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Envelope Echo Signal of Metal Sphere in the Fresh Water

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***Abstract*—**An envelope echo signal measurement is proposed in this paper using echo signal observation from the 200 kHz echo sounder receiver. The envelope signal without any object is compared with the envelope signal of the sphere. Two diameter size steel ball (3.1 cm & 2.2 cm) and two diameter size air filled stainless steel ball (4.8 cm & 7.4 cm) used in this experiment. The target was positioned about 0.5 m and 1.0 meter from the transducer face using nylon rope. From the echo observation in time domain, it is obviously shown that echo signal structure is different between the size, distance and type of metal sphere. The amplitude envelope voltage for the bigger sphere is higher compare to the small sphere and it confirm that the bigger sphere have higher target strength compare to the small sphere. Although the structure signal without any object are different compare to the signal from the sphere, the reflected signal from the tank floor increase linearly with the sphere size. We considered this event happened because of the object position approximately to the tank floor.

***Keywords*—**echo sounder, target strength, sphere, echo signal

I. Introduction

SONAR (Sound Navigation and Ranging) systems have many similarities to radar and electro-optical systems. The operation of sonar is based on the propagation of waves between a target and a receiver. There are two type of sonar systems are passive and active. In a passive sonar system we only analyze sound energy produced by the target. In active sonar systems, sound waves propagate from a transmitter to a target and return back to a receiver [1]. Sonar have been used widely for many application such as submarine navigation, ship velocity measurement, underwater object clarification, bottom topography, vehicle location detection, water velocity measurement and fisheries technology. In fisheries applications, sonar devices better known as the echo sounder. Echo-sounders transmit a pulse of acoustic energy down towards the seabed and measure the total time taken for it to travel through the water, the sound pulse is generated by a transducer that emits an acoustic pulse and then "listens" for the return signal. The time for the signal to return is recorded and converted to a depth measurement by calculating the speed of sound in water. Echo sounder can also refer to hydro acoustic defined as active sound in water (sonar) used to study marine animal. The first successful underwater transducer developed was a 540 Hz electro dynamically driven circular plate, conceived and designed by Reginald A. Fessenden in 1912 and patent was awarded in 1913 [2].

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After that, many inventions produced especially for underwater application such as underwater communication, ocean topography, submarine navigation, object classification and so on.

An acoustic method for the detection of fish was first reported in the scientific literature in 1929. Continuous waves (CW) at a frequency of 200 kHz were directed across ponds containing goldfish. As the number of fish intercepted by the acoustic beam changed, so the amplitude of the signal can record using an oscillograph [3]. Acoustic waves or sound waves provide the best mean of exploration in the underwater environment and propagate well compared than others. In the turbid, saline water of the sea, both light and radio waves are attenuated far more in the water and their working ranges are greatly reduced [4].

Although cameras and lasers are extensively used for certain applications, their working are typically well below five meters. For this reason, forward looking scan sonar is used for a varied number of underwater applications, such as obstacle avoidance, mid water mind detection and surveillance [5]. Nowadays, the underwater fisheries acoustic technology (echo sounder) thrived rapidly. Despite the earlier applications of sound waves are used to detect fish, this method has been extended to use for other application like marine habitat observation, fish school, fishery tools, effect to the marine ecosystem and marine animal behavior.

II. Sphere as a Reference Target

Acoustics is the most effective tool for monitoring underwater object because of the sound's ability to propagate long distance in water [6]. Target strength measurement using echo sounder is one challenging method in studying the underwater animal. The estimation of underwater animal by the echo-integrator method requires sonar that has been accurately calibrated [7]. The easy technique can apply in echo sounder calibration is using a object whose acoustic properties are known. Several types of sphere have been used as calibration and reference target in sonar equation, in particularly, ping pong ball [8], cooper, tungsten [9],[10] and steel ball [11],[12]. Although, the TS value of the object are known, but it is important that theoretical predictions should be tested by experiment. Most target strength measurements have been made by what may be called the conventional method, in which measurements of the peak or average intensity of the irregular echo envelope are made at some long range and then reduced to 1 yd [4]. Generally, envelope voltage target will be measure and compare with the envelope voltage reference target (TS sphere). Sphere echo voltage measurement is the best practical way in calculating target strength, especially when to quantify object at certain distance from the sound source. Echo characteristic of the object can be observe easily and this technique also can facilitate us to design sounder device for many application.

The goal of this experiment is to obtain envelope echo signal structure of the sphere.

III. Methodology

This method of measurement employs a standard target whose acoustic scattering properties are known. Two diameter size steel ball (3.1 cm & 2.2 cm) and two diameter size air filled stainless steel ball (4.8 cm & 7.4 cm) used in this experiment. The target was positioned about 0.5 m and 1.0 meter from the transducer face. The sphere was suspended by nylon rope in reservoir tank containing fresh water as shown in fig. 1.

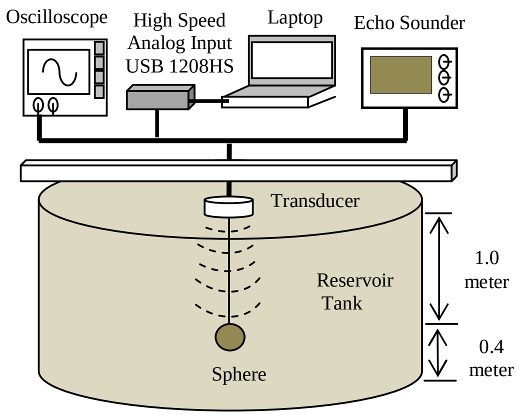

Fig. 1 The sphere were positioned about 1 m from the transducer face

Modified dual frequency commercial echo sounder model JMC V1082 used in this research. The experiment used 200kHz frequency and 600 sample echo signal from the transducer will read directly into digital oscilloscope and computer using high speed analog input USB 1208HS. The velocity of sound set up at 1480 m/s which is for fresh water. Envelope signal for each type sphere will be measure at 1 meter and 0.5 meter distance. The echo signal for each sphere were recorded into strip chart graf using TracerDAQ for six seconds.

IV. Result And Discussion

Data recordings were made for signal without any object and signal with the sphere in water as shown in Fig. 2. The data were classified base on amplitude signal in time domain. The echo signals for different type of sphere are shown in Fig. 3 and Fig. 4 for 1.0 m and 0.5 m respectively. The envelope for each echo represented by the dashed curve.

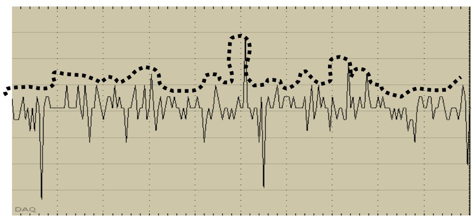

Fig. 2 Echo signal without any object representation in strip chart graf

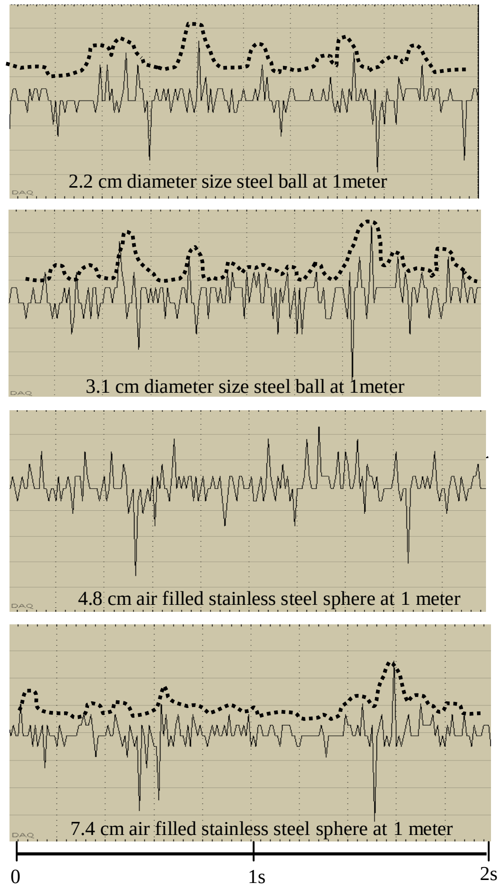

Fig. 3 Underwater Metal Sphere Echo signal at 1 meter distance

From the echo observation in time domain, it is obviously shown that echo signal structure is different between the size, distance and type of metal sphere. An example signal recorded for steel ball at 0.5 meter distance is higher than 1.0 meter distance.

TABLE I
Peak Value of The Sphere From Strip Chart Graf at 0.5 Meter

Sphere diameter	Upper peak	Lower peak	Vpeak
3.1 cm steel ball	11.8935	11.8594	17.05 mV
2.2 cm steel ball	11.9033	11.8740	14.65 mV
4.8 cm stainless steel ball	11.9082	11.8691	19.55 mV
7.4 cm stainless steel ball	11.9082	11.8594	24.40 mV

TABLE II
Peak Value of The Sphere From Strip Chart Graf at 1.0 Meter

Sphere diameter	Upper peak	Lower peak	Vpeak
3.1 cm steel ball	11.8398	11.8105	14.65 mV
2.2 cm steel ball	11.8984	11.8740	12.20 mV
4.8 cm stainless steel ball	11.9033	11.8691	17.10 mV
7.4 cm stainless steel ball	11.9131	11.8691	22.00 mV

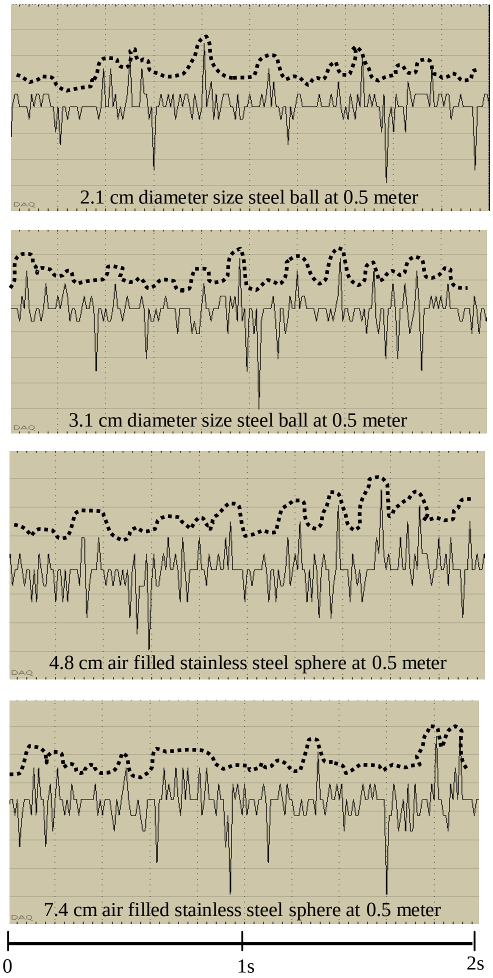

Fig. 4 Underwater Metal Sphere Echo signal at 0.5 meter distance

The peak value for each type of sphere at 0.5 m and 1.0 m are shown in Table I and Table II respectively. Peak value increase when the distance between transducer and the object decrease. Although the structure signal without any object are different compare to the signal from the sphere, the reflected signal from the tank floor increase linearly with the sphere size. We considered this event happened because of the object position approximately to the tank floor. From echo voltage comparison we also found that the amplitude envelope voltage for the bigger sphere is higher compare to the small sphere and it confirm that the bigger sphere have higher target strength compare to the small sphere.

V. Conclusion

The envelope echo signal of two type sphere was measured using high speed analog input USB1208HS, in order to compare peak value and signal structure at the different distance. Base on the result we found that the peak value for each steel ball are different compared to its size. Bigger sphere produced high amplitude voltage compare to the small sphere. Although recording echo signal in time domain was completed, further observation must be conduct in frequency domain using FFT analysis in order to get accurate value.

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