THE DIRECT READING OF ULTRASOUND DISTANCE METER

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MAY 2006

"I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of the Degree of Bachelor in Electrical Engineering (Industry Power)."

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Date : ....9/5/06..........

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May 2006

"I hereby declared that this report is a result of my own work except for the excerpts that have been cited clearly in the references."

Signature : ……………………………………
Name : Siti Afizah Mohd Ali Hanafiah
Date : May 2006

Dedicated to my beloved family;
my father, Mohd Ali Hanafiah
my mother, Sawiyah Yahya
my siblings,
my best friend, Siti Sarah Hussain
who giving me full support and courage

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Praise to Allah S.W.T the Most Merciful and Most Compassionate. Peace be upon him, Muhammad, the messenger of God.

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ABSTRACT

Ultrasound is sound with a frequency approximately above 40kHz, greater than the upper limit of human hearing. The ultrasound waves follow the rules of propagation and reflection; it can be reflected and absorbed by a medium. The ultrasound can be produced by sending a high frequency alternating for example using ultrasonic transmitter. Hence this project is done to implement the direct reading of ultrasound distance meter. This approach is used in order to measure the distance (in centimeter) using ultrasound signal to a target. Air is used as the medium for the ultrasound to transmit while the distance is horizontally located. The SRF04 consists of transmitter and receiver, requiring a short trigger pulse and providing an echo pulse. The echo line is therefore a pulse whose width is proportional to the distance to the object. Theoretically, ultrasound signal is send to a target then time is taken by counter (clock) and finally the distance will appear at 7- segment display panel.

ABSTRAK

Ultrasound adalah bunyi yang menghasilkan frekuensi sekitar 40 KHz yang melebihi had pendengaran bagi seseorang manusia.Gelombang *ultrasound* mematuhi hukum pembiasan dan pantulan dimana ia dapat dipantulkan dan diserap oleh medium. *Ultrasound* boleh dihasilkan dengan menghantarkan frekuensi yang tinggi contohnya menggunakan pemancar ultrasonik. Justeru itu projek ini dihasilkan untuk mengukur jarak dengan memancarkan *ultrasound*. Dengan kaedah ini sesuatu jarak dalam unit sentimeter dapat diketahui apabila *ultrasound* dipancarkan ke arah sesuatu objek. Medium penghantaraan adalah udara manakala objek diletakkan secara melintang dari pemancar semasa ujian dijalankan. Pemancar dan penerima jenis SRF04 digunakan dalam projek ini dimana ia memerlukan signal pendek untuk dihidupkan dan akan menghasilkan gelombang pantulan dimana ia berkadar langsung dengan jarak dari objek tersebut. Secara teorinya, signal *ultrasound* akan dihantar ke target kemudia litar pengira akan menentukan masa yang diambil untuk signal dipantul dan diserap semula oleh penerima.Sebagainya outputnye, jarak akan dipaparkan pada panel 7-bahagian.

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CHAPTER 1

GENERAL PERSPECTIVE

1.1 Ultrasound distance meter

The ultrasound distance meter is to measures distance by emitting ultrasonic pulses and determining the length of time it takes for the reflected pulses to return and then display the distance at 7-segment display. From the time and the known speed of sound, it calculates a distance. Ultrasonic refers to sound frequencies greater than those the human ear is capable of hearing, which is in the frequency range from about 20 Hz to 40 kHz. Bats, by comparison, can detect sound of frequencies up to 120 kHz. The unit of frequency is the Hertz, where 1 Hz is 1 cycle/sec and 1 kHz is 1000 cycles/sec.

The speed of sound is related to the wavelength and frequency by the relationship:

$$\begin{aligned} &c = speed, \lambda = wavelength, f = frequency \\ &c = \lambda \times f \end{aligned} \tag{1.1}$$

The speed of sound in air is about 343m/sec. The speed of sound in water is about 1500 m/sec. So, for example, the wavelength of sound waves of frequency of 1 Hz in air is 343 m. For f = 10 kHz, the wavelength becomes 3.4 cm. Since the wavelength sets the resolution with which we can measure distances, so ultrasonic frequencies is important for distance measurements. The ultrasonic range finders operate in the range of about *40* kHz. Another advantage of ultrasound is that the sound waves can be more directed.

Generally, ultrasonic sensors are commonly used for a wide variety of noncontact presence, proximity, or distance measuring applications. 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

1.2 Objectives

The ultrasound distance meter has several important objectives to achieve. In completing this project few stages have to be following in order to make this project successfully done. Below are the objectives of this project:

1. To construct triggering circuit to give signal to transmitter so that ultrasonic pulse will be generate.
2. To design and construct a hardware of direct reading ultrasound distance meter that can determine the horizontal distance meter by sending an ultrasound signal to a target in cm.
3. To display the output of distance at 7 segment display panel in 3 significant numbers.
4. To test the reliability of the hardware in terms of accuracy and time.

1.3 Scope

The ultrasound distance meter consists of several circuits that are very important that need to be study of the operation and find the best design. Each component that been needed in this project had to been specific and fulfill the target of this project. After doing research and study, below are the main components and set as the scope of this project. It consists of three difference circuit:

1. Triggering circuit
2. SRF04 ultrasonic circuit
3. Counter and Display circuit

1.4 Problem Statement

Before the ultrasound distance meter been develop, the users face some difficulties to measure distance such as:

1. The equipments used are not high-tech created.
2. The reading is not precisely and accurate measured.
3. The devices cannot display the reading in digital value.
4. It required long time to complete the measure process.

These are few problems users face using conventional equipment:

1. Geologies face difficulties to measure distance from one surface to another surface.
2. Scientists especially surgeons have to know the exact location for detecting cancer cell.
3. Military should able to measure opponents coordinate precisely.

Below is few application of ultrasound distance meter that been applied in industry and commercials used:

1. To locate a school of fish
2. Medical purpose; physical therapy, cancer treatment, scanning fetus
3. Detect crack in metal widely used by geologies
4. Use as ultrasonic cleaners for jewellery, lenses

1.5 Layout of Thesis

This report consists of six chapters. Chapter 1 gives the overview of the entire project with a summary of the project background and the objectives of the project.

Chapter 2 consists of literature review that been used in order to understand and have a better view for this project. Therefore literature review on several of topic related had been done throughout this period throughout journals, books and related internet sites.

Chapter 3 discuss about methodology that consist of all the component that been used for this circuit. It also included the function and the operation of each component.

Chapter 4 consists of discussion on the result. It will show the final result for this project

Chapter 5 will gives the recommendations for this report and highlights the suggestions for the future development.

Chapter 6 will conclude the project that been develop.

CHAPTER 2

LITERATURE REVIEW

Reviews of available literature of this project have been performed to ensure more understanding to construct ultrasonic distance meter. The areas that were focused are on behavior of ultrasound through journals, books, and internet.

2.1 Progressive wave fields

The ultrasonic field produced by a transducer obeys all the physical laws of wave phenomena. It can be thought of as being produced by many small point sources making up the transducer face and thus producing a characteristic interference pattern at any point in the field. As ultrasound is propagated from the transducer, there is a zone where the overall beam size remains relatively constant (the near field), though there are many variations of intensity within the zone itself, both across and along the beam axis. This zone is followed by a zone where the beam diverges and becomes more uniform the far field. For a circular piston source of diameter D radiating sound of wavelength lambda, the Fresne zone extends from the transducer to a distance equal to D2/4 lambda (when D is much greater than lambda); beyond this distance is the Fraunhofer zone of the transducer [1]. For a given radius of the transducer, the near field becomes more complex (exhibiting more maxima and minima) as the wavelength of the ultrasound becomes shorter.

The acoustic field of a pulsed transducer can be thought of as being composed of contributions from all the frequencies within the bandwidth of a short pulse. It has been shown in Figure 2.1 that the near field is less structured than that of transducer, and that the length of the near field corresponds to that of transducer oscillating at the centre frequency of the pulsed field.

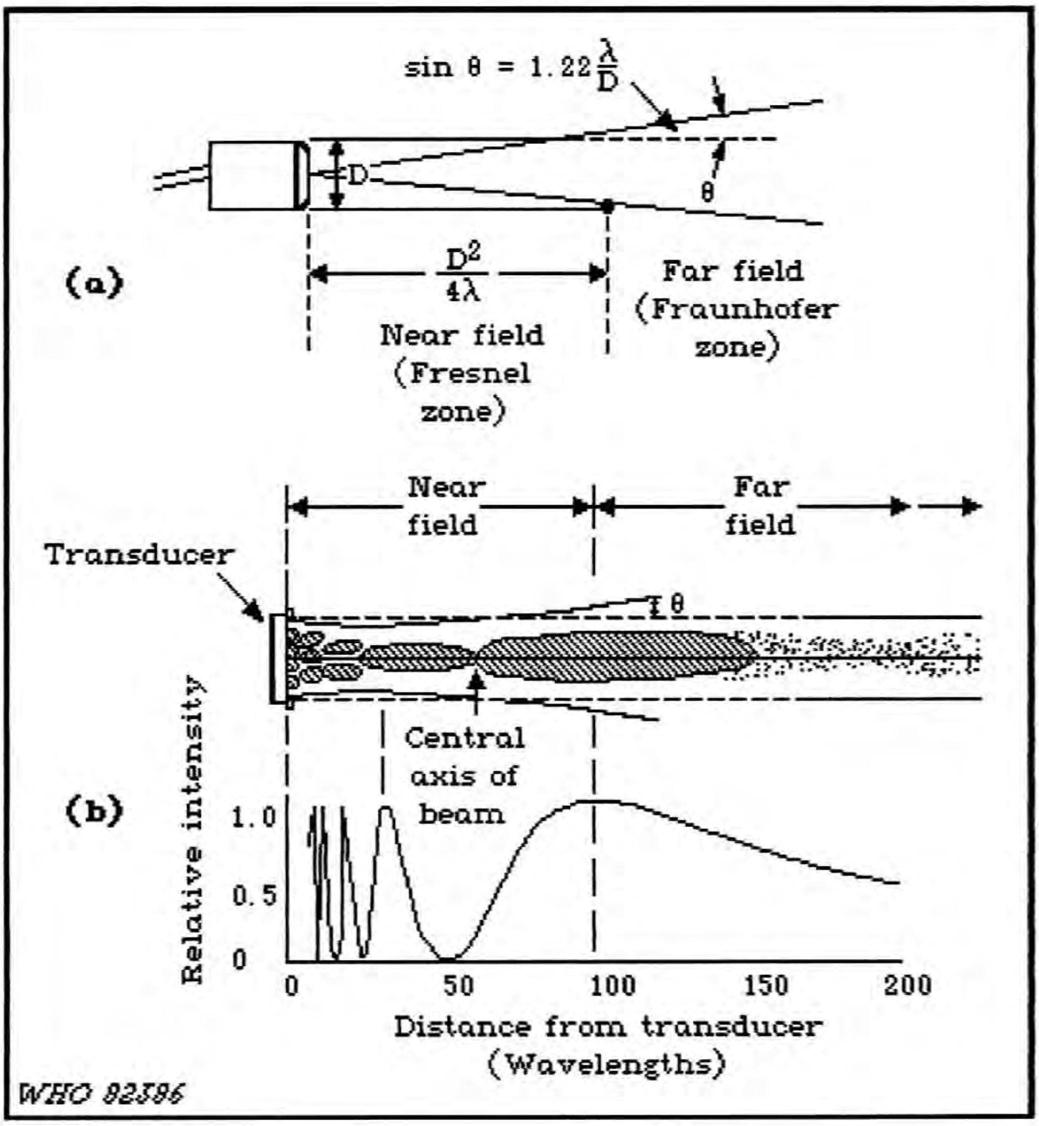

Figure 2.1: Prediction of ultrasonic waveforms in highly attenuating plastic materials [1].

2.2 Speed of Sound

The speed, c at which ultrasonic vibrations are transmitted through a medium is inversely proportional to the square root of the product of the density, σ and the adiabatic compressibility, B of the material, such that in equation 2.1. The speeds together with the frequency, f of the ultrasound determine the wavelength lambda, λ of the waves that are propagated as in equation 2.2.

$$c = (\sigma B) - 0.5 \tag{2.1}$$

$$\lambda = \frac{c}{f} \tag{2.2}$$

2.3 Measurement of ultraslow dynamic

Ultrasonic sensors are commonly used for a wide variety of noncontact presence, proximity, or distance measuring applications. 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 .The wide variety of sensors currently on the market differ from one another in their mounting configurations, environmental sealing, and electronic features. Acoustically, they operate at different frequencies and have different radiation patterns.

i. Variation in the speed of sound
ii. Variation in the wavelength of sound
iii. Variation in the attenuation of sound
iv. Variation of the amplitude

2.4 Speed of Sound in Air as a Function of Temperature

In an echo ranging system, the elapsed time between the emission of the ultrasonic pulse and its return to the receiver is measured. The range distance to the target is then computed using the speed of sound in the transmission medium, which is usually air. The accuracy of the target distance measurement is directly proportional to the accuracy of the speed of sound used in the calculation. The actual speed of sound is a function of both the composition and temperature of the medium through which the sound travels.

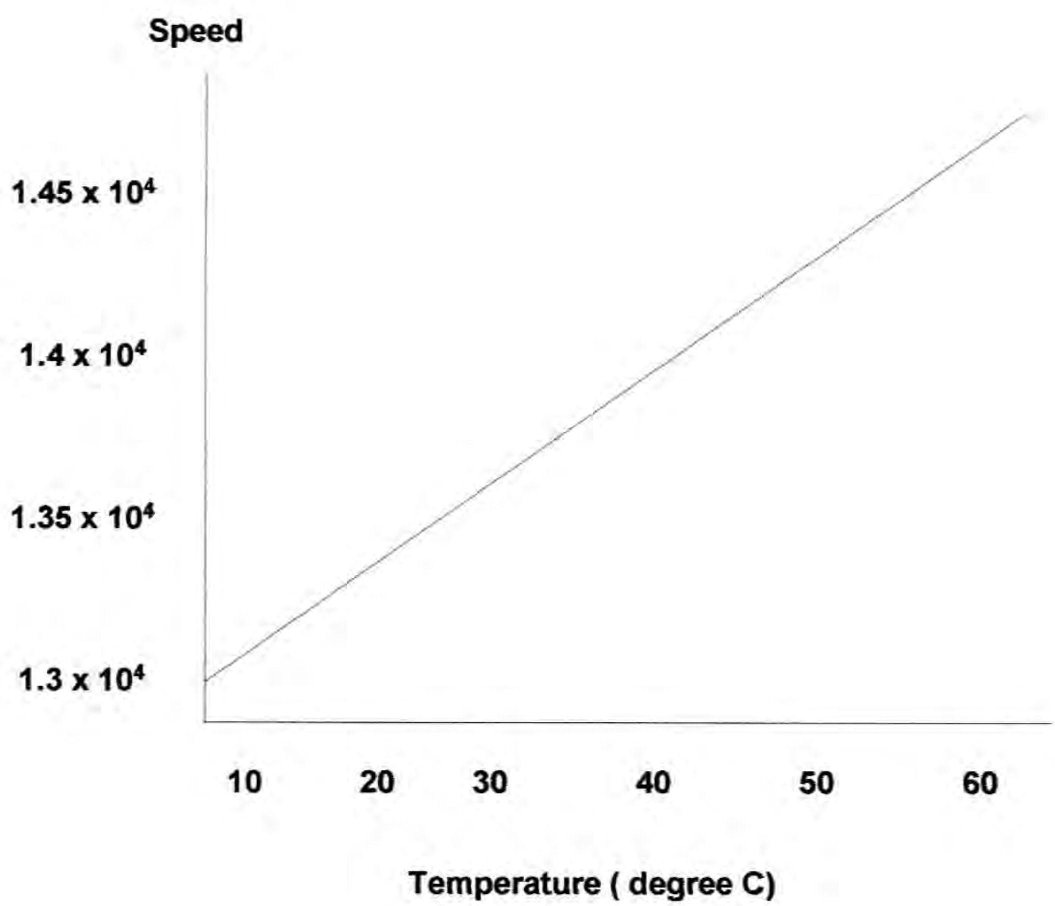

Figure 2.2: The speed of sound is plotted as a function of the temperature. At room temperature, sound travels at ~13,500 ips [2].

2.5 Wavelength of Sound As a Function of Sound Speed and Frequency

The wavelength of sound changes as a function of both the speed of sound and the frequency, as shown by the expression:

$$\lambda = \frac{c}{f} \tag{2.3}$$

Figure 2.3 is a plot of the wavelength of sound as a function of frequency at room temperature in air.

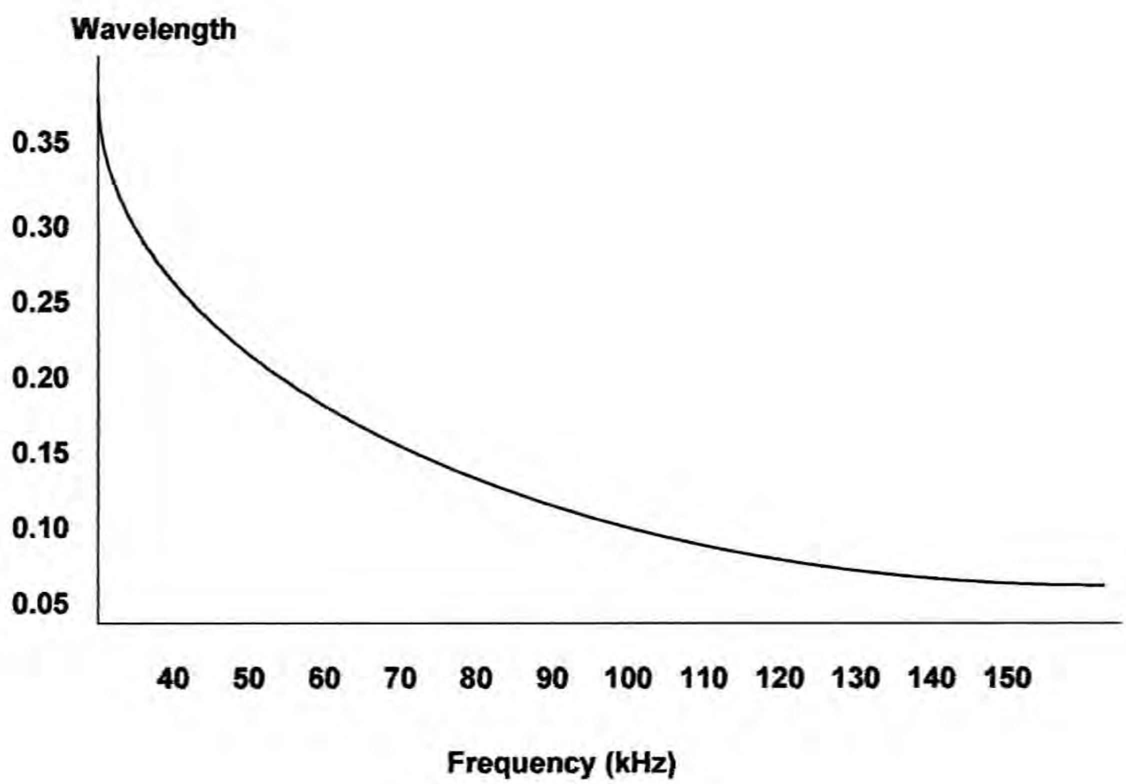

Figure 2.3: The wavelength of sound in air at room temperature is plotted as a function of frequency

2.6 Relative Echo Levels from a Flat Surface for different Ultrasonic Frequencies

If the sound pulse is reflected from a large flat surface, then the entire beam is reflected. This total beam reflection is equivalent to a virtual source at twice the distance. Therefore, the spreading loss for the sound reflected from a large flat surface is equal to 20 log (2R), and the absorption loss is equal to $2\alpha R$. For this to hold, it is important that the reflecting surface be both larger than the entire sound beam to ensure total reflection, and perpendicular to the sound beam [3].

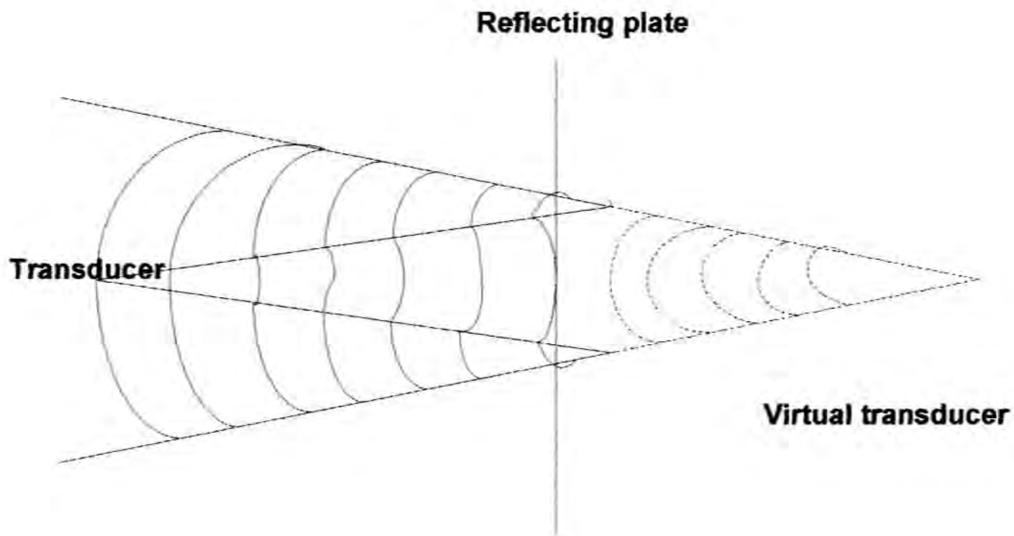

Figure 2.4: A sound beam reflected from a flat surface is equivalent to the sound as generated from virtual transducer at an equal range behind the reflecting plate.