Development and Analysis of a Representative Buoyancy Controlled Ocean Current Turbine

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Energy dense ocean currents represent an untapped renewable energy resource with the potential to power multiple coastal communities [1]. The Gulf Stream is possibly the most energy dense of these currents, with mean power densities exceeding 3.0 kW/m^2 [2]. Fluctuations in the location and intensity of the Gulf Stream create relatively large velocity variations at potential Ocean Current Turbine (OCT) deployment locations. A measurement of the Gulf Stream current has shown that in this region flow speeds can reach as low as 0.0-0.6 m/s and up to 2.5-3.0 m/s depending on location [3]. This variation in flow speed causes a large variation in the drag force on the system, and thus the operating depth of the OCT if operating elevation is not controlled. The Gulf Stream also has direction variations with standard deviations of 5-10° [3], which complicates multi-point mooring system design. A representative single-point moored OCT was designed to better understanding its dynamics, as well as provide a working model control system development and testing. Analysis of this single-point moored turbine shows that is has an inherent resulting pitch angle that is a function of flow speed. Since hydrokinetic turbines must have a near zero-pitch angle to achieve peak efficiency it is important minimize this resulting angle. Therefore, a movable buoyancy design was included in this system. For simplicity, the movable buoyancy system is comprised of a series of ballast tanks, housed within the main buoyancy tanks, between which water is transferred. These buoyancy tanks allow the center of gravity to be adjusted fore and aft within the turbine. A closed-looped pitch control algorithm has been designed to control the flow of water, and evaluated using ProteusDS. This pitch controller enables the turbine to remain in the optimum position and orientation throughout a wide range of operating conditions.

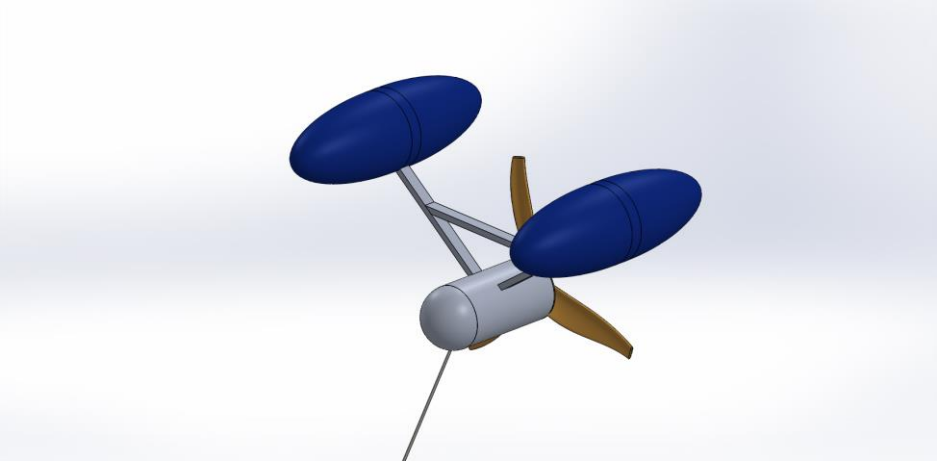

Figure 1: Modeled Buoyancy Controlled Ocean Current Turbine

ACKNOWLEDGEMENTS

This material is based upon work supported by the National Science Foundation under Grant No. ECCS-1307889.

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