Wave Energy Conversion Buoy

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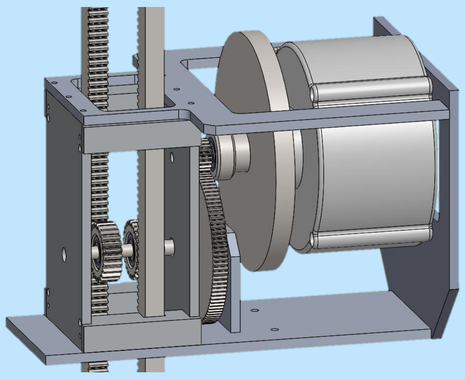
Introduction: The Wave Energy Conversion Buoy (WECB) is a point absorber wave energy device that converts energy from ocean waves to electrical power. The device takes the relative motion between two buoys (the spar and the float) to drive a rack and pinion gear system which in turn spins a generator. The ultimate goal of this ongoing UNH research project is to help supply electricity to the facilities on Appledore Island. This was a continuation of last years efforts, which had produced a prototype. Testing was done so that the components of the WECB could be analyzed and redesigned. Improvements were made to the design of the Power Take-Off, follower buoy, spar, and electronics in order to maximize the energy that will be captured from the waves. Higher quality components were used as well as more precise machining. The final design is measured at 30 feet in length and at roughly 300 pounds.

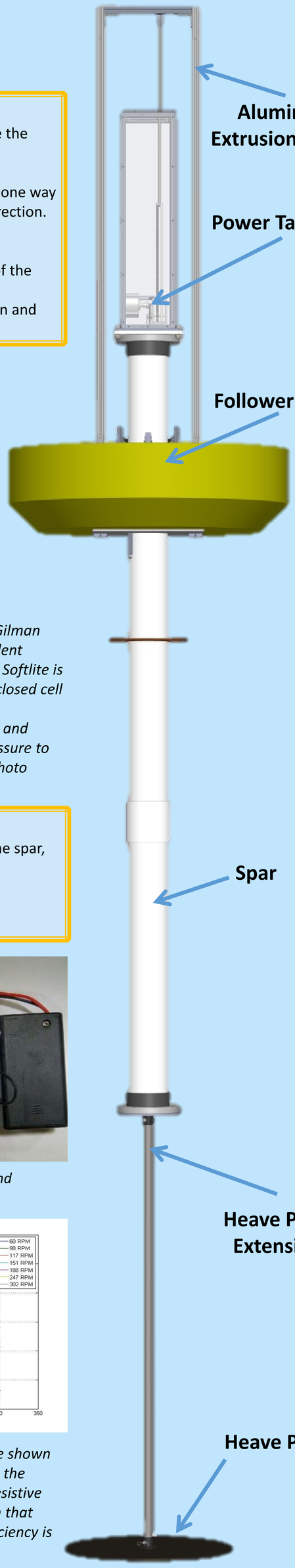
Design



Power Take Off:

The Power Take-Off (PTO) unit is designed to translate the linear motion between the follower buoy and spar to rotational motion to turn the shaft of the generator.

- Dual Rack and Pinion system incorporates two one way bearings to maintain a consistent rotational direction.
- Reduced friction by eliminating unnecessary components and rearranging system
- Flywheel stores rotational inertia at the peak of the wave
- Waterproof PTO housing with rigid construction and clear siding



Follower Buoy:

- Oscillates in response to the passing waves
- Optimized to have a smaller natural period in order to be more responsive to passing waves
- Larger water plane area and decreased mass increases dynamic response
- The hydrodynamic characteristics of the 2013/14 team's float were analyzed using a high speed camera and OPIE software
- A 1/10th scale model of the final design was used to prove that the buoy responsiveness was dependent on the mass and water plane area
- Constructed with 4.5lb/ft density Softlite Ionomer foam by the Gilman Corporation for optimal for durability , performance, and buoyancy

The float was manufactured from Softlite by the Gilman Corporation. The ionomer properties render excellent performance when the resin is extruded as foam. Softlite is the toughest, most durable, flexible, low density, closed cell structure foam on the market. It is extruded as a continuous sheet and is spirally wound using heat and pressure. The outside is densified by heat and pressure to form a strong, abrasion resistant outer coating. Photo courtesy of the Gilman Corporation

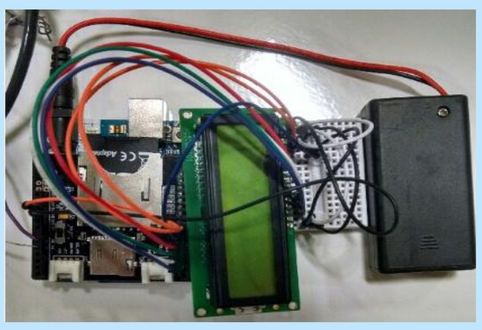
Left: OPIE test of the 2013/14 prototype

Spar and Heave Plate:

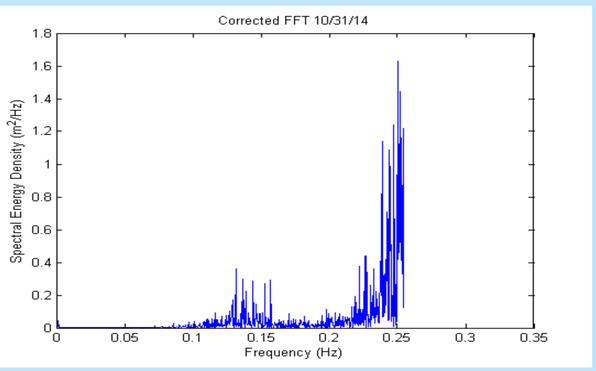
- Hydrostatic analysis was used to maintain equilibrium of the spar, with the improved stroke length
  - The spar was lengthened by 5 feet
- Designed for minimal dynamic response
- Heave plate reduces vertical motion of the spar

Electronics:

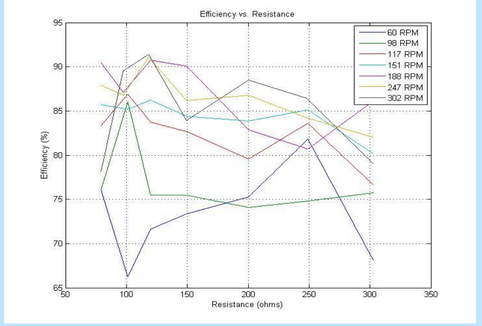
- 300 Watt, 3-phase AC generator passed through a DC rectifier circuit
- Wave characteristics measured with underwater pressure sensor on site
  - Data analyzed using fast Fourier transform
  - Dominant wave period determined to be 4 seconds
- Remote live feed of buoy statistics using cellular connection
  - Voltage
  - Relative Displacement of Buoy and Spar



Electronic hardware used to record and transmit buoy statistics



Corrected fast Fourier transform of pressure sensor data demonstrating a dominate wave period of 4 seconds

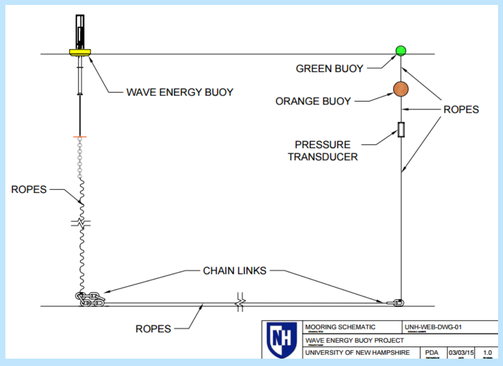


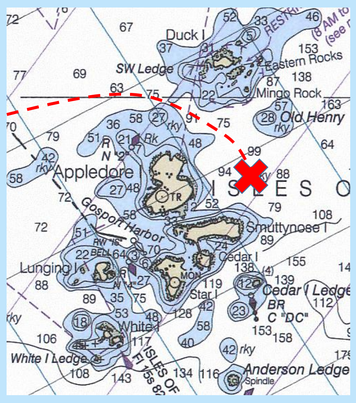
The efficiencies for the generator are shown above. The input rotational speed to the generator is varied along with the resistive load on the generator. It can be seen that between 100 and 120 ohms, the efficiency is the highest

Testing

Deployment:

- Field testing was done on the previous WECB at the Isle of Shoals test site on October 31, 2014 on the UNH research vessel, The Gulf Challenger
- Step by step procedure was developed for transportation and loading
- Field testing of our buoy was done on April 16, 2015





Above: Destination for deployment at the Isle of Shoals Detail from NOAA chart 13278, 25th edition, December 2000.

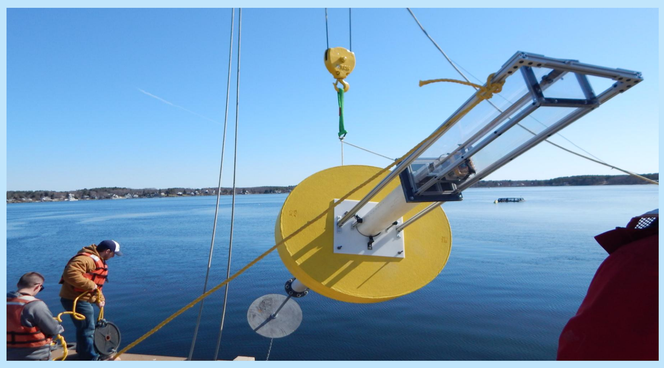
Left: Mooring schematic for buoy deployment

Bottom: Buoy deployed on April 16, 2015

Results:

- The buoy, with a 5 foot radius and 18 inch height has a theoretical period of 0.28 seconds and is designed to be responsive to local waves at the Isle of Shoals
- Friction reduced in the PTO by utilizing higher quality parts, more precise machining and elimination of unnecessary components
- Stroke length increased to 38 inches to harvest maximum power from a wave
- Electronics added to monitor and record measurable buoy statistics
- Mooring system designed and implemented
- Awaiting second deployment to determine water to wire efficiency

Left: Buoy being towed by the UNH research vessel, The Cocheco. The buoy was towed instead of carried on board because of it's increased size. It was towed to an area where the depth and wave characteristics were comparable to the isle of shoals.



Left: Buoy being lowered in to the water by a crane at the UNH pier in Newcastle, NH

Conclusion: The Wave Energy Conversion Buoy team has constructed a functional and improved point absorber buoy. The buoy generates power by using the relative motion between two buoys (the middle spar buoy and the follower buoy) to drive a dual rack and pinion gear system, that in turn spins a generator. The 2013/14 buoy was initially deployed in order to evaluate the performance. Considerable improvements were made to the design of the PTO, the follower buoy, spar, and electrical components. The intent of the project was to demonstrate wave energy as a viable source of renewable energy for powering the Shoals Marine Laboratory located at the Isle of Shoals.

Acknowledgements:

Buoy manufactured by Gilman Corporation, Gilman CT • Sea Grant New Hampshire • UNH Mechanical Engineering Department • UNH Ocean Engineering Department • Matt Rowell • Prof. Carlos Andre Dias Bezerra