Applications of Magnetic Induction and Localization to an Autonomous Underwater Vehicle

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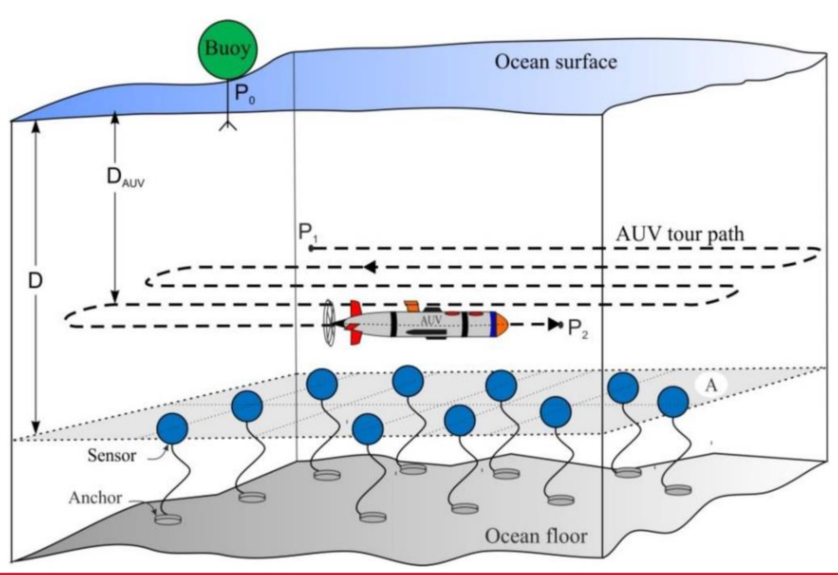
ABSTRACT

Autonomous robotics has become widely popular for various industrial applications. For underwater applications, there are some issues with communication due to the high signal attenuation in water. Through prior experiments, Magnetic Induction (MI) has shown to have promising result in underwater applications with low power consumption. Localization is the one idea in robotic navigation and is done through the creation of a copper coil in the XYZ directions. Using these 3 coils, a robot's position can be precisely determined relative to the coil and a network of these coils can be created to collect data on the robotics location in the water. This research explores the application of MI to autonomous vehicles, in hopes of being able to create an underwater network of Autonomous Underwater Vehicles (AUV) which would be able collect data and deliver it throughout the network.

INTRODUCTION

- There are many industries that rely on collecting, transmitting, and analyzing data in both fresh and saltwater environments.
- The overall goal of this research is to utilize a new form of wireless communication in conjunction with alternative communications to create an underwater network of communication hubs for autonomous robotics.
- The focus of this research is to explore Magnetic Induction as a means of providing the communication between he AUV and the Network.
- It is important to include external electronics, such as envelope detectors, attached to the AUVs to capture measurement readings. This was the main contribution to this research project

[1]Underwater Network Architecture



THEORY

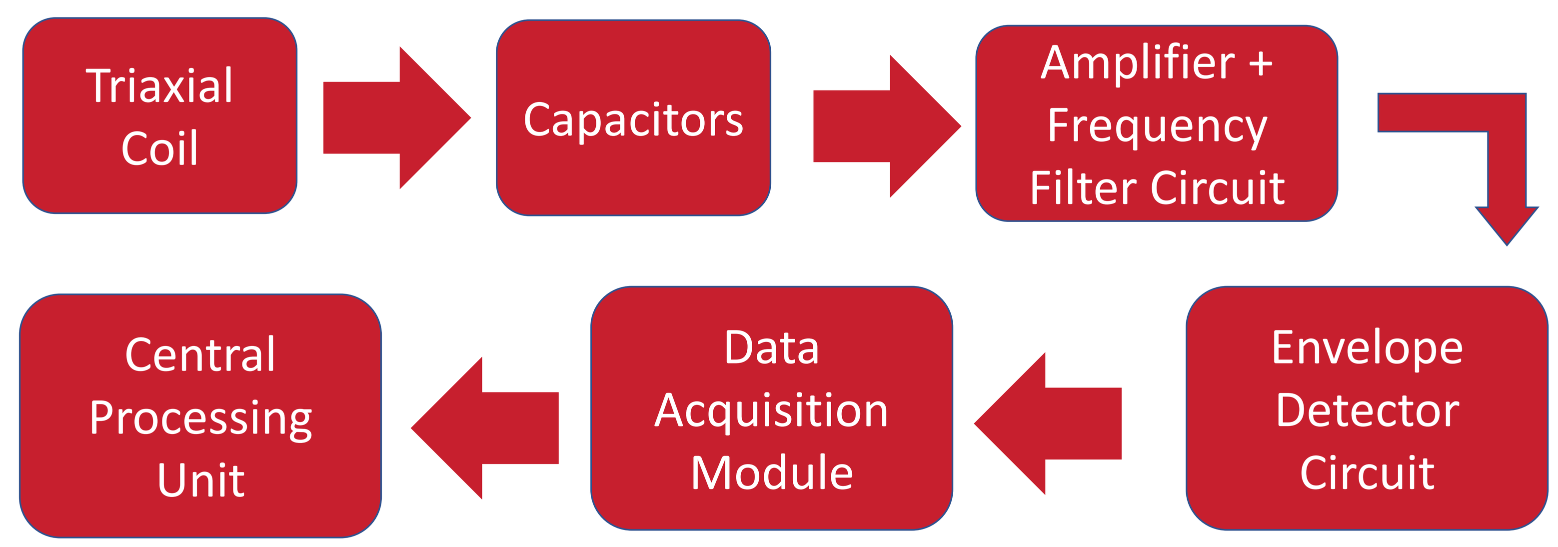
- **Localization** allows a robot to understand where it is located relative to its surroundings. In the case of this experiment the goal is to use a network of triaxial coils to collect induced voltage readings which can be broken into an XYZ position.
- The main issue with Localization is that there is an uncertainty of where the robot is based on the data coming from the sensors. This can be solved using a particle filters which uses probability to estimate where the robot is located.

Triaxial Coil

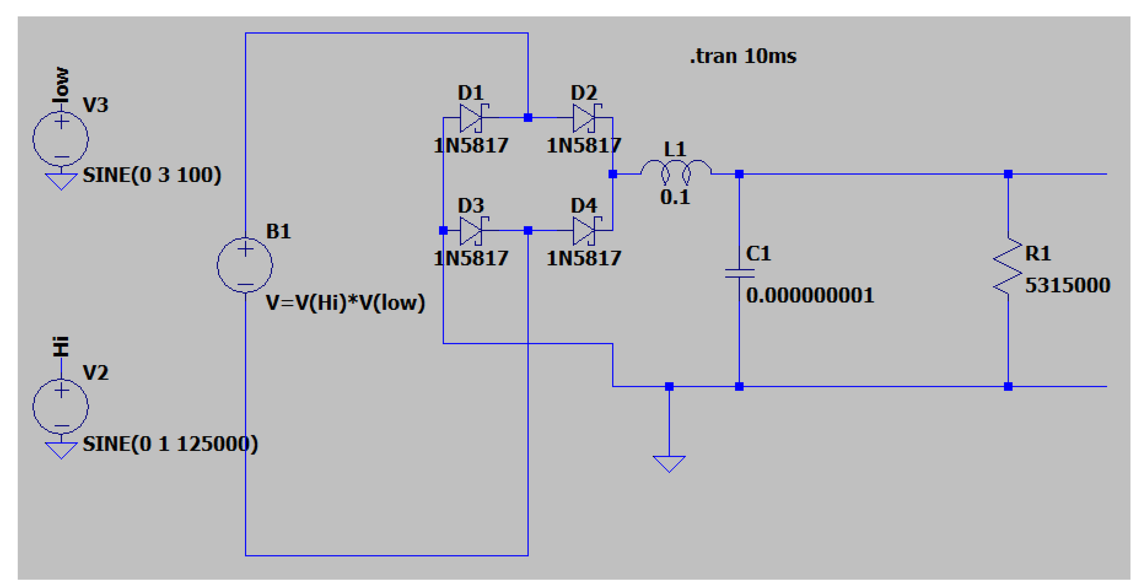
- **Magnetic Induction** is the creation of an electric current/voltage through a changing magnetic flux.
- Magnetic Induction, in theory, would reduce packet delivery error, propagation delay, increase the bandwidth of operating frequencies, reduce data transmission affected by noise, and it can operate at a higher frequency than traditional underwater communication so there is potential for a significantly higher data transfer.
- There hasn't been much development on MI in underwater applications in the past, but the research that has been done has shown to have adequate potential.

DESIGN APPROACH

Problem: How to capture and process the voltage values caused by Magnetic Induction from the Triaxial Coils



Design Approach to capture data and process data to be fed into the Network's CPU

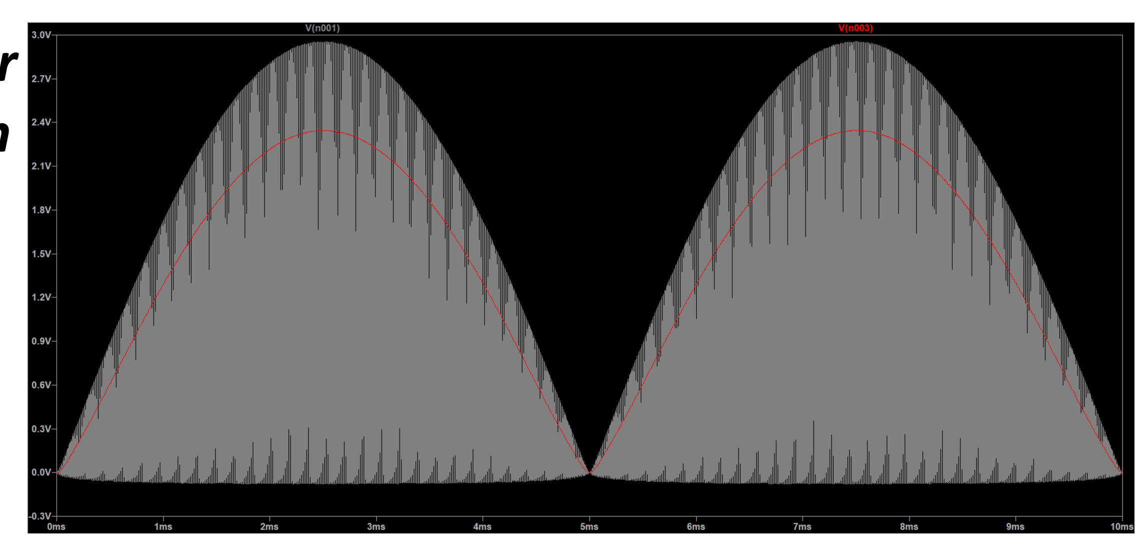


Envelope Detector Circuit

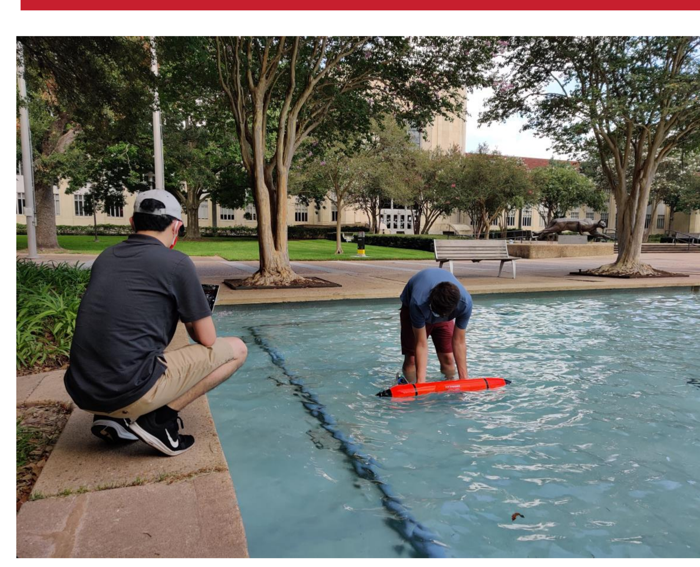
Envelope Detector Circuit Simulation Output

Input: 125kHz with varying Voltage Amplitudes from

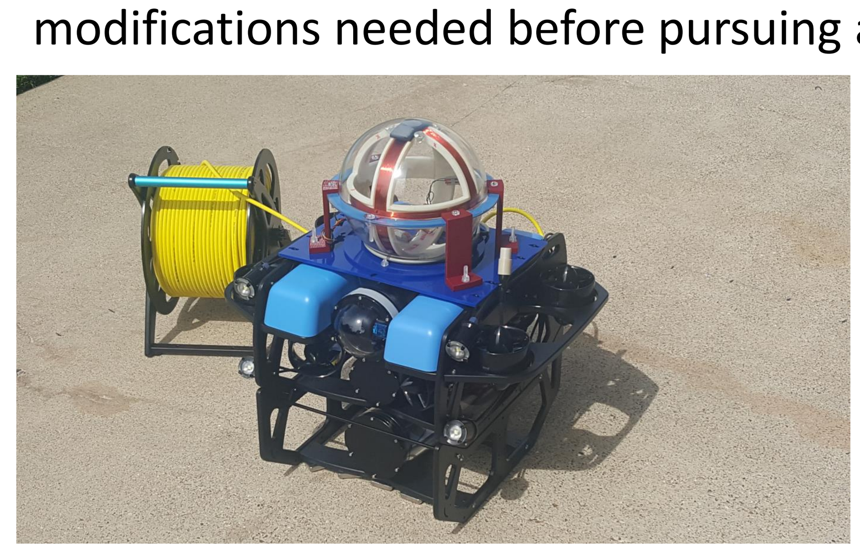
0-3 [V]



EXPERIMENTATION



The AUV was tested at the University of Houston Cullen Fountain and Reflection Pool. There were many issues that arise with the buoyancy and control system. There would need to be further modifications needed before pursuing a more advance test.



A similar design to the BlueROV with the Triaxial Coil would be applied to the Riptide ROV. This Coil would serve as the transmission MI Signal

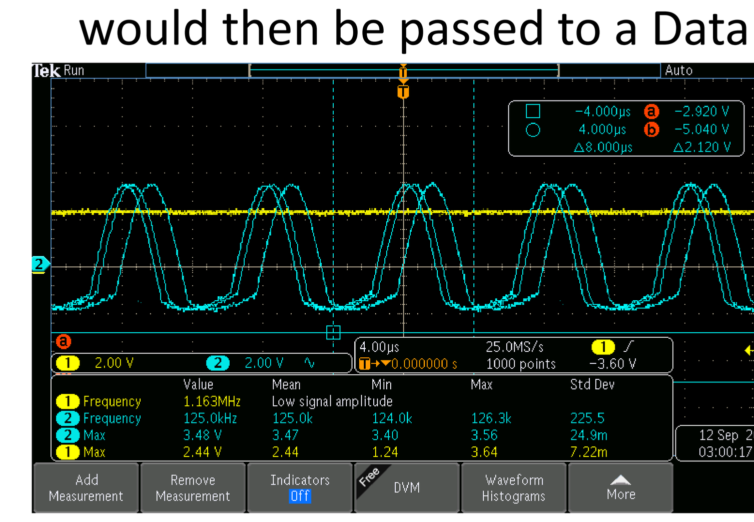
RESULTS

AUV Controls

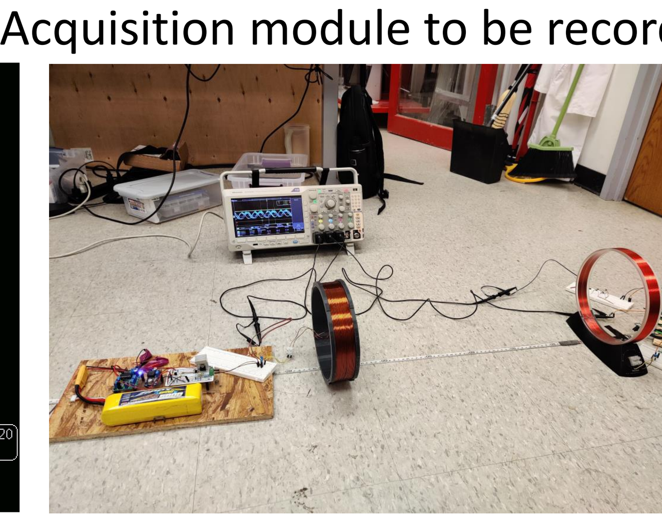
- Using the Riptide AUV resulted in many hardware and control issues. Due to the poor documentation these problems took a lot longer to solve.
- More work will be needed to get the basic AUV controls to work.

MI Communication

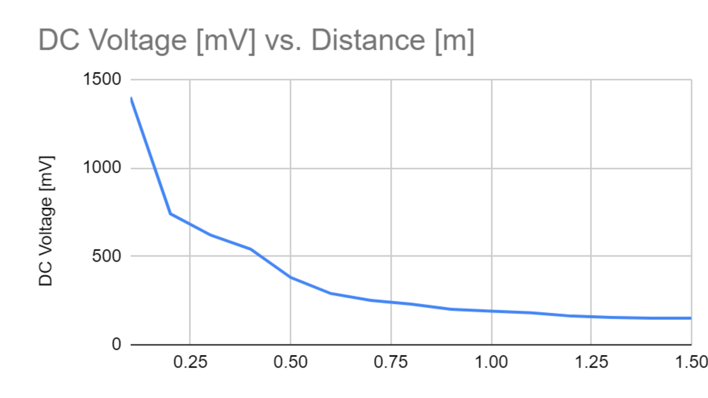
- Through alternative tests, MI communication has proven to work in underwater conditions and there is potential for improvement.
- The output of the Envelope Detector Circuit was able to capture the max voltage readings of the induced voltage (125KHz), this would then be passed to a Data Acquisition module to be recorded



Output of Envelope Detector Circuit



Envelope Detector Circuit Capturing readings from 2 copper coils



In our experiments the Envelope Detector Circuit was able to capture the values from the 2 coils at a maximum distance of 1.5 meters.

CONCLUSION

There is still a significant amount of research and improvements required in the future. However, there remains high potential for MI becoming an industry standard along side other forms of underwater communication.

<u>**Future Work**</u>

1. Designing the attachment of the Triaxial Coils on the AUV to not disrupt the weight balance and current control system.
2. Designing the electronics hub for the Data Acquisition module to be aboard the AUV
3. Testing MI applied to AUVs efficiently in alternative bodies of water, such as, salt water vs. freshwater.

RESOURCES

Acknowledgement

Dr. Miao Pan's team members and lab, Dr. Becker, Office of Undergraduate Research, Department of Electrical and Computer Engineering

Sources

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