Investigation of the Power Generated by a Disk Buoy-WEC Design

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INTRODUCTION

Moored oceanographic buoys are deployed to selected offshore locations in order to provide near-continuous measurement of data, such as variations of wind velocity, air and sea surface temperature, salinity, and air pressure. These data are initially stored onboard the buoy for later transmission at regular intervals to nearby oceanographic vessels or orbiting satellites for relay to specific sites for analysis, interpretation, and archiving for future analysis. Scientists utilize these field data to investigate both local and larger-scale changes in climate patterns and changes in the environment. Onboard batteries and solar panels are designed to provide power for onboard instrumentation and beacons. The specific offshore location where these buoys are located influences their response behavior. Onsite maintenance of buoys is expensive and is often necessitated by instrumentation failure, battery replacement, storm damage or vandalism. The National Data Buoy Center (NDBC) maintains several hundred moored buoys located off the coast of the United States and at other strategic remote locations. One example of reported vandalism involving the theft of solar panels from a Weather and Ocean Platform buoy operated by the NDBC was reported by Teng et al. (2009), and it illustrates the seriousness of this problem. As part of their strategy to enhance the buoy science missions while addressing the human interference with their moored buoys, the NDBC is developing an onboard BuoyCAM system (O’Neill et al., 2015; Black and Stewart, 2016). The BuoyCAM system is designed to capture a real-time panoramic view of the onsite environment, which is of primary interest to scientists, while at the same time providing a means to observe nearby shipping or other human activities.

The size and configuration of oceanographic buoy designs reflect their intended mission, the sea conditions at the anticipated deployment site, and installation and recovery methods. Disk buoy designs are quite popular because of their functionality, hull waterplane symmetry, design scalability, and ease of deployment and recovery. The waterplane diameters of disk buoy designs can vary from a few meters to up to 12 meters (Berteaux, 1991). In particular, the National Data Buoy Center of the National Oceanic and Atmospheric Administration (NOAA) operates many three-meter disk buoys (Timpe and Teng, 1992). The average power consumption of a range of disk buoy sizes and configurations was surveyed to establish the typical range of power that would need to be generated. Because the power consumption is dependent on the mission of the oceanographic buoy, this led to a fairly broad range of power requirements. The actual power consumption is also highly dependent on the weather, climate at the deployment site, and mission. For example, on a cloudy day, the transmission of data from the buoy via satellite to a target site turns out to be a critical scenario in terms of both time and power consumption. From a combination of open source equipment specifications and personal communications with the buoy operators (Lee, 2014), it was concluded that a reasonable estimate of the average power consumption is in the range of 0.1 to 6.0 W.

A review of wave energy conversion (WEC) concepts that had the potential to generate adequate power levels and could be incorporated into the design of a disc buoy was performed. Additional factors taken into consideration included mechanism simplicity, reliability, and maintenance. An encased modified SEAREV WEC device that converts the rocking motion of the buoy was selected for further study (Babarit, 2005; Babarit et al., 2006). A four-meter disk buoy was selected for this study to accommodate the possible size of the power take-off (PTO) system needed to generate enough electrical power. The PTO concept and its mooring system are presented in Fig. 1.