

Distance Meter Design Using Ultrasonic Sensor

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ABSTRACT: In the modern industrial life, different devices are manufactured for different purposes. But we have implemented a low cost distance meter using ultrasonic sensors. This suggested device uses commonly available ultrasonic sensor to measure the distance from the solid object of one to one and a half meters. This system is implemented on AT89C2051 microcontroller, name of specified locations are programmed on microcontroller. In this circuit, the microcontroller 89C2051 emits a series of pulses to the transmitter part of the transducer pair. The receiver part of transducer pair captures the signal which is reflected from the object that we desire to measure the distance. After processing the captured signal, the 89C2051 calculates the distance between the object and transducer pair by using the time of flight of ultrasonic signal and the distance is displayed on seven segment displays. This system is designed for a battery-powered model. This design is focused on low power consumption, small in size, lighter in weight, less time consuming process and easy manipulation.

I. INTRODUCTION

An ultrasonic sensor typically utilizes a transducer that produces an electrical output in response to received ultrasonic energy. The normal frequency range for human hearing is roughly 20 to 20,000 hertz. Ultrasonic sound waves are sound waves that are above the range of human hearing and, thus, have a frequency above about 20,000 hertz. Any frequency above 20,000 hertz may be considered ultrasonic. Most industrial processes, including almost all sources of friction, create some ultrasonic noise. The ultrasonic transducer produces ultrasonic signals. These signals are propagated through a sensing medium and the same transducer can be used to detect returning signals. In most applications, the sensing medium is simply air. Ultrasonic transducers send and receive waves for many types of sensing. Examples include distance, proximity, level, nondestructive evaluation, web break detection, counting, and security applications. They typically operate at their resonant frequency with various construction options, beam patterns, and power levels.

Ultrasonic Sensors: Ultrasonic signals are like audible sound waves, except the frequencies are much higher. Our ultrasonic transducers have piezoelectric crystals which resonate to a desired frequency and convert electric energy into acoustic energy and vice versa. The illustration shows how sound waves, transmitted in the shape of a cone, are reflected from a target back to the transducer. An output signal is produced to perform some kind of indicating or control function. A minimum distance from the sensor is required to provide a time delay so that the "echoes" can be interpreted. Variables which can effect the operation of ultrasonic sensing include: target surface angle, reflective surface roughness or changes in temperature or humidity. The targets can have any kind of reflective form – even round object and solid object. An ultrasonic sensor typically utilizes a transducer that produces an electrical output in response to received ultrasonic energy. The normal frequency range for human hearing is roughly 20 to 20,000 hertz.

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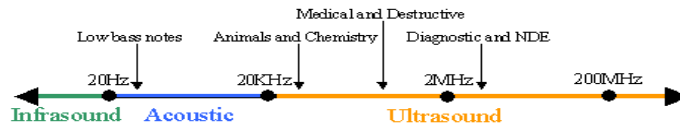


Fig.1 Frequency range

Ultrasonic sound waves are sound waves that are above the range of human hearing and, thus, have a frequency above about 20,000 hertz. Any frequency above 20,000 hertz may be considered ultrasonic. Most industrial processes, including almost all sources of friction, create some ultrasonic noise. The ultrasonic transducer produces ultrasonic signals. These signals are propagated through a sensing medium and the same transducer can be used to detect returning signals. In most applications, the sensing medium is simply air. An ultrasonic sensor typically comprises at least one ultrasonic transducer which transforms electrical energy into sound and, in reverse, sound into electrical energy, a housing enclosing the ultrasonic transducer or transducers, an electrical connection and optionally, an electronic circuit for signal processing also enclosed in the housing. Ultrasonic sensors have typically been used in applications such as detecting and identifying solid objects, measuring the shape and orientation of a work piece, detecting possible collisions between objects to avoid the collisions, room surveillance, flow measurement, and determining a type of material by measuring the absorption of sound. Ultrasonic sensors have been used for proximity or distance measurement. These devices typically transmit a short burst of ultrasonic sound toward a target which reflects the sound back to the sensor. The system then measures the time for the echo to return to the sensor and computes the distance to the target using the speed of sound in the medium. Sensors are devices which are designed so that they can detect or quantitatively determine physical parameters such as pressure, temperature, position or velocity over a measuring range. In automated industrial applications, sensors are used for numerous purposes. Sensors are used for a variety of applications including sensing the presence or absence of articles and sensing a distance or proximity of an article to the sensor, such as may be required for a process control application. Ultrasonic sensing systems provide a much more efficient and effective method of longer range detection. Ultrasonic sensors are widely used for numerous sensing applications for process control of production and packaging operations. Such sensing applications include container presence/absence detection, container size detection, product level detection, container orientation detection, container counting operations, material web control, tamper/safety seal detection, and surface coating detection.

Ultrasonic Transducer Configuration

Transceiver pair: It consists of a transmitter and receiver pair on the device. There are two different transducers for transmitter and receiver. The transmitter transmits and receiver waits for the reflected signals. The following figure illustrates the transmitter and receiver pair. Ultrasonic transceivers

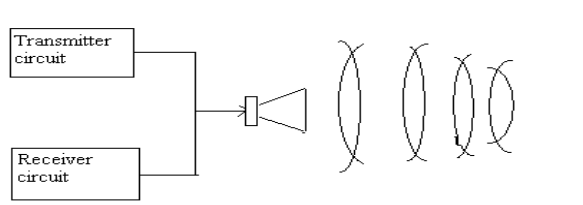


Fig. 2: Transceiver

traditionally are mounted with a transmitter and a receiver. The transmitter emits a ping (sound burst) which bounces off the nearest object and the receiver detects the returned signal. Using a micro-computer with a built-in timing device to detect the time of flight, it is possible to calculate the range of the object relative to the ultrasonic sonar. It consists of a

single transducer, which acts as transmitter as well as receiver. The electronics circuitry for transmitter and receiver actually differentiates the two functions. The following figure illustrates the Transmitter/Receiver.

The Specifications of Ultrasonic Sensors:

Dimensions(mm)	:	16φ*12h
Detectable range in meter	:	1- 1.10
Directivity in degree	:	50
Weight in grams	:	2.0
Allowable input voltage	:	40kHz
Sensitivity in db	:	-63±3
Resolution in mm	:	9
Operating temp. range(°C)	:	-30 to +85
Cost	:	\$18

Hardware Description of Ultrasonic Distance Meter

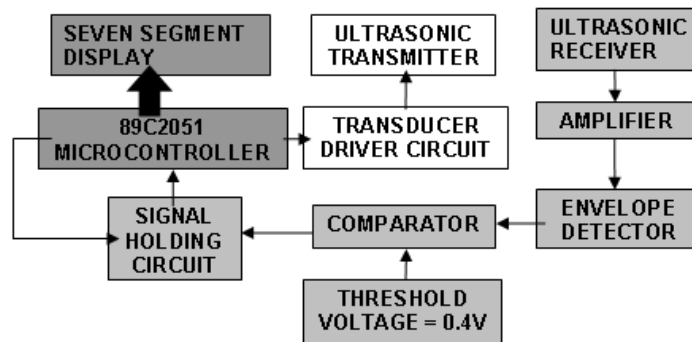


Fig.3 Block diagram of the system

Block diagram of the system is given in Fig 3. The heart of the system is microcontroller 89c2051 which is a 20 pin 8051 compatible microprocessor (including serial port) with 2k of FLASH memory. The PG2051 erases, programs, and verifies AT89C2051 chips in 6 seconds. As the AT89C2051 devices are FLASH, they can be reprogrammed as often as needed. The AT89C2051 programmer is fast, small and simple to use. In this diagram, 89c2051 is connected to the seven segment displays and transducer circuit. The microcontroller 89C2051 emits a series of pulses to the transmitter part of the transducer pair. The receiver part of transducer pair captures the signal which is reflected from the object that we desire to measure the distance. After processing the captured signal, the 89C2051 calculates the distance between the object and transducer pair by using the time of flight of ultrasonic signal and the distance is displayed on seven segment displays.

Design & Development of Ultrasonic Distance Meter

Hardware Development Phase: To make the hardware development easy and uncomplicated, the whole product is divided into the small modules. Each of the modules in which system/product hardware development is divided are decided by keeping in view that the complexity of the system is simplified into simple sub-systems which are easy to fabricate and test. Each of the subsystem also represent basic element of the complete system. The various modules in which the system is divided are:

- Power supply unit.
- Ultrasonic Sensor Interfacing.
- Interfacing of microcontroller with seven segment displays.

The implementation of each of the modules is discussed below

Power Supply: Power supply is the most important part of any electronic circuit. Proper supply to the electronic component confirms the proper functioning of the electronic components and reduces the risk of component damage. Figure 4 give the circuit diagram of the power supply unit.

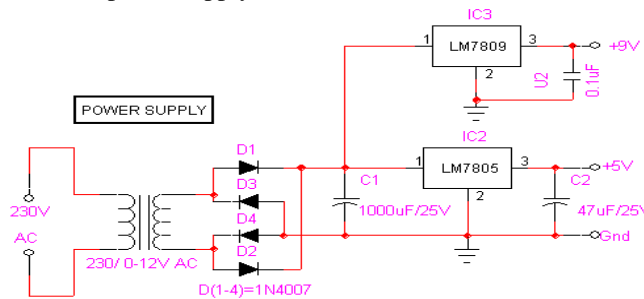


Figure 4 Power supply circuit diagram

The 12 V ac from the centre tap step down transformer is rectified using IN4007 rectifier diodes. IN4007 rectifier diodes can be used for the load current of 1 ampere. Two forward biased IN4007 diodes provide positive voltage and one reverse biased IN4007 diode provides the negative voltage. The output of the rectifier is connected to the filter capacitor and regulator ICs. Filter capacitor removes ripples and smoothen the rectifier's dc output. The smooth D.C supply is regulated using the regulator ICs. The regulated supply remains constant irrespective of variation in load and fluctuation in the supply. 78xx and 79xx series regulator ICs are fixed three terminal 3-terminal positive and negative type monolithic voltage regulators respectively. They have internal current limiting and with proper heat sink can deliver upto 1 ampere current. One regulator provides the voltage to microcontroller board and other provides the supply to all the other parts of the system. Figure shows the pin configuration of 7915. 79xx series regulator 7915 is used for the regulation of negative voltage.

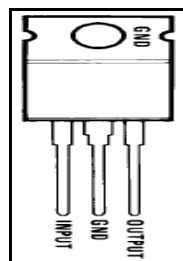


Figure 5: Pin Diagram of 7915

Ultrasonic Sensor Interfacing: An ultrasonic sensor typically utilizes a transducer that produces an electrical output in response to received ultrasonic energy. The normal frequency range for human hearing is roughly 20 to 20,000 hertz. Most industrial processes, including almost all sources of friction, create some ultrasonic noise. The ultrasonic transducer produces ultrasonic signals. These signals are propagated through a sensing medium and the same transducer can be used to detect returning signals. In most applications, the sensing medium is simply air. An ultrasonic sensor typically comprises at least one ultrasonic transducer which transforms electrical energy into sound and, in reverse, sound into electrical energy.

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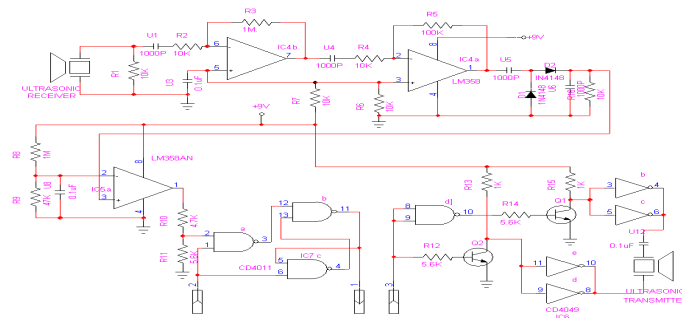
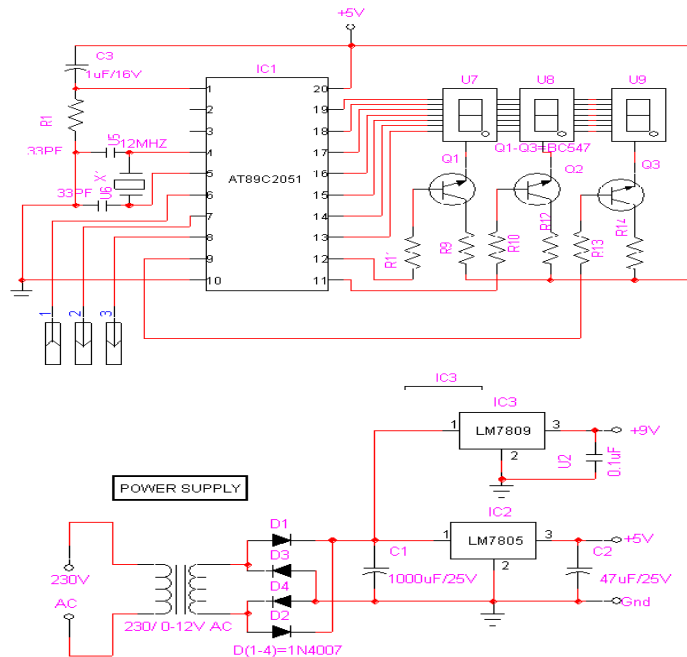


Fig. 6: Circuit diagram of transmitter and receiver

Interfacing of Microcontroller with Seven Segment Display: The heart of the system is microcontroller 89c2051 which is a 20 pin 8051 compatible microprocessor (including serial port) with 2k of FLASH memory. A seven-segment display, less commonly known as a seven-segment indicator, is a form of electronic display device for displaying decimal numeral that is an alternative to the more complex dot-matrix displays.



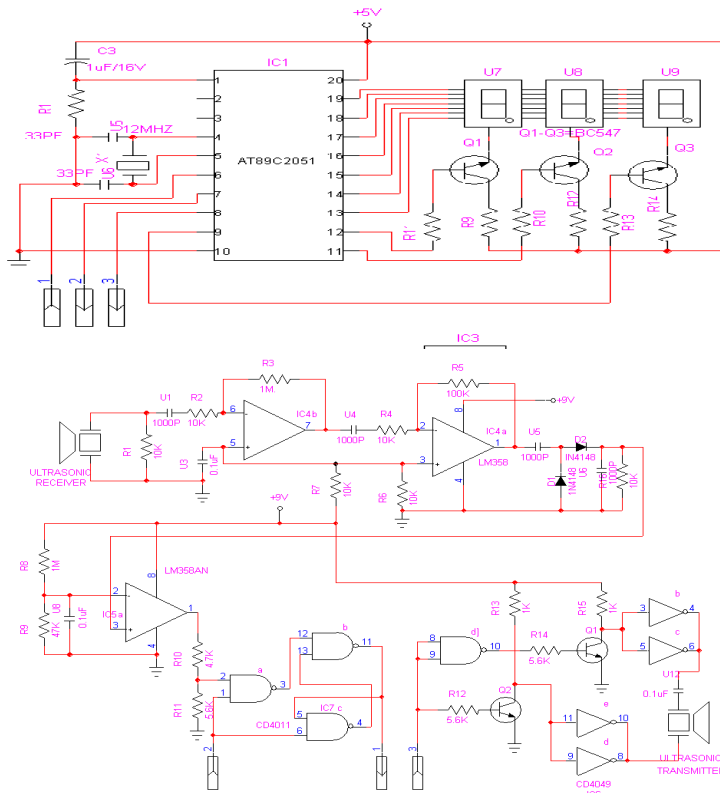


Fig. 7: Schematic of Ultrasonic Distance Meter

System Specifications

The developed system has particular type of specifications.

Features

- Ready to use
- Easy to handle
- Fully solid state design
- Compact in size
- Robust mechanical design
- Manual operation i.e. by using the ac input 220v or by dc batteries.
- Lighter in weight
- Easy to manipulate
- Less time consuming process
- To measure the short distance by using the ultrasonic sensors.

Technical Specifications

- Input supply : 220V AC, 50 Hz.
- Distance in meters: 1 – 1.10m

Physical Dimensions

- Length : 180 mm
- Width : 100 mm

➤ Maximum Height: 75 mm

Measurement of Distance: Ultrasonic sensor is used to measure the distance from one object to another. The distance depends on the frequency of the sensor. If frequency is increased, then the range of distance is also increased.

Table 1: Measured Distance

Sr.No.	Measured Distance in cm	Actual Distance in cm	Errors in mm
1.	15	14.9	0.1
2.	35	34.8	0.2
3.	55	54.8	0.2
4.	85	84.6	0.4

This table shows the measured distance by the sensor as compared to the actual distance. So, some errors can occur during measuring the distance. But the accuracy of this system is quite good.

Conclusions and Future Scope: In previous chapter, we have presented the results of the measured distance by using the ultrasonic sensors. This chapter gives the conclusion and the future scope of the work. The developed system is tested successfully by considering to measure the distance accurately by using the ultrasonic sensors. Ultrasonic sensor is used to measure the distance from one object to the. The range of this meter measuring distance is about 1- 1.10 meters. The distance depends on the frequency of the sensor. If frequency is increased, then the range of distance is also increased. It is a light weight device includes ultrasonic sensors and few electronic components. The broad beam angle ultrasonic sensors enable wide range environment recognition. The main functions of this system are the clear path indication and the environment recognition. All the aspects of aesthetics, engineering and ergonomics are considering while designing the enclosure of the system. The present system is used to measure the distance from one solid object to another. The developed system can be upgraded. By incorporating the wireless data transmission and reception with the system, distance can be measured from the remote locations. The sensors can be placed at the site of measurement and the measurement information can be send to the base station. This reduces the requirement of physically visiting the site for the purpose of measuring the distance. Also, We can successfully build a parking garage management and parking assistance device for use in multi-story parking garages, parking lots and personal garages. Our device will help keep track of garage utilization as well as assist drivers in parking their vehicles optimally. This device will resolve two issues involved in parking cars inside of buildings: preventing damage to garages and vehicles due to accidental collision with a wall. Also, it will relay utilization information to a garage manager as part of a larger effort to decrease the otherwise difficult and time consuming process of finding a parking spot. This is an exciting project because it will solve two real-world problems using knowledge that we have gained and provide us with an opportunity to learn how to use technologies with which we are not familiar with such as wireless data transmission and sensor implementation. We have personally selected this problem because we have both encountered difficulties while parking unfamiliar vehicles and have confidence that this problem can be solved. Another reason that we have selected this problem is because it will teach us more about analog circuit design and testing, a core skill of an electrical engineer.

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