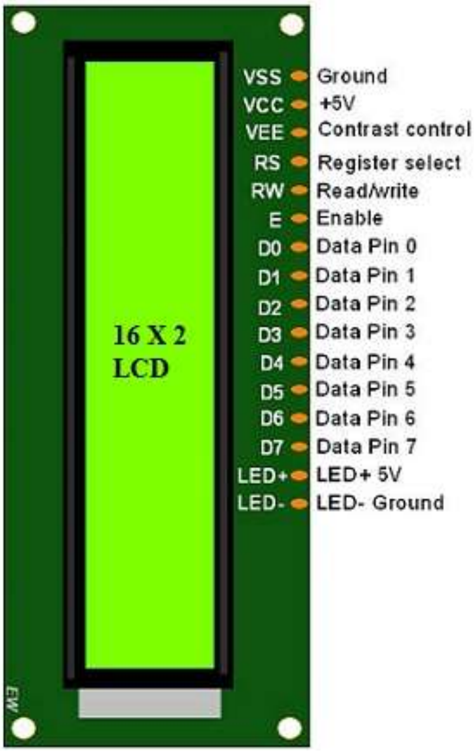

FIGURE 23: LCD DISPLAY 16×2 PIN DIAGRAM

3.4.4 Features of LCD Display 16×2

The features of this LCD mainly include the following:

- The operating voltage of this LCD is 4.7V-5.3V
- It includes two rows where each row can produce 16-characters.
- The utilization of current is 1mA with no backlight
- Every character can be built with a 5×8 pixel box
- The alphanumeric LCDs alphabets & numbers
- Is display can work on two modes like 4-bit & 8-bit
- These are obtainable in Blue & Green Backlight
- It displays a few custom generated characters

The Arduino Nano, Ultrasonic Sensor (HC SR-04) and 16×2 LCD Display forms the main components of our project. However we have also used certain more small yet useful components/equipments. They are mentioned below:

3.5 PRINTED CIRCUIT BOARD (PCB)

3.5.1 What is PCB?

Printed circuit boards (PCBs) are the foundational building block of most modern electronic devices. Whether simple single layered boards used in your garage door opener, to the six layer board in your smart watch, to a 60 layer, very high density and high-speed circuit boards used in super computers and servers, printed circuit boards are the foundation on which all of the other electronic components are assembled onto.

Semiconductors, connectors, resistors, diodes, capacitors and radio devices are mounted to, and “talk” to one another through the PCB.

PCB’s have mechanical and electrical attributes that make them ideal for these applications. Most PCB’s manufactured in the World are rigid, roughly 90% of the PCB’s manufactured today are rigid boards. Some PCB’s are flexible, allowing the circuits to be bent and folded into shape, or sometimes they are used where the flexible circuit will survive hundreds of thousands of flex cycles, without any break in the circuits. These flexible PCB’s comprise roughly 10% of the market. A small subset of these types of circuits are called rigid flex circuits, where one part of the board is rigid – ideal for mounting and connecting components, and one or more parts are flexible, providing the advantages of flexible circuits listed above.

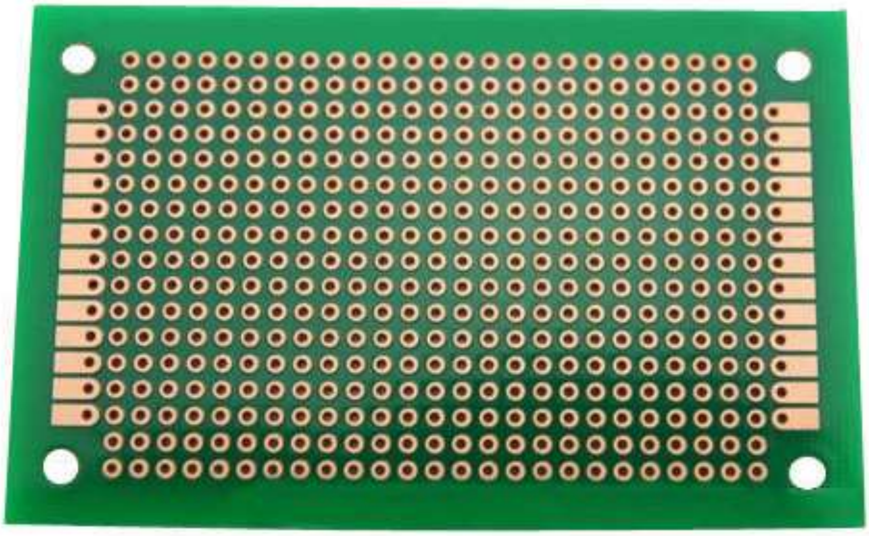

FIGURE 24: A BLANK PCB

3.5.2 Types of Printed Circuit Boards

Although all PCBs have the same fundamental objective, they are available in a wide range of designs and configurations to meet the needs of various applications. Some of the different types available on the market include:

- Single sided rigid
- Double sided rigid
- Multi-layered rigid
- Single layer flexible circuits
- Double sided flexible circuits
- Multi-layered flexible circuits
- Rigid-flex
- High frequency
- Aluminum-backed

3.5.3 Printed Circuit Board Design

PCBs come in a variety of designs, so it is important to have a thorough understanding of the design process. Some of the key elements to consider when designing a PCB include:

- Application for which the PCB will be used
- Environment in which the PCB will operate
- Amount of space and configuration required for installation
- Flexibility of the PCB
- Installation and assembly
- Selecting the right PCB design to suit these considerations significantly impacts manufacturability, production speed, product yield, operation costs, and lead times.

When choosing a fabricator for your PCB needs, be sure that they have the appropriate accreditations, to ensure that they have the quality system, experience, industry recognition and ratings to assure your project’s success. At Printed Circuits, we make it our goal to meet and exceed industry standards and have obtained a wide range of certifications and accreditations to do so, including:

- ITAR Registration
- Printed Circuits ISO 9001:2015 Certification

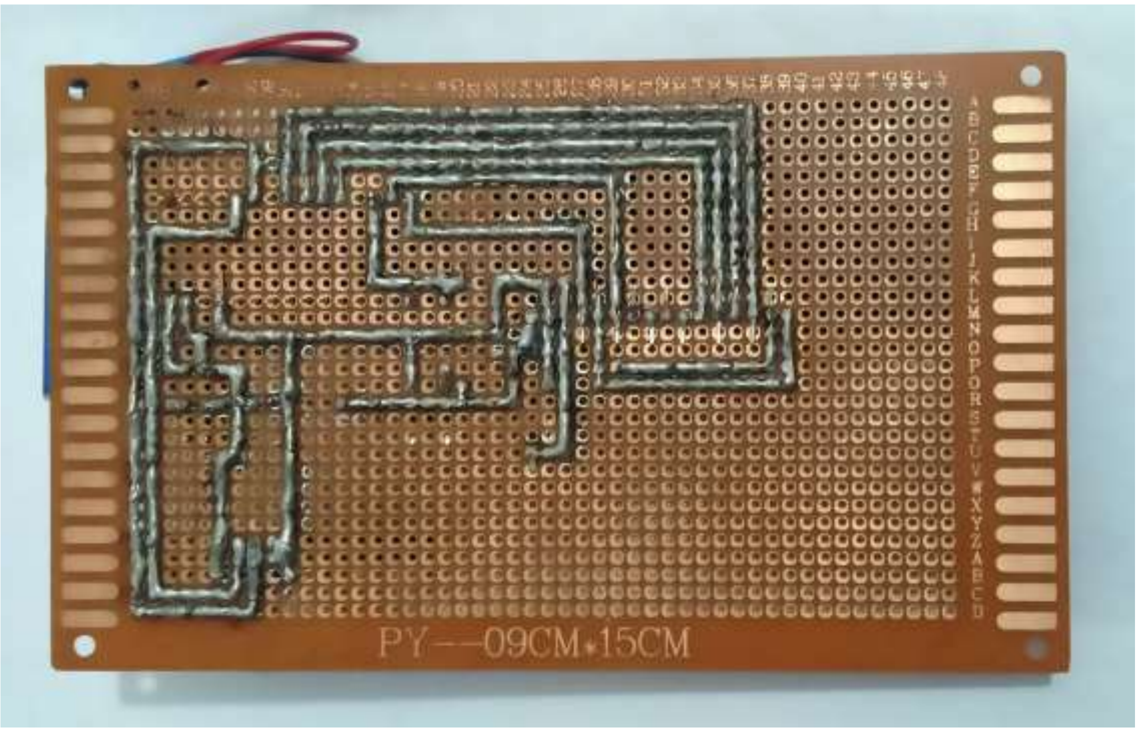

FIGURE 25: ACTUAL PCB (BACKSIDE) USED IN PROJECT

3.5.4 Printed Circuit Board Fabrication

The construction and fabrication of PCBs include the following steps:

- Chemically imaging and etching the copper layers with pathways to connect electronic components
- Laminating the layers together, using an bonding material, that also acts as electrical insulation, to create the PCB
- Drilling and plating the holes in the PCB to connect all of the layers together electrically
- Imaging and plating the circuits on the outside layers of the board
- Coating both sides of the board with soldermask and printing the nomenclature markings on the PCB
- The boards are then machined to the dimensions that are in the designer's perimeter gerber file

Once complete, the PCB board is ready for components to be assembled to it. Most commonly the components are attached to the PCB by soldering the components directly onto exposed traces – called pads – and holes in the PCB. Soldering can be done by hand, but more typically is accomplished in very high-speed automated assembly machines.

Two of the most common PCB assembly methods are surface-mount device (SMD) or thru-hole technology (THT). The use of either depends on the size of the components and the configuration of the PCB. SMD is useful for directly mounting small components on the exterior of the PCB, while THT is ideal for mounting large components through large pre-drilled holes in the board.

3.6 10K PRESET POTENTIOMETER

3.6.1 What is 10k preset Potentiometer?

A potentiometer is a variable resistor with three terminals, where Two terminals are connected to a resistive element and the third terminal is connected to an adjustable round wiper. The position of the wiper determines the output voltage.

•

FIGURE 26: A 10K PRESET POTENTIOMETER

This 10K ohm compact linear Potentiometer with plastic dust-cap is suitable for bread board as well as PCB. This is center tap type so two pins will measure full 10K resistance and on third pin resistance will vary in accordance to rotation. A small flat screw driver is used for changing the value.

FIGURE 27: ACTUAL POTENTIOMETER USED IN PROJECT

3.6.2 Specifications of Preset Potentiometer

- Material Used : Plastic
- Linear type with a single turn
- Compact size

- Value:- 0- 10K
- Resistance Tolerance:- ±10%
- Rotation angel:- 210 ±20 °
- Rotational Life Cycle:- 200 cycles
- Temperature range : - -55 to +125 °C

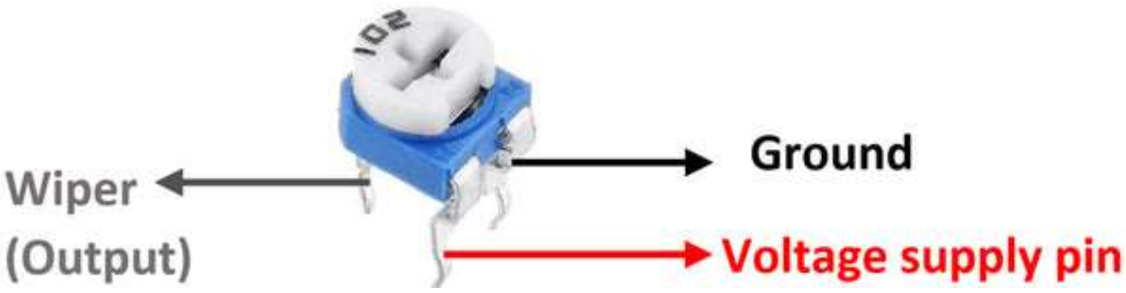

FIGURE 28: PIN DESCRIPTION OF PRESET POTENTIOMETER

3.7 9V BATTERY

3.7.1 What Are 9V Batteries?

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. A wide array of both large and small battery manufacturers produce versions of the 9V battery. Possible chemistries of primary (non-rechargeable) 9V batteries include Alkaline, Carbon-Zinc (Heavy Duty), Lithium. Possible chemistries of secondary (rechargeable) 9V batteries include nickel-cadmium (NiCd), nickel-metal hydride (NiMH), and lithium ion. The performance and application of the battery can vary greatly between different chemistries, meaning that some chemistiries are better suited for some applications over others.

FIGURE 29: A GENERAL PURPOSE 9V BATTERY

3.7.2 What Is The 9V Battery Used For?

The 9V battery is used in many different applications. 9 volt batteries can frequently be seen used in radios, smoke alarms, wall clocks, walkie-talkies, portable electronics, and much more. In the American prison system inmates have even been known to utilize the 9 volt battery to light cigarettes by adding a steel wool or wire to create an ultra hot contact point. This is not recommended as it can cause harm to you and your battery, but goes to show how many uses 9V batteries can have.

FIGURE 30: ACTUAL 9V BATTERY USED IN PROJECT

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

TABLE 5: TECHNICAL SPECIFICATION OF 9V BATTERY

3.8 LASER DIODE LIGHT – LASER LED LIGHT

3.8.1 What is laser diode light?

This low-cost Laser Diode or Laser Light is commonly used in security devices and pointers. This Red Laser diode is rated for 5mW with a nominal voltage between 2.2V and 3V. Just like other LED Diodes the Laser Diode should also be used with a driver circuit to limit the current through it. The wave length of Laser light normally range from 635nm to 66nm.

FIGURE 31: LASER DIODE LIGHT – LASER LED LIGHT

3.8.2 Specification of Laser Diode Light:

- Maximum Operating Voltage: 3V
- Operating Current: 45mA
- Color: Red
- Laser Pattern: Point

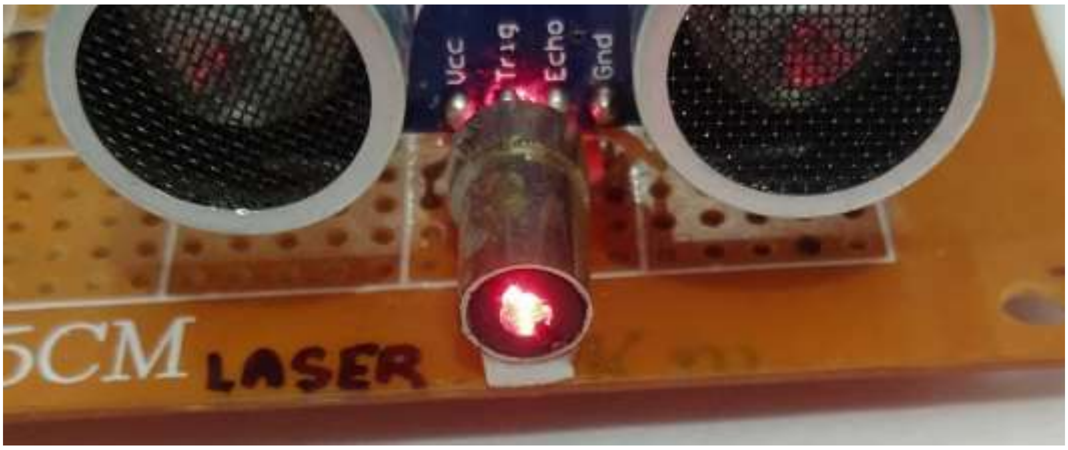

FIGURE 32: ACTUAL LASER DIODE LIGHT USED IN PROJECT

3.9 PUSH BUTTON AND TOGGLE SWITCHES

3.9.1 Push Button Switch

A push switch (button) is a momentary or non-latching switch which causes a temporary change in the state of an electrical circuit only while the switch is physically actuated. An automatic mechanism (i.e. a spring) returns the switch to its default position immediately afterwards, restoring the initial circuit condition.

FIGURE 33: A PUSH BUTTON SWITCH

A push button switch causes a temporary change in an electrical circuit only while the switch is physically pushed. A spring returns the switch to its original position immediately afterwards. The pushbutton is typically made of plastic or metal and may be flat-surfaced or contoured to the finger or hand. Also known as momentary switches, they are designed and manufactured to the highest quality standards. We offer push button switch types in wide ranges from standard to IP-rated. Our portfolio includes Alcoswitch and KISSLING switches and common applications include include emergency stop (e-stop) and alarm switches, calculator buttons, doorbells, and refrigerator light switches.

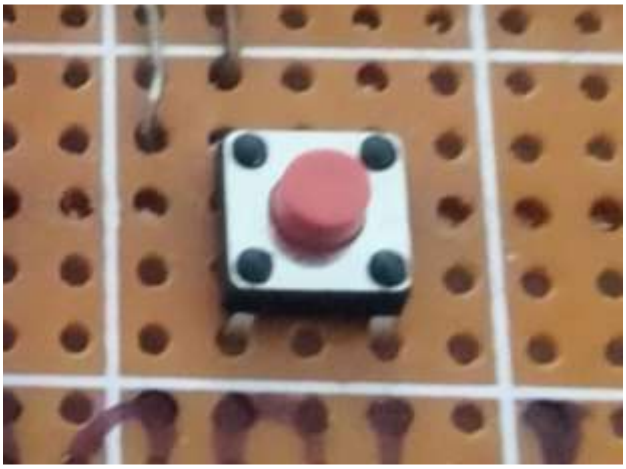

FIGURE 34: ACTUAL PUSH BUTTON SWITCH USED IN PROJECT

3.9.2 Toggle Switch

A Toggle Switch is an electromechanical switch which uses a lever or baton as an actuator. Toggle switches are available in many sizes and configurations and offer a wide range of uses. They are popular for their ease of operation and generally offer 1-3 positions to open or close a circuit.

FIGURE 35: A TOGGLE SWITCH

Toggle switches offer a variety of switching functions - SPDT, SPST, DPDT, DPST and multiple actuator and bushing options. Our toggle switches also come in different sizes, from miniature PCB mount up to power rated panel mounted switches.

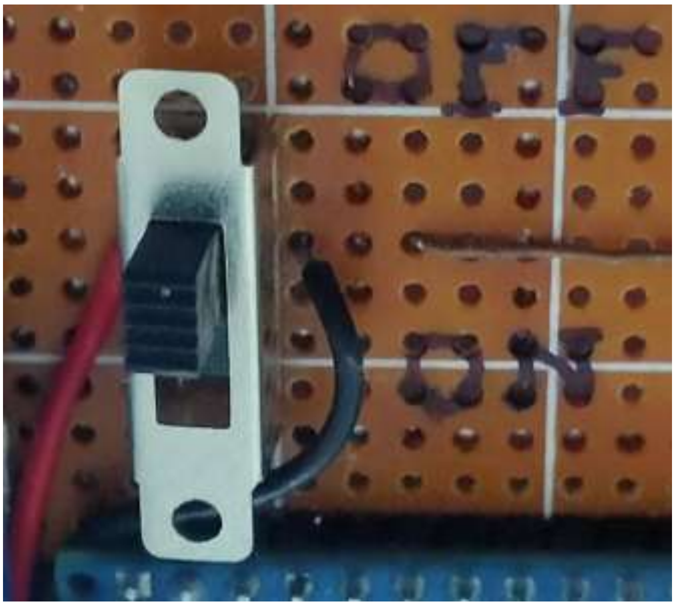

FIGURE 36: ACTUAL TOGGLE SWITCH USED IN PROJECT

After finalizing all the equipments and acquiring necessary information about them, we will discuss the methodology of incorporating all the parts/equipments together to form the required device, i.e. Distance measuring device based on ultrasonic sensor

We will discuss the methodology of the project in next chapter

CHAPTER 4

METHODOLOGY

4.1 INTRODUCTION

This chapter presents the methods and procedures that the we will use in gathering the necessary data required for the completion of the study. This includes the research design, time and locale of the study, population and sampling, research instrument, research procedures and statistical treatment of data.

The technique of distance measurement using ultrasonic in air include continuous wave & pulse echo technique. In the pulse echo method, a burst of pulses is sent through the transmission medium & is reflected by an object kept at special distance. The time taken for the pulse to propagate from transmitter to receiver is proportional to the distance of object. For contact less measurement of distance, the device has to rely on the target to reflect the pulse back to itself. The target needs to have a proper orientation that is it needs to be perpendicular to the direction of propagation of the pulses. The amplitude of the received signal gets significantly attenuated and is a function of nature of the medium and the distance between the transmitter and target. The pulse echo or time-of-flight method of range measurement is subject to high levels of signal attenuation when used in an air medium, thus limiting its distance range.

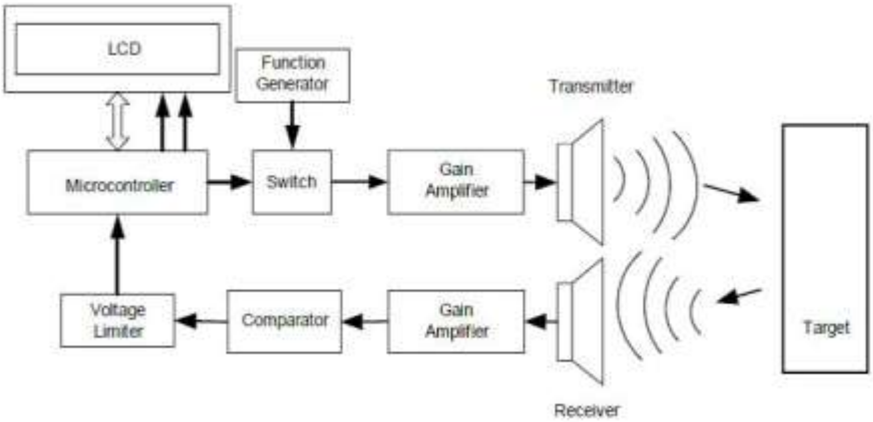

FIGURE 36: BLOCK DIAGRAM OF DEVICE

4.2 PROCEDURE

The method of making of our Mini Project Distance Measurement Using Ultra sonic sensor is that:

1. Take General Purpose PCB (Zero PCB) and take Arduino Nano and solder the all pin of Arduino Nano in Zero PCB.

2. Take Ultra Sonic Sensor and solder all pin of Ultra Sonic Sensor in Zero PCB.

3. Take 16*2 LCD Display and solder all the pin of 16*2 LCD Display.
4. Take 10K pre set Potentiometer and solder all pin in Zero PCB.
5. Take 9v Battery connector and solder all the wire in Zero PCB.
6. Take Sliding Switch and solder all pin in Zero PCB.
7. Take Push button and solder all pin in Zero PCB.
8. Take 10K resistor and solder it in Zero PCB.
9. Take Laser and solder all pin in Zero PCB.

4.3 CONNECTIONS

The connection of all components is that:

- The +ve wire of 9V battery connector connectS to one pin of Sliding Switch and another pin of Sliding Switch connect to VIN pin of Arduino Nano.
- The GND wire of 9V battery connector connect to the GND pin Arduino Nano.
- The VCC pin of Ultra Sonic Sensor connect to 5V pin of Arduino Nano
- GND pin of Ultra Sonic Sensor connect to the GND pin of Arduino Nano
- Echo pin of Ultra Sonic Sensor connect to the D2 pin of Arduino Nano
- Trig pin of Ultra Sonic Sensor connect to the D3 pin of Arduino Nano.
- The VSS pin of 16*2 LCD Display connect to the GND pin of Arduino Nano.
- VDD pin of 16*2 LCD Display connect to the 5V pin of Arduino Nano
- V0 of 16*2 LCD Display connect to the Mid pin of 10K pre set Potentiometer
- RS pin of 16*2 LCD Display connect to the D12 of Arduino Nano
- RW pin of 16*2 LCD Display connect to the GND pin of Arduino Nano
- E pin of 16*2 LCD Display connect to the D11 pin of Arduino Nano
- D4 pin of 16*2 LCD Display connect to the D8 pin of Arduino Nano
- D5 pin of 16*2 LCD Display connect to the D7 pin of Arduino Nano
- D6 pin of 16*2 LCD Display connect to the D6 pin of Arduino Nano

- D7 pin of 16*2 LCD Display connect to the D5 pin of Arduino Nano
- A pin of 16*2 LCD Display connect to the 5V pin of Arduino Nano
- K pin of 16*2 LCD Display connect to the GND pin of Arduino Nano.
- The first pin of 10K pre set Potentiometer connect to VDD (5V) pin of 16*2 LCD Display
- Mid pin of 10K pre set Potentiometer connect to the V0 pin of 16*2 LCD Display
- Last of pin of 10K pre set Potentiometer connect to the GND pin of 16*2 LCD Display.
- The first pin of Push button connect to 5v pin of Arduino Nano
- Second pin of Push button connect to the D10 of Arduino Nano.
- One side of 10K Resistor connect to the D10 pin of Arduino Nano, another side of 10K Resistor connect to the GND pin of Arduino Nano.
- Vcc pin of Laser connect to the 5v pin of Arduino Nano and GND pin of laser connect to the GND pin of Arduino Nano.
- 9V battery connector is connect to the 9V battery

4.4 PROGRAMMING

The programming of arduino and other components is done on an Open Source Arduino Software (IDE) based on a very simple hardware programming language called processing, which is similar to the C language. After the sketch is written in the Arduino IDE, it is uploaded on the Arduino board for execution.

The code used for programming is:

```
#include <LiquidCrystal.h>

#define Trigger 3
#define Echo 2
const int RS =12, E = 11, D4 = 8, D5= 7, D6 = 6, D7 = 5;
LiquidCrystal lcd(RS, E, D4, D5, D6, D7);
long time=0;
int distance=0;
int Mode=0;
int num=0;
int num1=0;
```

```
void setup()
{
 lcd.begin(16,2);
 pinMode(Trigger,OUTPUT);
 pinMode(Echo,INPUT);
 pinMode(10,INPUT) ;
 lcd.print("   WELCOME TO");
 lcd.setCursor(0,1);
 lcd.print("  MINI PROJECT");
 delay(1000);
 lcd.clear();
 lcd.setCursor(0,0);
 lcd.print("DISTANCE MEASUREMENT USING ULTRA SONIC");
 delay(1000);
 while(num<20)
 {
  lcd.scrollDisplayLeft();
  delay(500);
  num++;
 }
 lcd.setCursor(0,0);
 lcd.print("SENSOR  ");
 while(num1<12)
 {
  lcd.scrollDisplayLeft();
  delay(500);
  num1++;
 }
 delay(1000);
 lcd.clear();
 lcd.print("    MADE  BY");
 lcd.setCursor(0,1);
 lcd.print("Praddhumn  SINGH");
 delay(1000);
 lcd.clear();
 lcd.print("   Mohd Tabish");
 lcd.setCursor(0,1);
 lcd.print("     Husain");
 delay(1000);
 lcd.clear();
 lcd.print("     Shachi");
 lcd.setCursor(0,1);
 lcd.print("   Shrivastwa");
```

```
 delay(1000);
 lcd.clear();
 lcd.print("    Shashwat");
 lcd.setCursor(0,1);
 lcd.print("   Srivastava");
 delay(1000);
 lcd.clear();
 lcd.print("UnderSupervision");
 lcd.setCursor(0,1);
 lcd.print("Mr.Brajesh Singh");
 delay(1000);
}
void loop()
{
 lcd.clear();
 digitalWrite(Trigger,LOW);
 delayMicroseconds(2);
 digitalWrite(Trigger,HIGH);
 delayMicroseconds(10);
 digitalWrite(Trigger,LOW);
 delayMicroseconds(2);
 time=pulseIn(Echo,HIGH);
 distance=time*340/20000;

 if(digitalRead(10)==HIGH){
 Mode++;
 lcd.clear();
 lcd.print("  MODE  CHANGE");
 delay(1000);
}
if(Mode==1){
lcd.clear();
lcd.print("Distance:");
lcd.print(distance/30.48);
lcd.print("Ft");
lcd.setCursor(0,1);
lcd.print("Distance:");
lcd.print(distance/100.);
lcd.print("M");
}
else{
lcd.clear();
lcd.print("Distance:");
lcd.print(distance);
```

```
lcd.print("Cm");
lcd.setCursor(0,1);
lcd.print("Distance:");
lcd.print(distance/2.54);
lcd.print("In");
}
if(Mode==2){
lcd.clear();
Mode=0;
lcd.print("  MODE  CHANGE");
}
delay(500);
}
```

4.5 WORKING

The working of this device is that.

- Battery gives Power to the device
- Sliding Switch is use to turn on and off the device.
- Ultra sonic sensor is use to transmit and receive the Ultra Sonic Sound Waves.
- Arduino Nano use as microcontroller to calculate the data which is coming from Ultra Sonic Sensor and display the data on 16*2 LCD Display.
- 16*2 LCD Display is sse to display the data coming from Arduino Nano.
- 10K pre set Potentiometer is use to adjust the contrast of display.
- Push button is use to change the mode from centimeter to inch, meter, feet and back to centimeter.
- 10k resistor is use to GND the D10 pin of Arduino Nano when we do not push the push button.

CHAPTER 5

FINAL COSTING

5.1 INTRODUCTION

In this chapter we will discuss about the cost of different equipments that we have used in our project. One of the aims of this project is to try and maximum reduce the cost wherever possible without compromising with the quality of parts used.

Cost of all the equipments are mentioned in the table below:

SR.No.	EQUIPMENT	PRICE
1.	ARDUINO NANO	319
2.	ULTRASONIC SENSOR HC SR – 04	75
3.	16×2 LCD DISPLAY	133
4.	PRINTED CIRCUIT BOARD	29
5.	10K PRESET POTENTIOMETER	6
6.	9V BATTERY	19
7.	LASER DIODE LIGHT – LASER LED LIGHT	50
8.	PUSH BUTTON SWITCH	5
9.	TOGGLE SWITCH	5
10	9V BATTERY CONNECTOR	8
11	SOLDER WIRE	40
12	MALE HEADER PIN	7
13	RESISTOR 10K	3
	TOTAL	

TABLE 6: COST OF EQUIPMENTS

CHAPTER 6

CONCLUSION

6.1 SUMMARY

This chapter contains the main points from the findings taken from the experiments and the conclusions formulated and future scope that the project propose. This study is about the use of an “Ultrasonic Distance Measuring Device”. In essence, it aimed to answer the following questions:

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

(2) Does it do a better job of taking measurements than the ones that already exist?

(3) Is it too complicated to adapt the device?

(4) How much distance can the ultrasonic distance measuring device achieve?

(5) Can the device take measurements with minimal to no errors?

6.2 FINDINGS

The following are the findings that came about from the procedures taken to answer the questions:

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

  For a typical consumer, it will not be cheap to create the device as it takes a budget of about 150-200 SAR to buy the components. But the price can be considerable for tech hobbyists because most of the components can be reused for other projects.

- Does it do a better job of taking measurements than the ones that already exist?

  Yes, the device does a better job in real life applications especially in terms of time. The device will take only 1.5s to take measurements regardless of distance while a device such as a measuring tape can take much longer to take measurements especially if the distance that needs to be measured gets longer. (11s on average with a measuring tape)

- Is it too complicated to adapt the device?

No, it will not be complicated to adapt the device at all due to its simplicity in terms of operation. But an improvement can be done on the device in terms of portability.

- How much distance can the ultrasonic distance measuring device achieve?

  The sensor of the ultrasonic distance measuring device prototype is capable of measuring a distance of up to 400 cm.

- Can the device take measurements with minimal to no errors?

  Yes, the device can take measurements with only a 1-3% margin of error. This margin of error increases by a percent as the distance from the object's surface grows.

6.3 CONCLUSION

The design process, detailed implementation methodologies, project planning, and progress of the Distance Measurement Using Ultrasonic Sensor mini project was presented. The project focuses on measuring desired distance from an object and providing data on the LCD Display. The designed placement of the ultrasonic sensors detect distance from objects at the ground and through water as well up to a maximum of 4m. The results show that the results for measured distance is satisfying for use in the sewer inspection system being developed. It can also be used for other devices requiring distance measurement of an object or obstacle. As shown, the system is implementable in the robotic sewer blockage detection system. The distance of the blockage from a specified entry point in the sewer pipeline can be calculated by adding travelled distance by the robotic vehicle and the distance of the blockage from the robotic vehicle. The accuracy of distance of blockage will be sufficient for normal practical uses. The system can be easily implemented in other devices and systems requiring the measurement of distance of an object or an obstacle from stationary or moving observation point where the ultrasonic sensor will be located.

The importance of the project is calculating accurate distance from any obstacle that we want to measure. The device can be used in many different fields and categories like distance calculation in construction field, robots, car sensor to avoid obstacles and many other applications. The building process of the device was based on using as much as possible from the courses taken in the university, like Micro Processor, Basic Electrical Engineering, Multimedia and systems and Electronics Devices and also practical work in the laboratories.

The final engineering prototype was delivered in Week 5 which met all the proposed features in addition to the extra features discussed. Compared to previous designs presented in the Department of ECE at FGIET, this project uniquely stands out for being universally-portable for any user capable of physically carrying the device. Many challenges and deadlines were faced on the course of the project such as patiently waiting for components shipping delays, learning to interface with new hardware, combining the separate project codes and coming up with new optimized generator design. Therefore, the completion of this mini project within 5 weeks is an accomplishment for all team members and supporting members.

6.4 SOURCES OF ERROR

- The speed of sound is variable in different mediums & also depends on temperature of the medium, so manual manipulations are required on calculated distance.
- Signals get weekend as they propagate through the medium .Attenuation depend on frequency of the signals putting a constraints on the range of the systems.
- The size of the object should be of the order of wavelength of signal for it to be detected. So object should not be very small.
- The object should be placed near the rotational axis of transmitter. At wider angles less reflection takes place.
- The object should be a good reflecting surface.

6.5 FUTURE SCOPE

For future development, distance measurement using ultrasonic sensor must be enhanced to account for more details which were currently ignored such as moving objects, objects that are not in perpendicular with the device, distance in mm etc.

This is a very economic technology and can be used in several other fields as well, few are listed as below:

- Can be used as parking assistance systems in vehicles with high power ultrasonic transmitter.

- Can be used as burglar alarm with suitable additional software for homes and offices.

- Can be a used in liquid level measurement.

- Can be used to find breakdowns in wires or threads.

The packaging team must ensure that the final product is lighter than the current prototype and has an ergonomic design. Also, a feature must be integrated to save acquired data for future use in a memory card or a smartphone. Smartphone integration can further widen the features of the Distance Measuring Device Based on Ultrasonic Sensor.

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