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CONSTRUCTION AND PERFOMANCE EVALUATION OF AN ULTRASONIC DISTANCE METER

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ABSTRACT
Ultrasonic distance meter can be used to measure distance without contact, which is the use of ultrasonic wave at 40 KHz for distance measurement. The ultrasonic distance meter employs an ultrasonic module that consists of an ultrasonic transmitter and receiver, along with an ATMEGA 328microcontroller. It works by transmitting a short pulse of sound at a frequency inaudible to the ear (ultrasonic sound). Afterward, the microcontroller listens for an echo. The MCU calculates the distance based on the speed of sound at 25^0c ambient temperature and shows it on LCD display. Using it, we can measure distance up to 4 meter, with an accuracy of 1cm. In this project, we excite the ultrasonic transmitter unit with a 40 KHz pulse burst and expect an echo from the object whose distance is to be measured with an average accuracy of 3mm and an error difference of 1cm. The importance of this research is calculating accurate distance for any obstacle that we want to measure. This device can be used in many different fields such as in Physics, Engineering, Research and Production and other categories, spanning in endless applications.

Keywords: ultrasonic distance measurement, microcontroller, echo, LCD display and ultrasonic sensor

INTRODUCTION

According to Li, and Libermann, (2007); defines sound as a mechanical vibration transmitted by an elastic medium through the displacement of particle within the medium. The range of frequencies that human(s) can hear is approximately between 20Hz – 20KHz, this range by definition, is the audible spectrum and varies by individuals and generally reduces with age. The ear is most sensitive to frequency around 3500Hz. Sound above 20KHz is known as Ultrasound, while sound below 20KHz is called infrasound.

The speed in which sound travels depends on the medium which it passes through. In general, the speed of sound is proportional to the stiffness of the medium and its density. Also, the physical properties and the speed of sound changes with the conditions in the environment. The speed of sound in the air depends on the temperature. In the air, speed is approximately 345m/s, in water 1500m/s and in a bar of steel 5000m/s.

When travelling through a medium, the intensity and amplitudes of sound waves reduces, this is called attenuation and is the main reason why echoes from deeper structures are weaker than echoes from superficial areas.

RESEARCH METHODOLOGY

COMPONENTS USED FOR THE CONSTRUCTION

In this research work, experimental method of research was used, in carrying out the study.

Table 1: Showing components used and their quantity

S/N	NAMES OF COMPONENTS	QUANTITY
1.	ATMEGA 328 (AVR microcontroller)	1
2.	HC – SR04 (ultrasonic – sensor)	1
3.	L78LO5 (Voltage regulator)	1
4.	10µf (Electrolytic capacitor)	2
5.	100µf (Electrolytic capacitor)	1
6.	100nf (ceramic capacitor)	1
7.	4.7l (Resistor)	1
8.	Push button	1
9.	Diode (IN4001)	1
10.	5k (Resistor)	1
11.	2 x 16LCD	1

STAGES OF CONSTRUCTION

- The power supply unit
- The sensor unit, and the microcontroller unit
- The display unit.

POWER SUPPLY UNIT

The power supply unit of the distance measuring meter is a sub-section of the distance meter, which supplies power of different voltage to different parts of the device. The whole system is powered through a 9v battery and it passes through a diode (IN4001) which blocks any negative voltage, but allow positive voltage to flow through. Then a capacitor of 100µf is used to filter the

9v coming from the battery and the L78L05, which is the voltage regulator is used to regulate the voltage to 5v. Then the output of the voltage from the voltage regulator is then passed through an electrolytic capacitor and ceramic capacitor, which is to ensure that the voltage is filtered well before entering into the micro controller. The reason why the voltage from the source (Battery) is filtered well and reduced to 5v is to ensure that, 5v dc voltage which is constant to the microcontroller is supplied to it and avoid the microcontroller unit, MCU from getting burnt.

SENSOR UNIT

Ultrasonic transmitter emitted an ultrasonic wave in one direction, and immediately starts the timing, when it is lunched. Ultrasonic spread in the air, and would return when it encounters obstacles on its path. The ultrasonic receiver would stop timing, when it receives the reflected wave.

The principle of ultrasonic distance measurement use the already known air spreading velocity, measuring the time from lunch to reflection when it encountered obstacles, and then calculate the distance between the transmitter and the receiver according to the time and velocity. Thus, the principle of ultrasonic distance measurement is the same with radar system.

Distance measurement is express mathematically as:$L = C \times T$

Where L is the measured distance, and C is the ultrasonic spreading velocity in air, also T represents time (T is half the time value from transmitting to receiving).

Ultrasonic ranging module, HC-SR04 provides 2cm – 400cm non-contact measurement function, the ranging accuracy can reach to 3mm that is the resolution that it can measure. The modules include ultrasonic transmitters, receivers and control circuit.

MICROCONTROLLER UNIT

The micro controller used in this project is the AVR ATMEGA 328P, which has 28 pins and 5 of these pins are dedicated pins. The dedicated pins are those pins that cannot serve any other purpose, but their functions are specified by the manufacturer, for example: pin 7 which is the power pin cannot serve any other purpose, but their functions as specified by the manufacturer, but just for power.

In this project, we make used of internal clock of the ATMEGA 328p, which has internal clock of 4MHz. The internal clock is used to calculate the time, the echo will return and be sensed by the sensor and the microcontroller will capture this time to measure the distance. In summary, the micro controller use the time the sound travelled and the time it returns, that is the time it sensed the echo

DISPLAY UNIT

The display unit is the section of the distance meter which displays the distance, the microcontroller is reading in from the HC-SR04 (ultrasonic sensor) device; the display unit also displays the writings, variables. That the operator or programmer puts into the program that he/she wants to display. The display unit consists of an LCD (Imo 16L which is a 2 x 16 LCD (2 rows, 16 column) and a preset resistor. The LCD contains crystals, which are located in the middle of two electrodes. These crystals are transparent when the electrodes are not energized; while on the other hand, they block light rays from passing through them, thereby forming on black dot on the screen. The 2 x 16 LCD has 16pins.

Fig1**:** Shows the inter-connections between the power supply unit, the sensor unit, the microcontroller unit, and the display unit

MODULE OPERATING PRINCIPLE

The measurement process is initiated by sending a trigger signal to the ultrasonic module. Firstly, stransmit at least 10μs high level pulse from the processor to the trig pin of the ultrasonic module, HC-SR04 as shown in fig2a. The module automatically generates 8 pulses of 40KHz ultrasonic sound from the transmitter in the direction of the object as shown in fig 2b. When this sound arrive at the receiver as echo, the module produces a signal at the echo pin whose high level pulse is proportional to the distance to be measured as shown in fig 2c. The module automatically generates 8 pulses of 40 KHz ultrasonic sound from the transmitter in the direction of the object as shown in fig 2b. When this sound arrive at the receiver as echo, the module produces a signal at the echo pin whose high level pulse is proportional to the distance to be measured as shown in fig 2c. The MCU calculated the time period between the generation for the waves and reception of the waves, which is proportional to the distance travelled by the waves Using the formula, MCU calculates the distance of the object and display the values on the LCD.

Test distance, cm = [High level time x velocity of the sound (340m/s)]

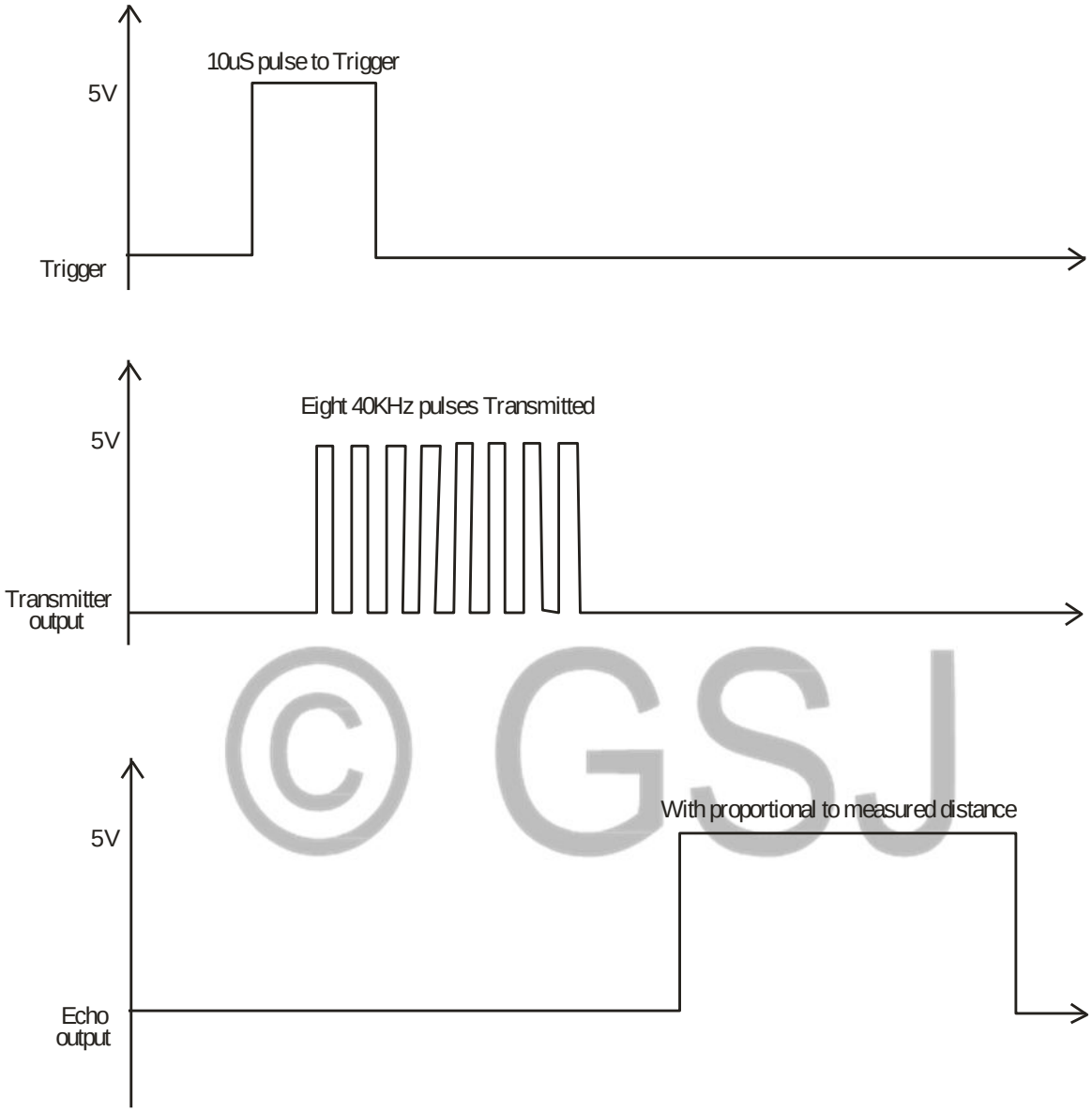
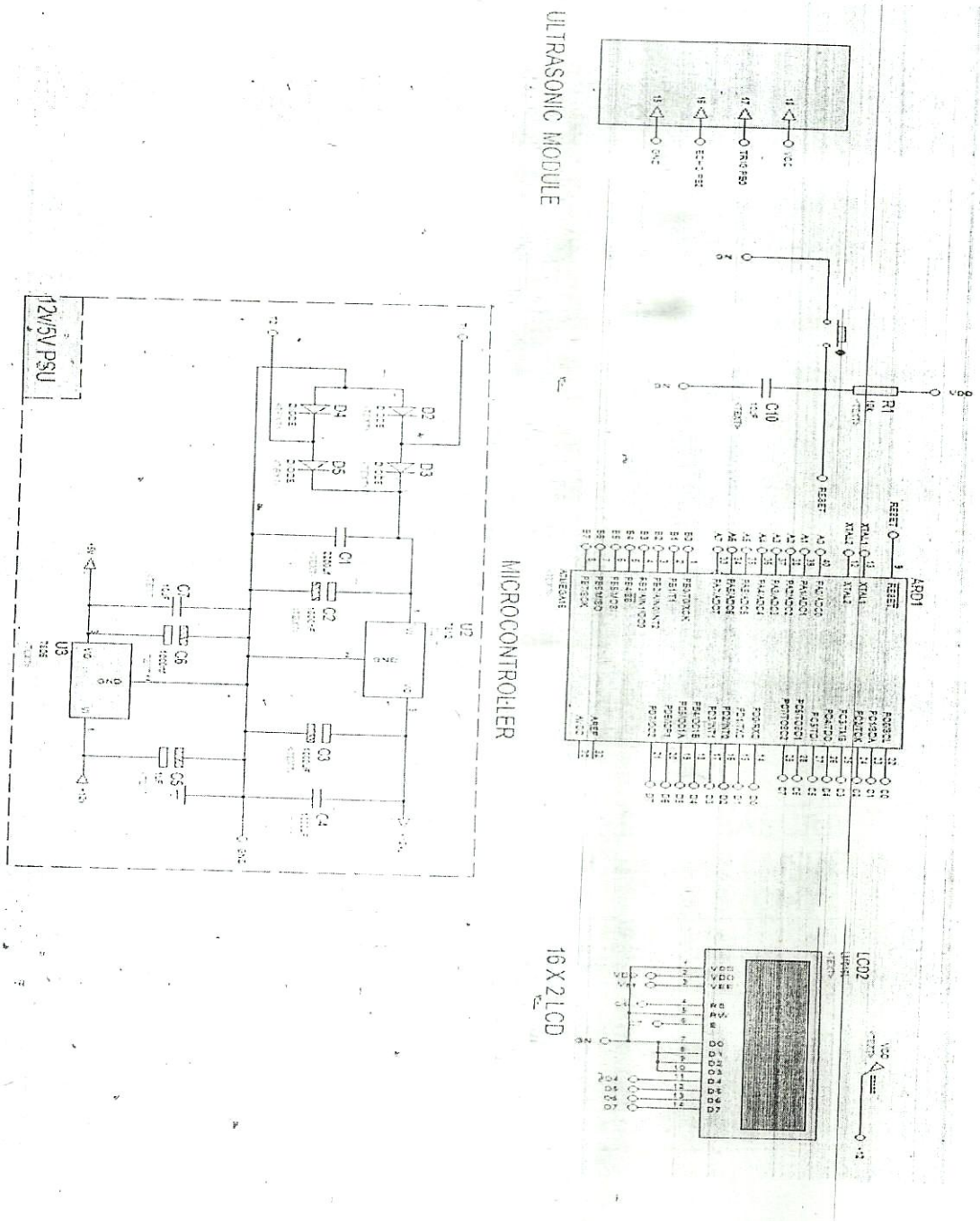


Fig 2: Showing HC-SR04 timing diagram. Source: www.ijareeie.com

Figure 3.3 Showing the circuit diagram of Ultrasonic Module



RESULT ANALYSIS, INTERPRETATION AND DISCUSSION

RESULT ANALYSIS

In this research work, room temperature of 25^0c was assumed. Hence, the velocity of ultrasonic in air is taken as 346m/s. Because the travel distance is very short, below 30cm, the travel time is little affected by temperature. It takes approximately 29.15μs, for ultrasound to propagate waves through 1cm. therefore, it is possible to have 1cm resolution in the system.

Measurements of travel have been taken for a number of distances at an interval of 5cm, three measurements have been taken for each distance, and the overage computed. The result of the measurements are shown in table 2

Table 2: Showing results of Measured Distance

S/N	ACTUAL DISTANCE (CM)	MEASURED DISTANCES (CM)	MEASURED DISTANCES (CM)	MEASURED DISTANCE (CM)	AVERAGE MEASURED DISTANCE
1.	5	4.00	4.00	4.00	4.000
2.	10	9.00	9.00	9.00	9.000
3.	15	14.00	14.00	14.00	14.000
4.	20	19.00	19.00	19.00	19.000
5.	25	24.00	24.00	24.00	24.000
6.	30	29.00	29.00	29.00	29.000

The measured distance is calculated on the basis of travel time. The formula to calculate the distance is give as

$$\text{Distance (cm)} = \text{Travel time} \times \frac{10^{-6}}{2} \text{ velocity} \times 2 \text{ m} / \mu\text{s}$$

Note that, ultrasonic waves travel to and from the object. Hence, the whole distance is divided by two (2). Also travel time is in micro seconds (μs)

DISCUSSION

From table 2, it can be observed that the constructed ultrasonic distance measurer can be used to measure distances below 4m, although with less accuracy.

The ultrasonic device is constructed in such a way that the transmitter and receiver are not evenly matched, resulting in errors in distance measurement. Errors in result also occur due to vibration from the surrounding and noise, which may interface with the sound waves being propagated.

CONCLUSION

In conclusion, the ultrasonic sensor is developed in order to detects, measure and calculate the distance of the target object. It was developed to measure distance, ranging from 0.5m to 4m, using sound waves generated by the sensor in measuring a given range, with high accuracy and precision. This device measures a given range or distance in a short period of time, and the result displayed on the LCD.

RECOMMENDATION

Few areas have been recommended for future improvement. These are; range, temperature control, device portability, software programming are several ideas and modifications that can be improved the performance of this system in the future to reduce errors

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