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Construction and Operation of Low Cost Hydrophone for Underwater Sound Detection

Yuvraj C. Mohite, P. N. Arotale

Department of Electronics and Communication Engineering, Vidya Pratishthan's College of Engineering, City, Baramati, India

ABSTRACT

As industrial activities continue to grow on the coast, underwater sound measurements are becoming of great scientific importance as they are essential to evaluate the impact of these activities on local ecosystems. In this paper, the use of commercial underwater recorders is not always the most feasible alternative, due to their high cost and lack of flexibility. Design and construction of more affordable alternatives from scratch can become complex because it requires profound knowledge in areas such as electronics and low-level programming. With the aim of providing a solution, low-cost alternative to commercial recorders is proposed to build. A properly working prototype will be assembled and it will be demonstrating adequate performance levels. The underwater recording device can be successfully deploying at selected locations along the coast, where it adequately recorded animal and manmade acoustic events, among others.

Keywords: Underwater Acoustic, Sound Pressure Level

I. INTRODUCTION

Underwater acoustics is the study of the propagation of sound water and the interaction of the mechanical waves that constitute sound with the water and its boundaries. The water may be in the ocean, a lake or a tank. Typical frequencies associated with underwater acoustics are between 10 Hz and 1 MHz. The propagation of sound in the ocean at frequencies. lower than 10 Hz is usually not possible without penetrating deep into the seabed, whereas frequencies above 1 MHz are rarely used because they are absorbed very quickly.

Sound in water is measured using an acoustic recorder which is the underwater equivalent of a microphone. A hydrophone measures pressure fluctuations, and these are usually converted to sound pressure level (SPL), which is a logarithmic measure of the mean square acoustic pressure.

As Sea Perch Vessel is cruising along the bottom of the ocean, pond or lake you might think, I sure wish I could hear what is going on down there. Simply placing one's head underwater would not help. One would not hear much, if anything at all. Furthermore, even if sound could be heard it would be difficult to decipher the sound. A question to ask oneself is "Is this because sound travels slower in water or does something else interfering with our ability to hear underwater? Let us first discuss the importance of underwater sound and then examine our ability to hear sounds and how this all relates with the Sea Perch Vessel.

There are many advantages of being able to hear what happens within a body of water. One such benefit is that with the right equipment (i.e. a hydrophone) sound at greater distances could be heard. Leonardo da Vinci once observed "If you cause your ship to stop, and place the head of a long tube in the water and place the outer extremity to your ear, you will hear ships at a great distance from you (Bardic, 1984). This is due to interesting phenomena. Sound waves travel about 30% faster in water then air (1450 feet per second to 1100 feet per second). The speed of sound in water can be modeled using the following equation. Where c is the speed of underwater sound, T is the temperature of the water, S is the salinity and z is the depth (Brekhovskikh, 2003).

$$C = 1449.2+4.6\,T - .055\,T^2 +.00029\,T^3 + (1.34-.10000T)\,(S-35) +01016\,z$$

It is interesting to note that as we increase the depth within water our sound travels faster and thus farther which allows things that are at greater distances to be hear.

When we say we ‘hear’ we are referring to our ability to pick up of pressure changes that result from vibrations as they travel through a medium. Our ability to detect “sound” is directly related to the intensity of these pressure changes. The relationship of pressure to intensity is as follows:

$$I = p^2 /\rho_0 c$$

In the equation the variables I = sound intensity, $\rho 0$ = density of the medium, c is the speed of sound in the medium (Yost, 2007). Thus the ability or inability to hear is due to the intensity at which sound waves are processed.

Simply submersing one’s head in water though would prohibit the sound to reach at a high enough register. This is because the primary way sound is heard is that the outer ear serves a sound collector that channels the sound into the middle and inner ear. The sound then reaches the ear drum and it vibrates; in turn causing other bones to oscillate sending signals to the brain (Raichel, 2006). The problems arise when the outer ear is filled with water (or any other substance). The substance prohibits the eardrum from vibrating and our second mechanism of hearing must kick in which is approximately 40 percent less effective than the primary mechanism. Furthermore, certain frequencies are prohibited eliminated the ease at which consonants are heard.

These difficulties are easily solved by using an apparatus that uses a different method to ‘hear.’ Hydrophones are an effective solution because of their ability to listen underwater sound. Hydrophones work similarly to microphones except they are designed to have an acoustic impedance (sound pressure generated by the vibration of molecules) to match water. They use a transducer (device that converts one type for energy to another) that provides an electrical output in response to an acoustic signal (Burdic, 1984). The electrical output is then converted back into an acoustic signal by speakers.

II. METHODS AND MATERIAL

The design for the hydrophone consists of approximately nine components that are relatively easy to assemble into a working hydrophone. Table 1 contains a list of all the components needed for the construction of the hydrophone, as well as the prices and number of required quantity. It also gives a brief description of the primary function of each part. The total price of 810 Rs is reasonable for a hydrophone of this quality.

A. Material List

Sr.no	Component Name	Quantity	Prices	Function
1	Microphone element	1	20	Primary component that converts acoustic signal to an electrical output
2	25 -ft Audio cable	1	300	Transfers electrical output from microphone element
3	Battery holder	1	20	holds the battery
4	C cell battery	2	60	Power supply of device and lm 386
5	Balloon	1	20	Provoid vessels for microphone element
6	Glue stick	2	30	For waterproofing
7	Electrical tape	1 roll	10	Seals connections
8	LM 386 drive kit	1	300	amplification
9	Speaker	1	50	for output
=			810	

Along with these materials two tools will be needed to construct the hydrophone. These tools include:

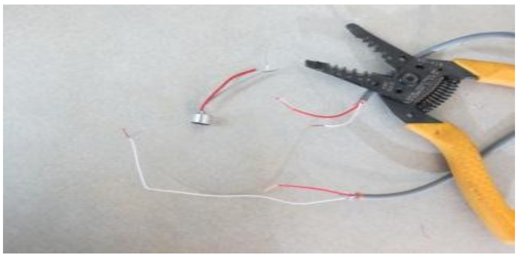
- Soldering Iron (needed to solder all connections)

- Wire strippers

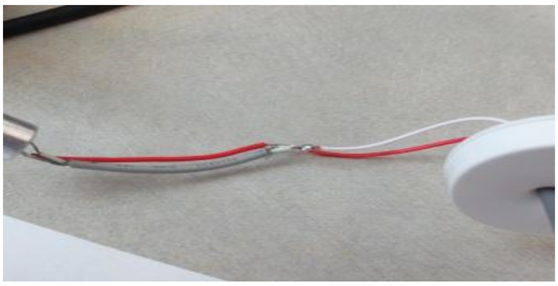
B. Instruction

The following section contains are step by step instructions on how to build the same hydrophone that was built for the purpose of this project.

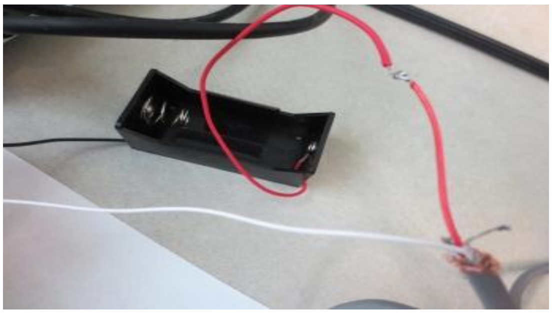
1. Using the wire strippers strip the ends of wire as well as the end of the audio cable. On far end leave the white lead 7 inches longer than the other.



2. Punch a hole (just big enough for the audio cable to pass through) into the carbon board.
3. Take 25 mm size pvc pipe and place it on carbon board.
4. Fix carbon board and pvc using glue stick.
5. For waterproofing purpose use balloon to cover-up microphone element and Seal the neck of balloon by applying a generous amount of glue around the pvc.
6. Connect the wires of the audio cable to the leads of the electret microphone element. Make sure you follow the correct pattern. Also be sure to solder all connections and wrap in electrical tape to ensure connection will be protected.



7. Connect the one end of the audio cable to the (+) end of the battery pack.
8. Feed the (-) end of the battery pack to ground terminal of signal conditioning circuit.



9. Connect the other end of the audio cable to the signal terminal of signal conditioning circuit.
10. Use 9v dc power supply for signal conditioning circuit.
11. Connect output terminal of signal conditioning circuit to speaker.

C. Troubleshooting and Key Notes

1. Before soldering the ends to the plug, make sure the connections are right by plugging it into a speaker source.
2.When you place the hydrophone in water the first couple of times balloon neck may be leak.

III. RESULTS AND DISCUSSION

Since the basis of this project was to provide instructions to build and operate a simple inexpensive hydrophone, this section will focus primary on how to operate the hydrophone as well as how to check to see if it works.

Once assembly of the hydrophone has been completed, you should be able to plug it into a speaker. If the hydrophone seems dysfunctional, check connections and try again.

Operation of this hydrophone is simple. Run the hydrophone's wire next to the audio cable and have the plug inserted into a speaker. With this set up you will be able to hear all the sounds that are coming from underneath the water's surface.

IV. CONCLUSION

When a underwater vessels is taken out for a spin, it is difficult without the aid of a device to hear what is going on underneath the water. A hydrophone provides as simple solution to this problem. The hydrophone is successful when it is able to answer three main questions. Is it inexpensive enough to be a feasible option? Can the device be reasonably easy to construct? And will it perform adequately enough to be useful? The hydrophone design presented within this report answers these three questions as well as provides additional benefit to the user.

The device constructed meets the first criterion is satisfied by having components that can easily be found and a total cost of under 1000 Rs. Furthermore, with some ingenuity the price could drop even more as people substitute parts with those they already have. The second constraint is also satisfied because design is very much easy to construct. As you construct your very own hydrophone it will be evident.

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