ANCHORFISH: Wave Energy Converter–Powered Charging and Data Transmission Station for Bio-Realistic Autonomous Underwater Vehicles (AUVs)

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Introduction

The Marine Energy Collegiate Competition is an annual event that challenges college students to address a problem in the Marine Energy Industry.

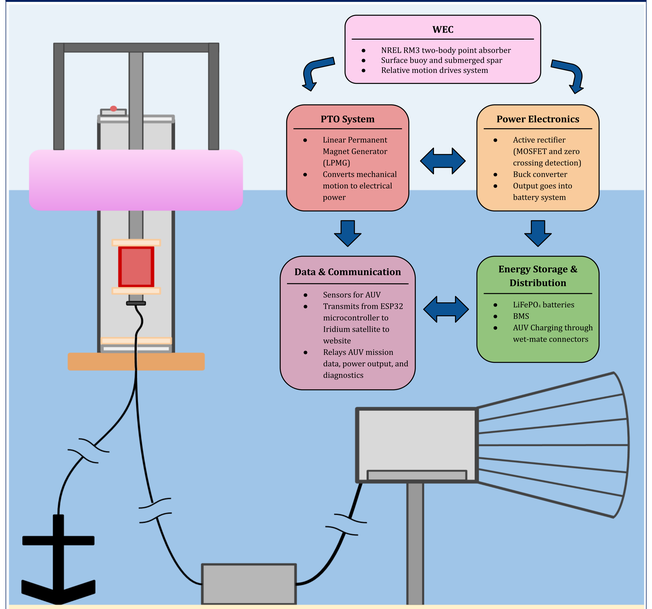
The Problem:

Bio-realistic Underwater Autonomous Vehicles (bio-AUVs)
- Research on marine life out in the sea or in aquaculture farms.
- Look like fish to get up-close info without alarming marine life
- Relatively small AUVs

Problems with Bio-AUVs:
- Battery life and mission length
- Tether connection for data transmission
- Must be manually brought to shore to charge/collect data

Solutions ANCHORFISH Provides:
- A station with a net for docking and charging in the ocean
- Renewable energy provided by wave-energy-converter (WEC)
- Data transmission from the station to a location on shore

Design Components



Point Absorber WEC: Includes PTO system, ESP32 transponder, buoy, heavy plate, and the BMS

UAV Docking Station: Contains a battery array and wet-mate charging system

Power Electronics: Has an active MOSFET-based rectification with a buck converter.

References/Acknowledgements

Figure 2: Neary et. Al, (2014). Methodology for Design and Economic Analysis of Marine Energy Conversion (MEC) Technologies. *Sandia National Laboratories*.

We acknowledge the support and guidance of our advisors Professor Arezoo Hasankhani and Julie Paprocki. And also, that of Pablo Matamala Cavajal, Roozbeh Ghasemi, and Landon Hartline as our student mentors

Technical Design

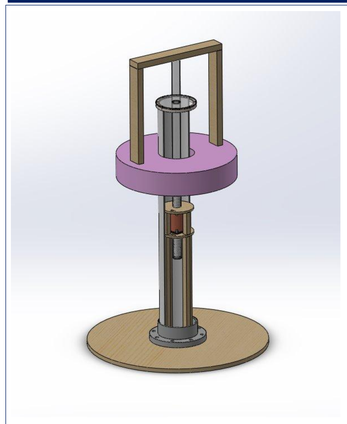


Figure 1: Solidworks Model of WEC system

Wave Energy Converter (WEC):

Scaled Model Overview:
- 1:27.4 scale Wave Energy Converter system based on the large-scale Reference Model 3 (RM3) point-absorber WEC concept
- Comprised of spar, heave plate, buoy, internal frame, and power take-off (PTO) components

Materials:
- Spar Pipe - 8" schedule 40 PVC pipe
- Heave Plate - 23/32" yellow pine plywood
- Buoy - 3" XPS R-15 foam board, 40mm x 40mm T-slotted hollow rail
- Power Take Off System – 10A max air coil solenoid, 1.5" N52 Neodymium disc magnets (80lb pull force), 2" clear scratch resistant acrylic round tube

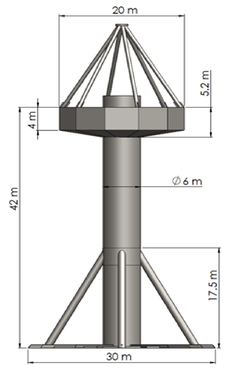


Figure 2: RM3 Concept used to determine scaling factor

Power Take Off:

- Linear permanent magnet generator (LPMG) design chosen
- 18 x 80lb pull neodymium magnets arranged by opposing pole in a central driveshaft

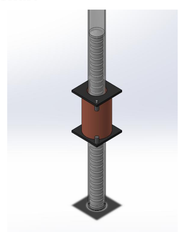


Figure 3: Solidworks model of Power Take off (PTO) System

Data Transmission:

- Data is transmitted via an RFM95W LoRa radio module connected to an ESP32 microcontroller
- Enables real-time reporting of mission data, diagnostics, and environmental conditions

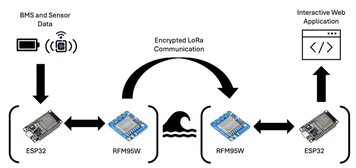


Figure 4: Long Range (LoRa) telemetry schematic

Power Electronics:

- Power conditioned using MOSFET-based rectification with zero-crossing detection
- Regulated through a buck-boost converter
- Energy is stored in lithium iron phosphate batteries managed by a 12C 3.7V Li Battery Management System (BMS)
- AUV Docking Station recharges using wet-mate connectors and passive guided entry.

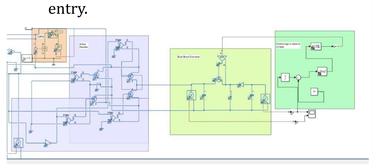


Figure 5:Power electronics system

Build and Test

Figure 6: Testing of the Power Take Off System

Testing Location & Environment
- University of New Hampshire Chase Ocean Engineering Wave/Tow Tank
- Simulates open-water conditions and wave heights similar to Gulf of Maine offshore aquaculture farms

Testing Objectives
- Evaluate PTO system performance
- Measure generated power output
- Withstand anticipated environmental conditions

Performance Validation
- Use measured power to assess full-scale system feasibility
- Determine the ability to:
  - Support data transmission
  - Communicate with AUV fleet
  - Implement underwater docking/charging station

Figure 7: Assembly of Spar and Internal Frame

Community Connections

For the Community Connections Challenge, the ANCHORFISH team focused on inspiring the youth to pursue careers in marine/sustainable energy through outreach to local schools.

Figure 8 depicts ANCHORFISH team member Vincent (left), helping Dr. Wosnik (right), a professor of Ocean Engineering at UNH, with his display at Ocean Discovery Day.

Figure 8: Ocean Discovery Day

Business Plan

ANCHORFISH's business plan targets organizations within the blue economy that use AUVs for ocean data collection and offshore operations. Through outreach, the team identified a clear need for reliable offshore power and data transmission. Early feedback from an Ocean Technology Manager within the US Integrated Ocean Observing System (IOOS) supports this, noting that "wave-powered AUV docking and charging systems are highly valuable for ocean observing operations and align well with current developments in the field."

Results

WEC-SIM:

This graph shows the absorbed power, which is the mechanical power related to the waves compared to the electrical power output of the PTO system overtime. This highlights how much energy is being converted and used.

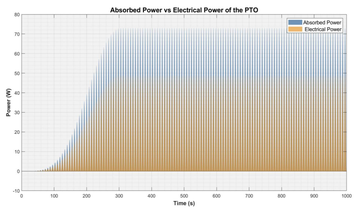


Figure 9: Results from WEC-Sim simulation

Life Cycle Assessment: Evaluates the potential environmental impacts associated with the proposed wave-powered charging station for AUVs. This assessment is intended to identify the major material and component contributors to environmental impact during the design stage and to support comparison of design choices for a more sustainable system.

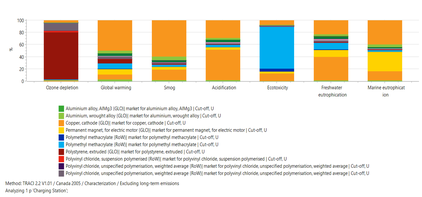


Figure 10: Life Cycle Assessment (LCA) of the ANCHORFISH project