

Distance Measurement of Object by Ultrasonic Sensor HC-SR04

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Abstract— There are several ways to measure distance without contact. The selection of distance measurement sensor in order to apply it in any application is very important to avoid any invalid experimental results. Measurement using ultrasonic sensor is cheapest among various other options. The paper proposed to build an efficient module that consists of ultrasonic sensor HC-SR04 with 89s52 microcontroller for distance measurement. This device make the use of microcontroller for calculation of distance and displaying the obtained results on LCD The experimental setup and result are described. And sensors's maximum range of object detection is 4m.

Key words: Distance Measurement, Microcontroller, Ultrasonic Module HC-SR04

I. INTRODUCTION

A distance detector is any device capable of measuring the distance between two points. The origin the distance between two points. The origins of distance measurement by means of graduated lengths of material such as chain, tape measure. Optical distance measurement, Electro-magnetic measurements are other methods of distance measurement. Since All kinds of devices or equipment nowadays, begin with the basic design, basic theory and then all the weakness followed by improvement step by step. Basically this ultrasonic technology is based on ultrasound and a common use of ultrasound is in range finding that perfectly related to the objective. It find applications in car parking system, Obstacle detection, level Detection, wall to wall distance measurement, robotic barrier and public security. Ultrasonic waves are high frequency sound wave. The frequency higher than 20 kHz is called ultrasonic frequency range. The human hearing range is between 20 Hz to 20 kHz. Properties of ultrasonic waves like reflection, transmission over large distances with no appreciable loss of energy make it suitable for distance measurement. Ultrasonic waves are suitable for both air and underwater[1].The accurate measurement of distance is major subject of study in the field of engineering and technology. Employing electromagnetic waves for distance measurement [2] gathered significance with the advent of research in the field of electromagnetism. The objective of this paper is to develop a device that can to used to measure a distance with high accuracy by ultrasonic sensor HC-SR04 using 89S52 micro controller. The range of 2cm to 4m with a resolution of 0.3cm is measured using HC-SR04 ultrasonic transducer. For contactless measurement device has to rely on the target to reflect the pulse back.

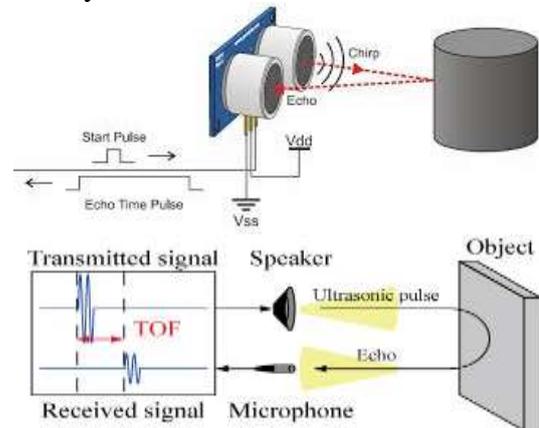


Fig. 1: Principle of Ultrasonic Distance Measurement

II. LITERATURE REVIEW

Distance measurement is activity of obtaining and comparing in real world .There are many types of distance measurement systems. One of the method of range-finding based on infrared (IR) techniques [3].We successfully eliminate the interference of the environment by means of circuit techniques; and let the low-cost IR sensor accurately detect the position of a target. The low power application of ultrasound is found in determination of viscosity, stress, strain, non destructive testing and acoustic emission . Ultrasonic medical and surgical devices operate in high power low frequency range for biological tissue cutting fragmentation [4]. The ultrasonic Generator is basically a transmitter that transmits ultrasound in the surrounding using air as a medium. Ultrasonic is also used for level as well as depth measurement. The ultrasonic range detector that uses Parallax's PING >>> ultrasonic sensor gives better performance ultrasonic sensor can able to detect range of 2cm to 2.5m with accuracy of 0.1cm [5].

III. METHODOLOGY

A. Principle

An Ultrasonic transducer uses the various physical characteristics of ultrasound of a specific frequency. The piezoelectric type is generally preferred due to its lower cost and simple to use. It is capable to transmit and receive the ultrasonic signal of a required strength. The Ultrasonic wave propagation velocity is subject to temperature of the medium, in the air it is approximately 340 m/s at 15°C of air or atmospheric temperature, the same as sonic velocity. The velocity (V) may be computed as a function of temperature as shown.

$$V = 340 + 0.6(T - 15) \text{ m/s,}$$

Where T= temperature, °C

Because the travel distance is very short, the travel time is not affected by temperature to a greater extend. 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. The distance travelled by the wave at time t seconds can be given by Distance (D) = $k \cdot V \cdot t$, where k - correction factor

The system design required familiarization with adopted technologies for non-contact range determination. The flaws in the infrared based system and the advantages of employing an ultrasonic wave based system was analysed in detail by referring to the systems designed based on these technologies. The hardware consists of:

B. Microcontroller section:

89S52 is a low power high performance CMOS 8bit microcontroller with 8KB of in system programmable flash memory. The device is manufactured using Atmel’s high density non-volatile memory. Its operating range is 4volt to 5.5 volt. It consist of three 16bit timer and counter and 32 programmable input output lines, 8 interrupt sources.

C. Display Section:

A 16x2 LCD is used as output by the controller to show any data or any information to user .The name 16x2 LCD means 16 numbers of data can be can be written on two lines. The data can be numbers (0-9) or letters (A-Z) of any symbol like “\$”, “#” or a space” “.In recent years the LCD is replacing LEDs or seven segment display due to many factors:

- It can display numbers, characters and graphics. Where other displaying unit like seven segments are limited only to numbers and few characters.
- To show a number or alphabet on LCD screen we need to just send the ASCII value to the data pin. Hence it’s easy to display characters and graphic.

D. HC-SR04 Ultrasonic module:

HC-SR04 is an ultrasonic ranging module designed for embedded system projects. Ultrasonic ranging module HC - SR04 provides 2cm - 400cm non-contact measurement function[7], the ranging accuracy can reach to 3mm. The modules includes ultrasonic transmitters, receiver and control circuit.

1) HC-SR04 has four pins:

- 5V Supply
- Trigger Pulse Input
- Echo Pulse Output
- 0V Ground



Fig. 2: Pin diagram of HC-SR04 ultrasonic sensor

E. Features:

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

F. Software:

Once the hardware is designed the program [6] is burned to the AT89s52 microcontroller using the IC programmer. The circuit works on 5v supply. The system can work well with battery.

To evaluate the performance of the distance measurement sensor with different objects. Experimental setup is constructed as shown in figure. Ultrasonic sensor is mounted and object is located in front of sensor The distance of object with sensor is adjusted and increased in order to evaluate the sensor’s result with different sensors. To inter face the sensor to AT89S52 microcontroller we need two I/O pins. One of them is external interrupt pin(INT0 or INT1) for measuring the pulse width at the echo pin. and any other pin say P3.5 for trigger.

- Connect the trigger pin of sensor to P3.5 of AT89S52
- Connect the echo pin of the sensor to INT0 (P3.2) of Microcontroller

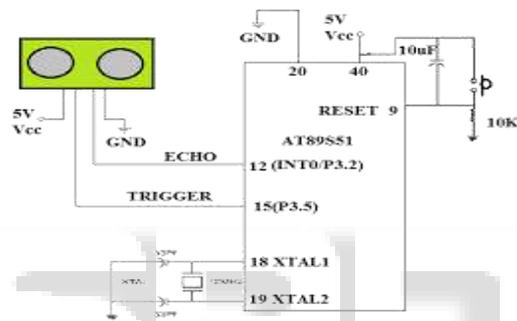


Fig. 3: Setup of Ultrasonic distance measurement system

IV. EXPERIMENTAL RESULTS

The technique is to develop a device that can be used to measure the distance of the target with high precision .Focus is given on lower range. Focus has been given on lower ranges considering the range of 2cm to 4m with the precision of ± 0.3 cm using standard ultrasonic transducer HC SR04. For contactless measurement of distance, the device has to rely on the target to reflect the pulse back to itself. 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. To check the design object is placed in front of sensor. The distance of the object increased and decreased in order to evaluate the performance of the sensor and distance calculated by the device which is compared to actual distance measured by scale, tape the actual circuit is shown below.

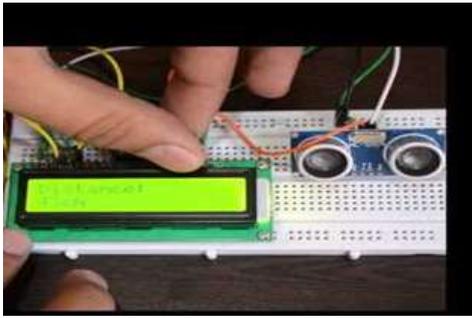


Fig. 4: Experimental Results

The experimental result for the distance measurement is shown in table. For calculating distance using this device, the target whose distance to be measured should always be perpendicular to plane of propagation of ultrasonic waves. Here actual distance is distance measured by tape or scale and measured distance is the distance measured by the ultrasonic sensor

V. EXPERIMENTAL RESULT

S.No.	Actual Distance(cm)	Measured Distance (cm)	% Error
1	20	22.40	12
2	40	43	7.5
3	60	63.40	5.66
4	80	84.05	5.06
5	100	101.40	1.40
6	120	120.80	0.66
7	140	140.30	0.21
8	160	160.60	0.37
9	180	180.20	0.11
10	200	200.20	0.10

Table 1: Results

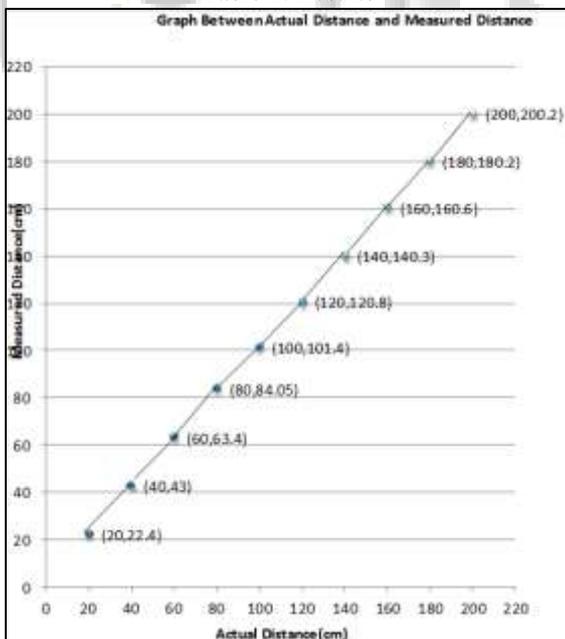


Fig. 5: Graph

The graph b/w actual value and measured value is almost linear. We observed that there is considerable error in the measured distance as compared to actual distance. Percentage error column shows the similar result .Error is large at the lower distance of the obstacle. Graph is plotted between actual distance and measured distance.

VI. CONCLUSION

This Ultrasonic distance measurement technique is low cost and simple. It is handy system for non contact measurement of distance. The device calculates the distance with suitable accuracy and resolution.It is better than parallax's PING sensor that can able to detect object in range 3m. This device has application in many fields.Besides, the application of ultrasonic sensors are wider than infrared sensor in robotic or any application. Future enhancement can be done by considering specific object's material or condition in order to avoid unnecessary error.

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