DEVELOPMENT OF DEPTH SENSOR SYSTEM FOR SEABED MAPPING USES ECHO SOUNDING TECHNIQUE

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This report is submitted in partial fulfillment of requirements for the degree of Bachelor in electrical engineering (Control, Instrumentation and Automation)

Faculty of Electrical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

JUNE 2012
I hereby declare that I have read through this report entitled “Development of Depth Sensor System for Seabed Mapping uses Echo Sounding Technique” and found that it has comply that fulfillment for awarding the degree of Bachelor of Electrical Engineering (Control, Instrumentation and Automation).

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Supervisor’s Name: Puan Arfah Syahida bt Mohd Nor
Date: …………………………………………
I declare that this report entitled "Development of Depth Sensor System for Seabed mapping uses Echo Sounding technique" is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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Date:  

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DEDICATION

Specially dedicated to my beloved family especially my husband, Saiful Bahari B Mohd Rasid and my kids, Faris and Sofiya whose very concern, understanding, supporting and patient. Thanks for everything. To All My Friends, I also would like to say thanks. The Work and Success will never be achieved without all of you.
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Thank you.
ABSTRACT

This project is purposely to develop a system to obtain a seabed mapping for Tasik Ayer Keroh, Melaka. The study is initiated by identifying the appropriate techniques to achieve the objectives of the study. Various techniques can be used to study the seabed mapping. In this study, the technique used is the Echo Sounding detection. A transducer is functioning as a tool used to detect the depth. Sensor used is a type of sonar sensors. Sonar sensor has a transmitter that serves to transmit signals in pulse and receiver which serves to receive a reflected signal with the echo technique. The distance is determined by the speed reflection of the signal to the sonar sensor multiplied by the time taken. In determining the efficiency of the chosen tool, tests were performed in advance. Three pools are used to test this tool. Once satisfied with the results of these three tests, then this tool is used to measure the depth of Tasik Ayer Keroh. Readings are taken for three lines which are line one, line two and line three. After that, the graphs are plotted for the three lines to see the difference in depth. There are a variety of interests and benefits from the detection of this depth at the lake. Among them is determining the appropriate water activity that suitable with the depth of the lake.
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CHAPTER 1

INTRODUCTION

1.1 Overview

The development of exploring the technique of seabed mapping started over 150 years ago [1]. The technique revolutionized over years. But some of the basic principle still remains until today. For example, the measurement call fathom which used weight that attached to a rope which were lowered to the bottom from the side of the boat. The weight had a hollow bottom so a sample of the sediment could be collected.

Echo Sounding took place in 1919 by French which also called fathometers [1]. As the ship travels on the surface of the water, a transducer on the hull of the ship emits a pulse of sound, a 'ping'. Sound will reflected if hit by a hard surface. A receiver that placed on the ship’s hull will captured the 'ping' sound and the time taken for this to happen is recorded by the device. Then, the calculation of depth automatically measured using this equation:

\[
\text{Distance} = \text{speed} \times \text{time} \quad (1.1)
\]

Since the density of water is different compared to the air, the speed of the sound molecule in the water also differ. As the water particles are closed together than gas particles in air, so sound travels faster in the water than in air. So it is possible to use different frequencies for different purposes.
Figure 1.1 shows how the depth is determined using 4kHz of frequency. The sensor was placed at the bottom of the ship and emit the pulse. The coverage area is in only 4° from the transducer. The smaller value of frequency, the smaller coverage of transducer.

Figure 1.1: This illustration depicts the principle of sediment echo sounding, which uses a narrow beam of high energy and low frequency. [1]
1.2 Problem Statement

Lake is well known as one of the sources of life. Sometimes it is used as a recreation place, the source of drinking and also as a source of income from life inside. But, some of the activities cannot be done because of the depth of the lake not clearly known. It is difficult to estimate the depth of the lake caused by the uneven ground. Using Echo Sounding Technique, the transmitter will transmit the sound to the seabed and the sound will bounce back to the receiver when it hits the seabed. The speed and time of the sound travel in this process is used to determine the depth of the seabed.

1.3 Objectives

There are four objectives of this project which are:

1.3.1 To understand the echo sounding techniques.
1.3.2 To develop a depth sensor system for seabed mapping using Echo Sounding Technique.
1.3.3 To analyze the accuracy of seabed mapping.
1.3.4 To determine the depth of the river using echo sounding technique.

1.4 Scope of Project

Techniques described in this project are used to map the shape of the seafloor. There are several methods to collect the data of the river's depth. But the aim is to develop a Depth Sensor System using Echo Sounding Sensor. The transmitter of the transducer enables the system to generate a swath of sound. The sound is reflected by the seafloor at different angles and received by the receiver transducer at slightly different times. The device will be tested at Taman Rekreasi Air Keroh, Melaka.
CHAPTER 2

LITERATURE REVIEW

2.1 Overview

This chapter reviews existing project created to get an idea about the project design, conception and any information that related to the project. There are many creations and innovations of projects that have been done by other researchers with differences concept and design. This chapter also covers the researches related to the subject. This will provide a clearer understanding of the system and its design. This chapter will discuss on overall theories and concept of the project. The purpose of this chapter is to explain the review of the theories used to in order to implement the project. The understanding of the basic theory is a very important as a guideline. This project is all about the development of Depth Sensor System for Seabed mapping uses Echo Sounding Technique.

2.2 Fundamentals of underwater sound

Human can covers frequencies from 20Hz to 20kHz but others species like marine mammals can extend outside the human hearing range. Sound below 20Hz is often referred as infrasound and sound above 20kHz referred as ultrasound. In order to measure the sound, several factors must be taken into account. The intensity, pressure, acoustic impedance and attenuation factors play the important role in measure the sound. Due to the different
characteristics of air and water, the measuring of sound also differs which is water have pesspressure 60 times larger than in the air[3].

Table 2.1: Different pressure in air and water [4]

<table>
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<tr>
<th>Pressure in air re 20 µPa/Hz</th>
<th>Pressure in water re 20 µPa/Hz</th>
<th>Comments from Kinsler&amp; Frey: Fundamentals of Acoustics</th>
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<tr>
<td>0</td>
<td>62</td>
<td>Lower limits of human hearing</td>
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<tr>
<td>60</td>
<td>122</td>
<td></td>
</tr>
<tr>
<td>120</td>
<td>182</td>
<td>Threshold of hearing</td>
</tr>
<tr>
<td>140</td>
<td>202</td>
<td>Threshold of pain</td>
</tr>
<tr>
<td>160</td>
<td>222</td>
<td>Threshold of direct damage</td>
</tr>
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In areas with a very strong acoustics contras at the seabed, sound will be reflected back into the water column and not penetrate into the bedrock. Sound from several of sources can be recorded over great distances. Unfortunately, this sound will be attenuated when the distances increase.

2.3 Sensor of Seabed Mapping

A transducer model which can function as transmitter and receiver. In underwater, the transducer is improving for exchanging voice and data. All obtained data were generating using Matlab[5].
Figure 2.1: Transducer structure [6]

Figure 2.1 shows the basic transducer structure made from 1 to 3 composite ceramic matching with aluminium. In their experiment, the ceramic was replaced by piezocomposite materials due to its sensitivity [6]. The aluminium placed at the middle of ceramic layer and not required in improving the performance but it is need to provide a mounting support. The acoustic waves which reach at the receiving transducer and change to electrical signal at the electrical port.

The acoustic transducer response characteristics and the effect of underwater sound pulse on receiving system are studied. In order to get the result, an equivalent circuit of acoustic transducer was constructed. A capacitor act as a piezoelectric transducer due to its electric dissipation. The impedance which is inductor, resistor and capacitor also added because transducer radiates acoustic energy [7].

Figure 2.2: Equivalent lumped-circuit of piezoelectric transducer considering the line losses [7]
Meanwhile, by using electro hydraulic effect intense sound is produced. A charging-discharging circuit, trigger switch, discharge switch, transmission cables and control unit are use as sound source system.

![Figure 2.3: Collocation plan form of source and transducers [7]](image)

From the experiment, underwater countermeasure equipment can be developed from sound pulse generating system [7].

### 2.4 Method of Seabed Mapping

The seabed mapping using Single Beam Echo-Sounder (SBES) is the one useful method for seafloor characterization. In the SBES previous studied stated that the determination of the energy ratio of the first and second bottom return to characteristics of the seafloor [8]. Measure of theoretical and acoustic model was compared in the time domain and frequency [9]. The study of seafloor characterization was made by using neural network and seafloor classification method build upon the parameterization of the reverberation probability density. The research conducted in the three different depths based on frequency which is 12kHz, 38kHz and 200kHz [8].
Multi-Beam Echo Sounders offer the hydrographic surveyor the ability to measure and record seabed bathymetry over a wide swath beneath the survey vessel. MESB is more expensive if compared to SESB system. The imaginary data available from multibeam echo sounders have improved in quality of imagery. The footprint size of the imagery data from the MESB is generally large [10].

2.5 Combination of Underwater Acoustic and Radar Instrumentation.

Combination of underwater acoustic with radar instrumentation for seabed mapping is tested in a research. Quantitative Echo Sounder (QES) are widely used for ecological studies and fisheries resources survey. Meanwhile the Ground Penetrating Radars (GPR) has been used for several years as a non-destructive method of locating subsurface objects in the ground.
The acoustic pulses of the echo sounder are reflected at the sea floor and the reflected echoes are received by the transducer. The elapsed time between the outgoing pulse and the returning echo is a measure of the depth. At the same time, the data of seabed mapping were also taken by the GPR. The data then displayed as a sea bottom cross-section. From the research, it is proof that the combination of the two methods is a powerful technique for exploration the sea bottom [11].

2.6 Existing Project

The Echo Sounder EM 300 can be used at a depth of 10m up to 5000m. The frequency chosen for EM 300 is 30kHz. At each 1000m depth, this Echo Sounder allows 140° coverage. The transducer is smaller compared to the last model allowing easy installation and also accurate in shallow water. The special function of EM 300 includes phase detection and calibrated seabed acoustic imaging.
Figure 2.6 explain how EM 300 function in collecting data to measure the seabed mapping. The EM300 system has been used to map the seafloor widely around the world, from Vancouver Island, to the rift zones of Hawaii, to the Galapagos Islands.

2.7 Conclusion

After revising all the related articles and journal about this project, author has clear understanding for this project. The Echo Sounding is the technique to determine the depth of water using sound pulses. The time was recorded from the emission of pulse to echo receiver and then, the depth calculated from speed of propagation of sound through water. The sound speed in the water is slightly different in air.
Transducer is a commonly sensor used to find the water depth by using a quick pulses of sound called sonar. The instrument panel will display the information given by the transducer. The depth of water can be recorded in feet or meters.