Project Review on Ultrasonic Distance Measurement

Prakhar Shrivastava, Praveen Kumar, Ankit Tiwari

Abstract*— 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 coloured 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 0.5m to 4m with the accuracy of1cm.This project is used to measure the distance by using ultrasonic sensors. 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 AT mega microcontroller 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 Micro Processor, Basic Electrical Engineering, Multimedia and systems and Electronics Devices and also practical work in the laboratories.

***Index Terms*— Nowadays, measure, calibration., LCD module**

I. INTRODUCTION

An ultrasonic sensor houses a transducer that emits high-frequency, inaudible acoustic waves in one direction when the transducer element vibrates. If the waves strike and bounce off an object, the transducer receives the echoed signal. The sensor then determines its distance from the object based on the length of time between the initial sound burst and the echo's return. Ultrasonic sensors require fairly accurate timing circuitry, so acoustic sensors really require a processor of some sort to drive them. Ultrasonic sensors should be a first choice for detecting clear objects, liquids, dense materials of any surface type (rough, smooth, shiny) and irregular shaped objects. This makes them one of the most ideal choices for measuring the height of containers which could be of different shapes, sizes, color and material.

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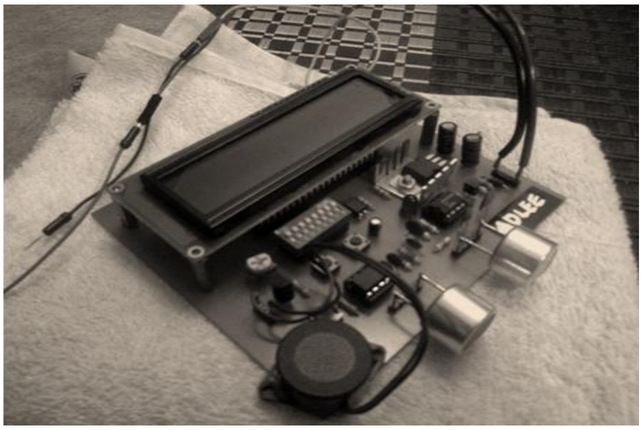
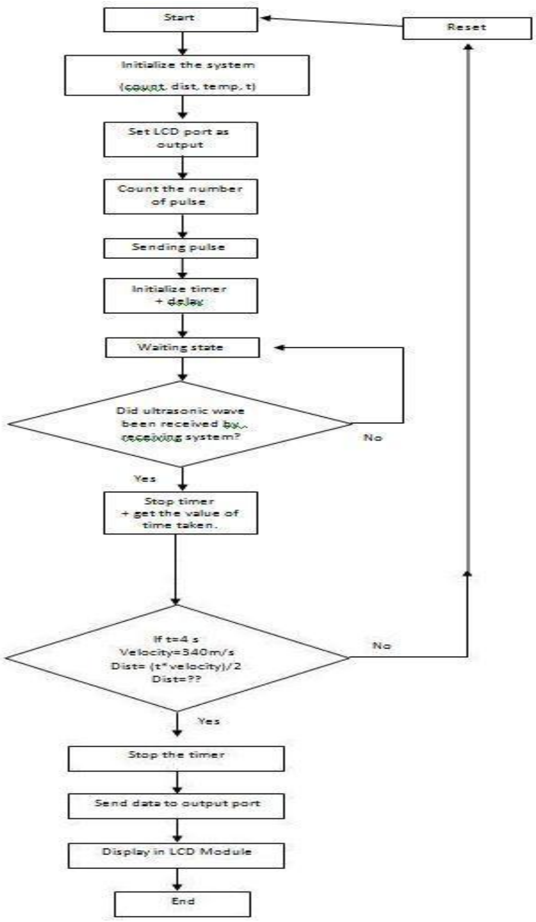


Fig 1- Front-view of Ultrasonic Distance Measurement Device

The transmitter transmits the ultra sonic waves towards the object and according to the time taken by echo from the transmitter to object and object to receiver, the distance is calculated. If the obstacle is in the designated range the comparator sends the signal to microcontroller which in turn sends an output signal as shown through block diagram in fig2.



II. ULTRASONIC TRANSDUCER

Ultrasonic sensors (also known as transceivers when they both send and receive) shown in fig2 work on a principle, which evaluate attributes of a target by interpreting the echoes from radio or sound waves respectively. Ultrasonic sensors generate high frequency sound waves and evaluate the echo which is received back by the sensor. Sensors calculate the time interval between sending the signal and receiving the echo to determine the distance to an object.

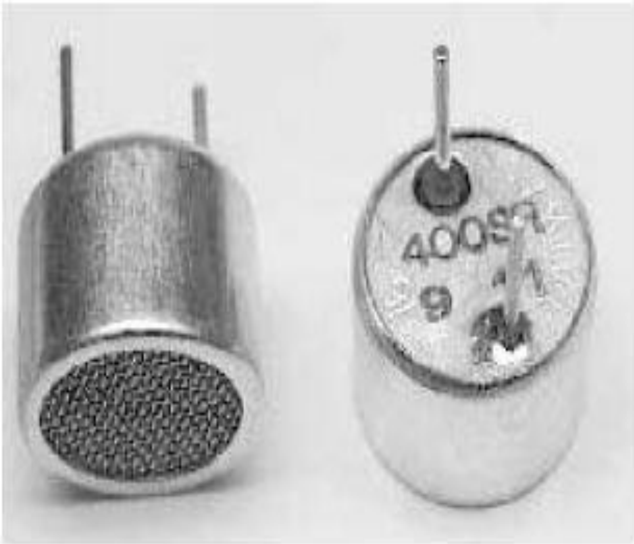


Fig 3- Ultrasonic Transmitter and Receiver Pair

I.II. AT89S51 Microcontroller

The microcontroller is used to generate 40 kHz sound pulse. It reads when the echo arrives; it finds the time taken in microseconds for to and from travel of sound waves. Using velocity of 330 m/s, it does the calculations and shows on the LCD Module and display the distance in centimeters. It used In-System programming (ISP) to be programmed.

AT89S51 is a low-power, high-performance CMOS 8-bit microcontroller with 4K bytes of In-System Programmable Flash memory. The device is manufactured using Atmel's high density nonvolatile memory technology and is compatible with the industry standard 80C51 instruction set and pin out.

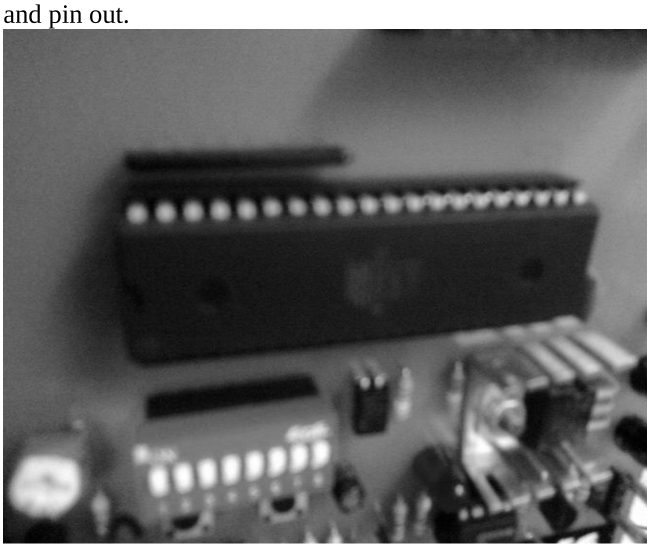


Fig 4- 89S51 Microcontroller

The on-chip Flash allows the program memory to be reprogrammed in-system or by a conventional nonvolatile memory programmer. By combining a versatile 8-bit CPU with In-System Programmable Flash on a monolithic chip, the Atmel AT89S51 is a powerful microcontroller which provides a highly flexible and cost effective solution to many embedded control applications.

By measuring the time taken for the whole process, it will use the arithmetic operation that has been programmed in AT89S51 microcontroller in order to obtain the distance. Lastly, the output will be display at LCD Module.

III. SYSTEM OBJECTIVES

From the issues that have been discussed in the previous section, the objectives of this project were set out as below:

1. Precise and fix measurement of low range distance
2. To measure a distance at any obstacle.
3. Operating range of 0.5m up to 4 m with an accuracy of 1 cm.
4. Design a simple circuit and find a suitable hardware for this project.

IV. MATHEMATICAL MODEL

All ultrasonic sensors have their specific radiation pattern associated with it. This acoustic radiation pattern is a function of spatial angle called beam angle. Beam angle, Ω is defined as the total angle between the points at which the sound power reduces to half its peak value, commonly known as 3 dB points. The spot diameter of the beam can be formulated as:

$$D = 2R \tan (0.5\ \Omega)$$

D = spot diameter in centimeters.
R = target range in centimeters.
Ω = beam angle in degrees.

Radiation pattern consists of a main lobe and side lobes. Radiation power is dominant mainly in the front region of the sensor, so as to say that the main lobe is directly in front of the sensor, followed by side lobes sidewise with null region in between these lobes. Radiation pattern is mainly determined by factors such as the frequency of operation and the size, shape and acoustic phase characteristics of the vibrating surface. The beam pattern of the transducer is independent of its nature as a transmitter or receiver. In most of the application, side lobes are suppressed and narrow beams are used. This suppression is achieved by the processing system and so, the radiation pattern of the transducer may not be same as the radiation pattern of the whole ultrasonic sensing system. The narrowness of the beam pattern is a function of the diameter of the radiating surface to the wavelength of the sound at the operating frequency. As the D/λ ratio increases, beam narrows out whereas as D/λ ratio decreases, beam broadens. For most of the application narrow beam is desired and therefore D/λ ratio should be more.

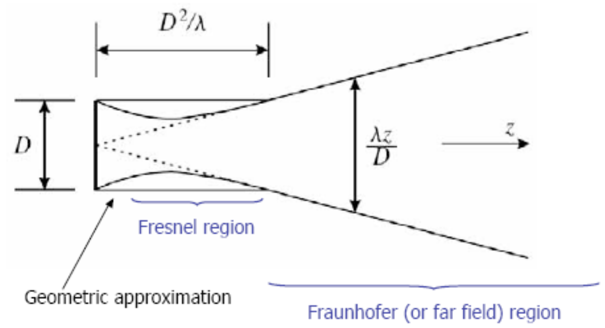


Fig 5- Geometric approximation of the ultrasonic beam width

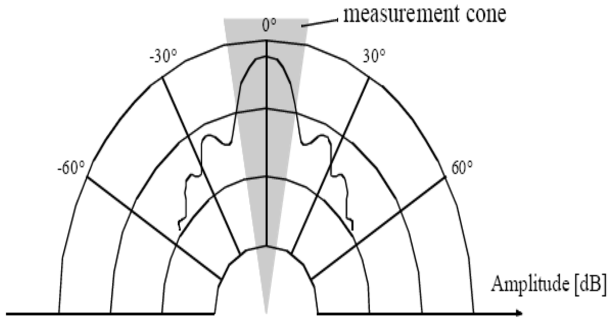


Fig 6- Beam pattern with respect to amplitude

V. SOURCES OF ERROR

1. The speed of sound is variable in different mediums & also depends on temperature of the medium, so manual manipulations are required on calculated distance.
2. 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.
3. 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.
4. The object should be placed near the rotational axis of transmitter. At wider angles less reflection takes place.
5. The object should be a good reflecting surface.

VI. SCOPE

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

1. Can be used as parking assistance systems in vehicles with high power ultrasonic transmitter.
2. Can be used as burglar alarm with suitable additional software for homes and offices.
3. Can be a used in liquid level measurement.
4. Can be used to find breakdowns in wires or threads.

VII. CONCLUSION

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.

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