Design of Ultrasonic Radar

Haitham K.Ali, Jihan S. Abdaljabar, Sura M.Abdullah

Abstract: Ultrasonic technology has been on the market for years and is still considered a trusted technology throughout the industry. The design of the Ultrasonic Radar is very useful for many applications like homes, shops, military and object detection. The aim of this work is to build an ultrasonic transceiver which is basically one kind of a radar system to get exact distance and angle for fixed objects placed around the device based on the speed of ultrasonic waves in open air. An Arduino microcontroller was used to transmit and receive the ultrasonic waves through 40 KHz in order to provide the flexibility of usage requirements. A delay occurred between the transmitted and the received waves govern the reflection of sound. Some tests were done using two kinds of alarms first: the visual alarm which done by a personal computer screen designed to be a radar screen. Second the audible beep alarm which done by an LCD digital screen.

Keyword: Arduino microcontroller, LCD digital screen, Ultrasonic Radar

I. NTRODUCTION

Ultrasonic is a non-contact level measurement method that uses sound waves to determine the process material being measured. Ultrasonic transmitters operate by sending a sound wave, generated from a piezo electric transducer, to the media being measured. The device measures the length of time it takes for the reflected sound wave to return to the transducer. A successful measurement depends on reflection from the process material in a straight line back to the transducer. However, there are various influences that affect the return signal. Factors such as dust, heavy vapors, tank obstructions, surface turbulence, foam and even surface angles can affect the returning signal. That is why the conditions that determine the characteristics of sound must be considered when using Ultrasonic measurement. [1]

II. ULTRASONIC RADAR APPLICATIONS

There are several applications of ultrasonic radar some of them are explained as shown below:

1. Presently, the detection techniques of laser, radar, infrared ray and ultrasonic have been widely applied at the aspect of water depth measurement. The research of the water depth measurement system backing up with high ratio of capability to low price has ended at Ultrasonic Range Finder. The difficulty in measuring water depth and object detection will no longer be a complicated issue. A simple technique to determine water depth and object detection was done by employed sensors like ultrasonic transducer. Ultrasonic transducers are connected in this part. Angle is measured through this mechanical part therefore it can conveniently determine water depth and object. This technique has provided a useful tool to more accurately to identify the water depth and object in order to illustrate the noble methodology for measuring water depth and object detection using Ultrasonic sounds to provide efficient and effective ways.[3]

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2. Nondestructive testing of concrete structures is one of the essential tasks for estimating or assessing the quality. In order to validate the advanced NDT equipment's like Radar and Pulse Echo, a unique large scale reinforced concrete specimen was cast at SERC, Chennai, with columns and beams of different sizes, cross section having different percentages of reinforcement. For radar measurements, 1.6 GHz antenna was used over the grid lines. The pulse echo technique was adopted with an antenna array of 55 KHz and the data was collected over the same grid points. [4]

3. 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 the 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, the distance can be measured up to 2.5 meters. In this circuit, a 40 kHz transducer is used for measurement in the air medium. 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.[5]

4. The problem of trees assessment is increasingly felt either as a life quality problem or as a safety problem within the city management. One of the main causes of the collapse of a tree is the decay of the bearing capacity of some of the primary roots caused by some kind of pathology. According to these phenomena experiments have been carried out to check if one or more geophysical techniques were able to see, with the necessary geometrical and physical resolution, the decay. The tested techniques were: ultrasonic tomography, electric tomography and radar. The problems arisen from the small dimensions of the objects were fixed either increasing the frequency of the testing fields or reducing the size of the probes. The results show very promising possibilities of applications of these quite common geophysical techniques to the non-invasive testing of trees, piles and building wood.[6]

5. Currently, vehicles are often equipped with active safety systems to reduce the risk of accidents, most of which occur in urban environments. The most prominent include Antilock Braking Systems (ABS), Traction Control and Stability Control. All these systems use different kinds of sensors to constantly monitor the conditions of the vehicle, and act in an emergency. The use of ultrasonic sensors in active safety systems for urban traffic was done. Adaptive Cruise Control (ACC) for urban traffic based on ultrasounds is presented as an application example. The proposed system has been implemented in a fully-automated prototype vehicle and has been tested under real traffic conditions. The results confirm the good performance of ultrasonic sensors in these systems.[7]

III. ULTRASONIC RADAR SYSTEM OVERVIEW

The designed ultrasonic radar system, as shown in figure (1), consists of the following parts:

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A. Microcontroller (Arduino)
B. Servo motor
C. Interface
D. Sensor for transmitting and receiving

And for displaying the signal there are two ways:

A. Computer screen
B. LCD screen

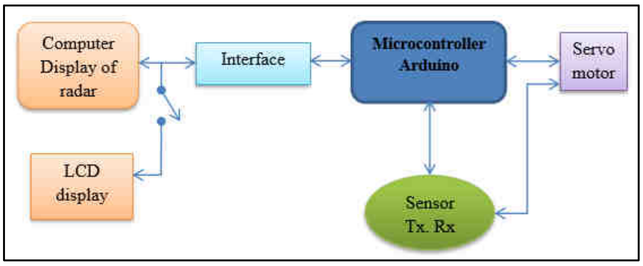

Figure (1): The block diagram of the designed ultrasonic radar.

A. ICROCONTROLLER ARDUINO

The Arduino microcontroller is a powerful single board computer that has gained considerable traction in the hobby of professional market. The Arduino is open-source which can be used to develop interactive objects, taking inputs from a variety of switches or sensors, and controlling a variety of lights, motors, and other physical outputs.

B. SERVO MOTOR

Servomotor is a servomechanism. It is a closed-loop servomechanism that uses position feedback to control its motion and final position. The input to its control is some signal, either analogue or digital, representing the position commanded for the output shaft.The motor is paired with some type of encoder to provide position and speed feedback. In the simplest case, only the position is measured. The measured position of the output is compared to the command position, the external input to the controller. If the output position differs from that required, an error signal is generated which then causes the motor to rotate in either direction, as needed to bring the output shaft to the appropriate position. As the positions approach, the error signal reduces to zero and the motor stops.

The operating principles are:

1. We supply short 10µS pulse to the trigger input to start the Module.
2. The module will send out an 8 cycle burst of ultrasound at 40 kHz and receive echo.
3. The received Echo is a pulse width signal in proportion to the range. You can calculate the range through the time interval between sent trigger signal and received echo signal using below given formula [8].

Test distance = ((high level of time)*velocity of sound (340 m/s))/2

C. INTERFACES

The interface between the PC and microcontroller is represented by a USB cable (A plug to B plug). The Arduino automatically draw power from either the USB connection or an external power supply.

D. SENSOURSES

The sensor contains the transmitter Tx, which is used to transmits the signal that used to detect the targets, and the receiver Rx, which receive the signal from the detected targets.

IV. TESTING OF ULTRASONIC RADAR SYSTEM

The Ultrasonic Radar block diagram shown in figure (1) was connected to detect objects leis around the radar and the output was displayed by two methods first: the visual alarm output signal which done by a designed radar screen , second :the audial beep output signal which was done by an LCD digital screen connected to a Krypton Board.

A. Testing the visual signals of the ultrasonic radar:

In order to see the visual signal it's important to have a radar screen, so a designed program by language C++ program was made to convert the monitor of a personal computer into a radar screen. Many testes were done in order to measure the distance and the angle of the objects from the ultrasonic radar, and these testes and there results can be explained as follows:

Test 1: using one constant target at a distance 50 cm away from the Radar:

The first test was done by putting one constant target at 50 cm away from the radar as shown in figure (2).

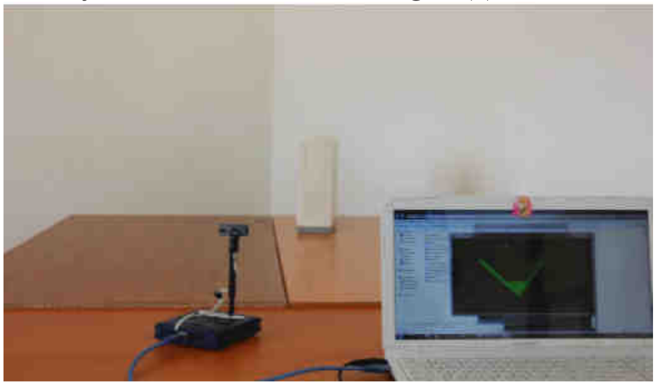

Figure (2) shows the overall system with a one constant target.

Figure (2) shows the radar and the personal computer at the lead of the picture and the white rectangle shape represents the constant target. The results of the radar screen can be shown in figure (3)

Figure (3): Display a one big static target at a distance of 50cm

After comparing the distance in real and the signal on the radar, the results were very similar to each other so this proves the accurate results of the ultrasonic radar. The transmitted and received pulses are drawing by the RC oscilloscope of the laboratory; the test of this section depends on two different ranges From figure (3) the horizontal axes represents the distance of the object from the radar and the vertical axes represents the angle of that object for the radar. The target shape in the radar display is not uniform geometric shape because the body of target isn't smooth but it contains holes. The received and transmitted pulses are sketching by using the oscilloscope .The results of the transmitted pulse was measured and the results are shown in figure (4).

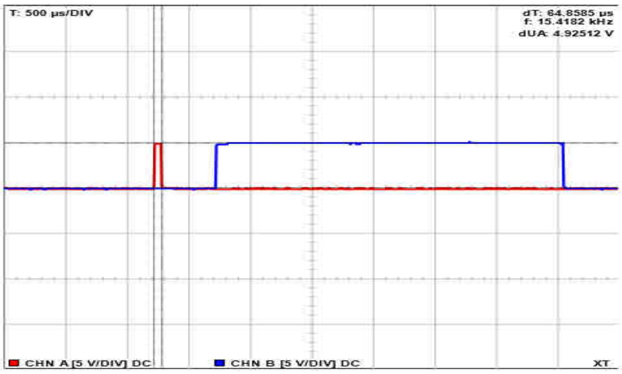

Figure (4) represents the transmitted pulse.

Where; Red color represents the transmitting cannel
Blue color represents the receiving channel
dT is the time difference
f is the frequency
dUA is the voltage difference

The dT in this test represents time difference which adjusted to measure the transmitting pulse (i.e. the pulse duration). The measured time of the transmitting pulse is 64.85 µs and the frequency=1/time, so f=15.41 KHz.

The dUA is the voltage difference that is constant in all tests approximately to 5V.

Moreover the duration time of the received pulse was measured and the results are shown in figure (5)

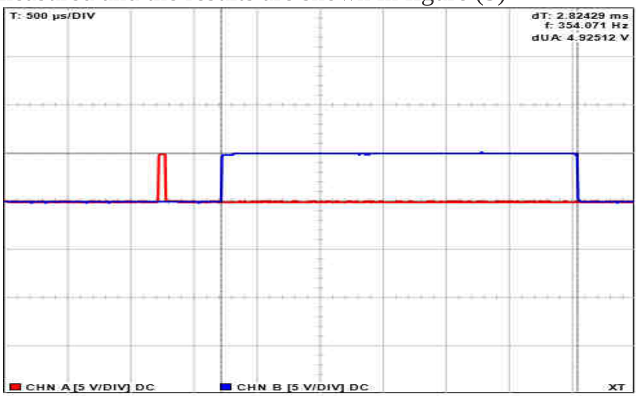

Figure (5): receiving pulse.

From figure (4) and figure (5) there were a delay between the transmitting and the receiving time and this delay can be shown in figure (6).

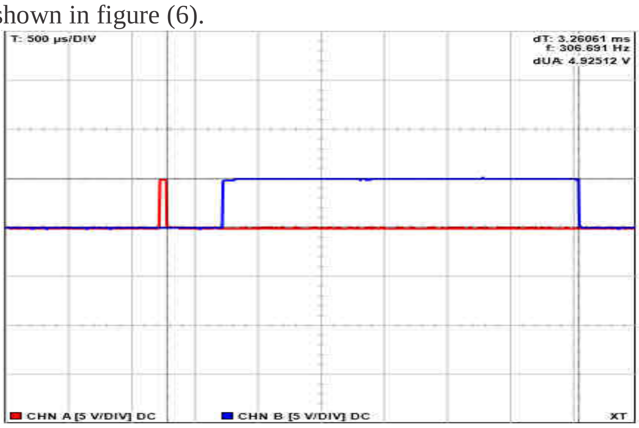

Figure (6) showed the time delay (or the dT) between the last edge of transmitter to that of receiver.

The distance in practice can be calculated by the following formula:

Detailed Distance Formula:

((µS / 58 = centimeters or µS / 148 = inch or the range = Duration of high level) * (Sonic Velocity 340M/S))/ 2

DISTANCE=2.824*1000/58 = 48.68 cm

The distance in reality (50cm) is approximately equal that of the ideal range (48.689 cm).

Test 2: using one constant target at distance 150 cm away from the Radar:

Another test was done by taking the same target that used before in test 1 but now on a distance of 150 cm away from the radar. The object on the radar screen can be shown in figure (7)

Figure (7): display for one static target at a distance of 150cm.

From figure (7), the distance measured is exactly 150 cm which improves the quality of the ultrasonic radar, also the transmitted pulse duration and frequency of the oscilloscope shown in the figure (8).

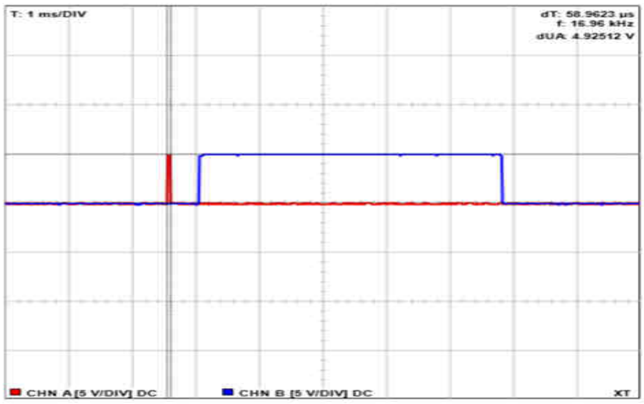

Figure (8) transmitting pulse at 150cm.

The pulse, the duration and the frequency of the received signal of the oscilloscope can be shown in figure (9).

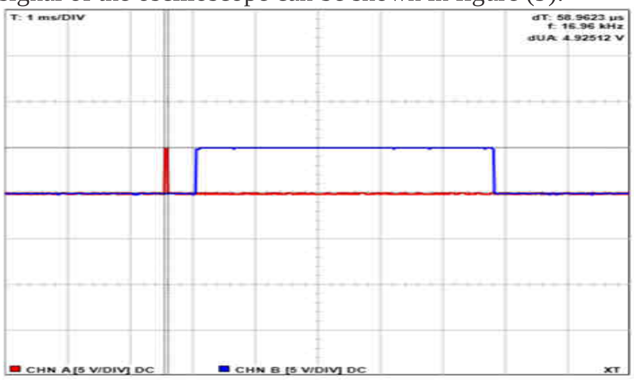

Figure (9) the receiving pulse for the target at 150 cm distance

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From the above two figures , figure (8) and figure(9), there was a delay time between transmitting and the receiving pulses which can be calculated and the results shown in figure (10).

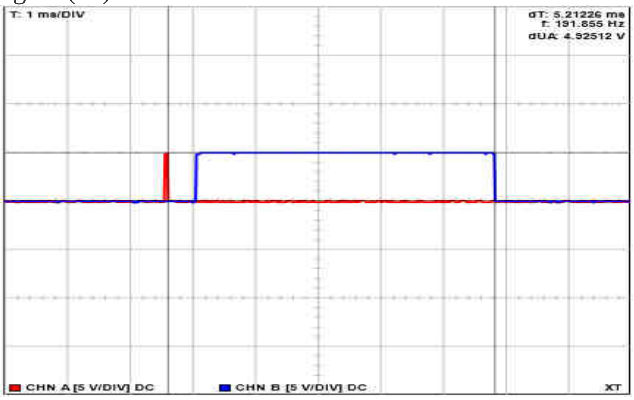

Figure (10): receiving pulse for the target at distance 150cm.

It's important to mention that the delay is equal to the constant pulse which is representing the piezo constant pulse plus the receiving pulse duration.

Test 3: using three constant objects with different places.
The third test was done by taking three static targets instead of one static target as shown in figure (11).

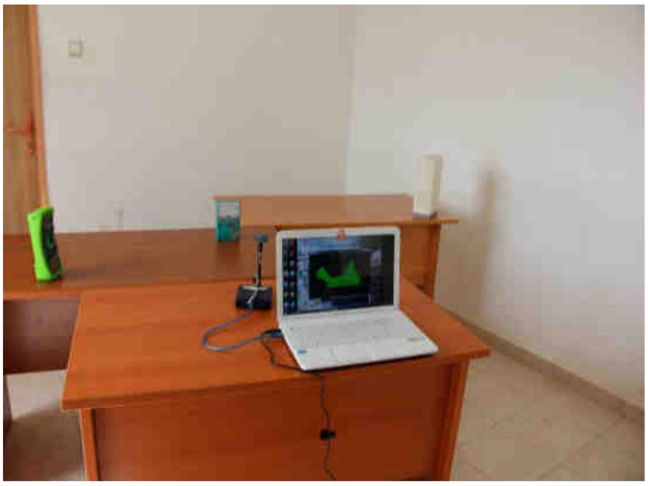

Figure (11): testing for three static targets.

From figure (11) three targets were used which can be shown at the end of the picture, and in front of them there are ultrasonic radar and the radar screen, represented by the computer screen. The shape of the targets, there distances and there angles shown in figure (12)

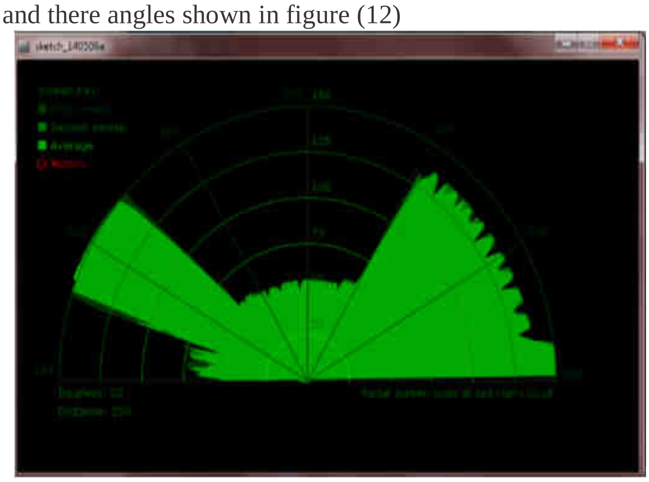

Figure (12): Display for three static targets.

Test 4: using a dynamic object:
The last visual test was done for the a dynamic target as shown in figure (13)

Figure (13) the test of the dynamic target.

Moreover, Figure (14) view radar screen for the dynamic target shows the distance and the angle of this target on the ultrasonic radar screen.

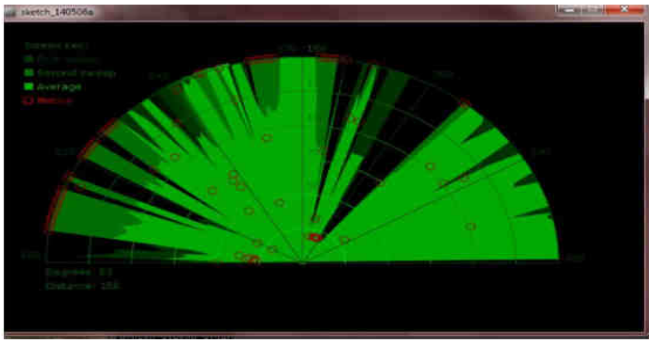

Figure (14): Display for dynamic target.

A. ***Testing the audible signals using the LCD digital screen:***

In this test an LCD screen connected to a bread board was used to measure only the distance by the following tests:

Teste 1: using single object at 150 cm far from the LCD screen:
(The maximum range of LCD is 4m), for all cases we got an error of (5-10cm). If distance in reality 150cm, we got 145cm in the display as shown in the figure (15).

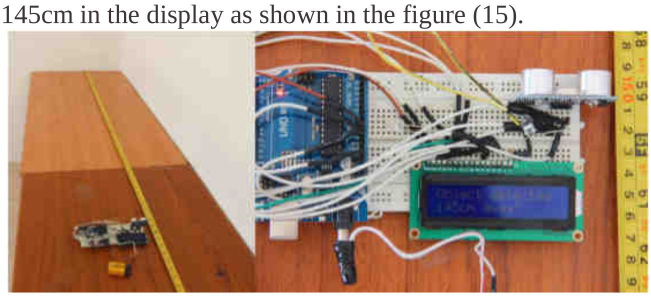

Figure (15): testing LCD at 150cm.

Teste 2: using single object at 223 cm far from the LCD screen:
If distance in reality 230cm, but we have 223cm in the display as shown in the figure (16)

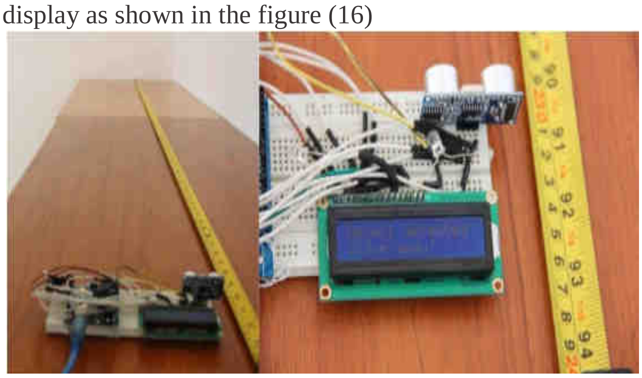

Figure (16): test of LCD at distance 230cm

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V. CONCLUSION

In this paper many tests have been done. The whole assembly is mounted on a servo motor in order to cover the half plane .Some test were performed to investigate the effects of some parameters (such us testing the transmitting and receiving pulses for one big static target, testing the range for more than one static target, and testing the dynamic targets testing of the LCD) which have a direct effect on the performance for the designed system measurements. A delay occurred between transmitted and received waves govern the reflection of sound, it is proportional to the distance between obstacle and the device. Hence the delay is scaled appropriately to get the distance, the following conclusion are derived:

1. Maximum range of the design need system is 150cm.
2. The coverage
3. Area of the ultrasonic radar depends on the rotation of radar by 180˚.
4. There is no error for testing for the smooth dynamic and static target; otherwise there were some errors form the unsmoothed static object and the dynamic targets.
5. The receiving pulse width greater than the transmitting. 6. In the LCD test, there is an error about (5-10cm).

REFERNCES

1. F L. Corp "Ultrasonic Transmitters vs. Guided Wave Radar for Level Measurement (White Paper) by FLO-CORP (Flow Line Options Corp.),2011 ,
2. Dontabhaktuni Jayakumar , A. Pravalika, K. Pumachandra Rao ' Model Radar Implementation Using Ultrasonic Sensor' , paper published in November 2014.
3. S. D. Gupta , A.A. Haque, A. R. Sudip Majumder, "Design and Implementation of Water Depth Measurement
4. and Object Detection Model Using Ultrasonic Signal " , paper published in October 2012.
5. S.G.N. M urthy, B.Sangoju, H.Wiggenhauser, N.R.Iyer , "Application of Radar and Ultrasonic Pulse Echo for Testing Concrete Structures , paper, July 2009.
6. Md. Shamsul Arefin, Tajrian Mollick , "Design of an Ultrasonic Distance Meter" , paper ,published in March 2013.
7. L. Sambuelli, L. Valentina Socco, A. Godio ," Ultrasonic Electric and radar measurements for livening trees assessment" paper , published in Desember 2006.
8. A. Luciano, M.Vicente, T.Carlos, " Ultrasonic Sensors in Urban Traffic Driving-Aid Systems" , paper published January 2011.
9. Tech Support,Ultrasonic Ranging Module HC - SR04, http//www.services.elecfreaks.com.

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