ECE 455 Capstone Design in Electrical and Computer Engineering
Project Report

LOW-FREQUENCY ELECTROMAGNETIC EMITTING AUTONOMOUS BOAT FOR OFFSHORE PLANE RECKAGE RECOVERY

May 5, 2025

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1 Introduction

This project was developed to support the University of Wisconsin Missing in Action Recovery and Identification Project (UW MIA RIP), a program focused on locating and recovering U.S. service members who went missing during past wars. Many of these service members were lost when aircraft crashed in shallow coastal waters, especially in regions like Southeast Asia. Recovering their remains is difficult because traditional search methods are expensive and not always effective in those environments. Our team set out to design a low-cost, self-powered system that could help identify locations of underwater wreckage and assist with future recovery efforts.

The goal was to build an autonomous surface vehicle (ASV) that could generate a magnetic signal detectable by underwater equipment. This signal can help guide recovery teams to areas where aircraft debris might be buried or difficult to locate visually. We were challenged to stay within a budget of $500, use accessible materials, and build a system that could operate independently in the field.

To meet these goals, we constructed the boat using affordable components like PVC pipes for flotation, foam for stability, and a combination of wooden and polycarbonate boards for mounting electronics. A solar panel powers the system by charging two batteries, which then provide energy to the onboard electronics. These electronics include a flight controller for navigation, a Raspberry Pi for control, and a signal generator and amplifier to drive a coil that emits the magnetic field.

The boat is designed to follow GPS waypoints on its own, while also allowing manual control if needed. Electronics are enclosed in a waterproof box to keep them safe during outdoor testing. We used prebuilt circuit boards where possible to reduce development time and focus on integrating everything into a working prototype.

This report describes the design process, how the system works, and what we learned throughout the semester. We also discuss the challenges we faced and how future teams can continue building on this foundation to improve the technology and support the mission of recovering those who served.

2 Bill of Materials

Include a table with a list of all the materials. Include a description, quantity, cost/unit, total, and URL link for each item.

3 Circuit Schematics

In this section, provide detailed circuit schematics. Here is an example of how you insert a figure:

You can easily reference Fig. 1 (like that).

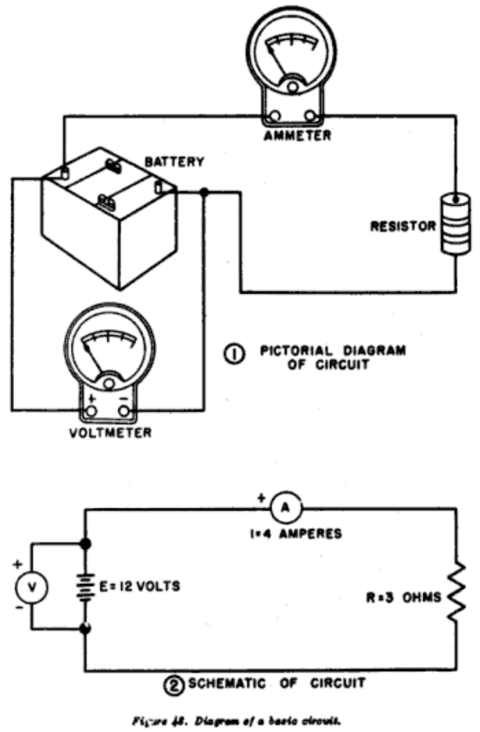

Figure 1: Caption

4 Simulation and Circuit Board Design

Include URL links to any circuit simulation or PCB design files. You can store them on a folder in OneDrive. **Please add me as an owner so I can access the files after your account closes.**

5 Hardware

The ASV's frame is built from two 4-inch diameter PVC pipes, each 28 inches long, mounted in parallel to provide flotation and structural support. A block of closed-cell foam is secured beneath the pipes to improve buoyancy and overall water stability. A 12-inch wide platform is built on top, consisting of a wooden plank for rigidity and a polycarbonate sheet for mounting structural components.

A waterproof enclosure is mounted at the center of the platform to protect onboard systems. Above it, a 100W solar panel is held in place by two custom 3D-printed vertical brackets. These mounts raise the panel above the deck to minimize shading and securely fasten it to the frame while allowing for easy removal or adjustment.

The motor is mounted at the stern using a custom 3D-printed flange that fits into a matching printed base. A rotating clamp mechanism wraps around the cylindrical motor body to hold it securely while allowing angle adjustment. A similar 3D-printed bracket is used to mount the rudder servo, ensuring proper alignment and stability during steering.

All 3D-printed parts were designed to be lightweight, modular, and compatible with the layered structure of the boat, making them easy to replace or modify in future iterations.

6 Electrical

The ASV is powered by two 12.8V 8Ah LiFePO4 batteries connected in parallel. A 100W solar panel mounted above the electronics enclosure charges the batteries directly, with a blocking diode to prevent reverse current during low-light conditions.

Power is distributed through three buck converters that step the 12.8V battery voltage down to 5V. One converter powers the Raspberry Pi, another supplies the SpeedyBee F405 V4 flight controller and GPS, and the third is dedicated to the servo motor. All components are placed inside a waterproof enclosure without mounting hardware.

The SpeedyBee F405 V4 flight controller runs iNav firmware and handles both GPS waypoint navigation and motor control. It outputs PWM signals to the brushed DC motor and rudder servo and receives location data from a GPS module. The GPS is soldered directly to UART6 on the flight controller: TX from the GPS is connected to RX6, and RX from the GPS is connected to TX6.

A FlySky FS-iA6B receiver is soldered directly to the RX2 pad on the flight controller for SBUS communication, enabling manual RC override when needed.

To generate a magnetic field, a 40 Hz sine wave is created by a prebuilt signal generator and passed through a power amplifier. The amplified signal drives a large copper coil wrapped around the boat's structure, producing a low-frequency magnetic field detectable by submerged sensors.

All electrical connections are made using soldered wires. Power and signal lines are routed manually inside the enclosure. Signal and high-current paths are physically separated to minimize noise. Fuses are installed on the battery output lines to protect critical components from short circuits.

The electrical system is simple, modular, and designed for ease of repair and future upgrades. Components can be swapped or rewired without requiring full system disassembly.

7 Coding

In this section, please provide links to your code or directly pasted in the report. You can create subsections in LaTeX like this:

7.1 Ultrasonic Sensor Code

7.2 Motor Code

Please write a paragraph summarizing the operation of the code. You should cite any references or resources that you used to make the code. You can conveniently cite sources like this: [1] and [2]. LaTeX is really nice for writing out equations too:

$$V = \oint \overrightarrow{E} \cdot d\overrightarrow{l} \tag{1}$$

You can use this tool to help: https://webdemo.myscript.com/. Also this: https://mathpix.com/image-to-latex. You can also easily refer to equations like this: 1.

8 Operating Instructions

In this section, please provide detailed, step by step instructions on how to operate your project (what buttons you have to push, different display readings, etc).

9 Troubleshooting

If your device is not fully working, describe exactly what is not working and the steps you have taken to fix it. If you are still unsure of the problem, carefully describe your next steps you would take if you had time.

10 Testing and Experiments

Here you can talk about your experimental results and include plots of any relevant data. The plots should be of professional quality. Use Python, MATLAB, or OriginLab. Excel in the engineering world is not professional.

11 Future Work

In this section, please discuss future work that needs to be completed.

References

[1] M. Manteghi, "A navigation and positioning system for unmanned underwater vehicles based on a mechanical antenna," 2017, pp. 1997–1998.

[2] A. Sheinker, B. Ginzburg, N. Salomonski, L. Frumkis, and B. Z. Kaplan, “Localization in 3-d using beacons of low frequency magnetic field,” *IEEE Transactions on Instrumentation and Measurement*, vol. 62, pp. 3194–3201, 2013.