Wave Energy Testing Using the Ocean Sentinel Instrumentation Buoy

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Abstract

The Ocean Sentinel instrumentation buoy was developed by the Northwest National Marine Renewable Energy Center (NNMREC) in collaboration with AXYS Technologies for the testing of wave energy converters (WECs). NNMREC is a Department of Energy sponsored partnership between Oregon State University (OSU), the University of Washington (UW), and the National Renewable Energy Laboratory (NREL). The Ocean Sentinel instrumentation buoy is a surface buoy based on the 6-meter NOMAD (Navy Oceanographic Meteorological Automatic Device) design, and provides power analysis and data acquisition, environmental monitoring, as well as an active converter interface to control power dissipation to an on-board electrical load. The Ocean Sentinel was deployed for the first time in August 2012 for the testing of a half-scale WEC, the WET-NZ device, which is the acronym for "Wave Energy Technology-New Zealand". The WEC and the Ocean Sentinel were moored at NNMREC's open-ocean test site north of Newport, OR for a six week period while the testing was performed. This paper presents the Ocean Sentinel instrumentation buoy platform, deployment, testing and data analysis.

Introduction

Ocean wave energy is an area of increased interest, with a number of wave energy converter (WEC) prototypes being developed around the world. Ocean testing facilities are essential to enable wave energy developers to demonstrate performance and survivability, and to optimize devices. Currently, the U.S. marine energy industry is challenged by the lack of proper and standardized infrastructure to deploy and test devices in the marine environment. In addition, many WEC technologies are ready for field trials, but are not sufficiently mature to be connected to the electrical grid for commercial power production. This paper presents the Ocean Sentinel instrumentation buoy solution that has been developed by the Northwest National Marine Renewable Energy Center (NNMREC) in collaboration with AXYS Technologies for the non-grid-connected testing of WECs. The Ocean Sentinel was completed in 2012, and was deployed for the testing of a WEC at the NNMREC open-ocean test site north of Newport, OR for a six week period during August - October of 2012.

The Ocean Sentinel Instrumentation Buoy

A novel Ocean Sentinel instrumentation buoy has been developed by NNMREC and AXYS Technologies for WEC testing. A concept diagram of the Ocean Sentinel testing a WEC is shown in Figure 1, with the deployed Ocean Sentinel shown on station in Figure 2. The Ocean Sentinel is a surface buoy, based on the 6-meter NOMAD (Navy Oceanographic Meteorological Automatic Device) buoy design. This instrumentation buoy facilitates open-ocean, stand-alone testing of WECs with average power outputs of up to 100 kW. Deployment is typically at a NNMREC test site that is approximately 2.5 nautical miles offshore from Yaquina Head, north of Newport, Oregon.

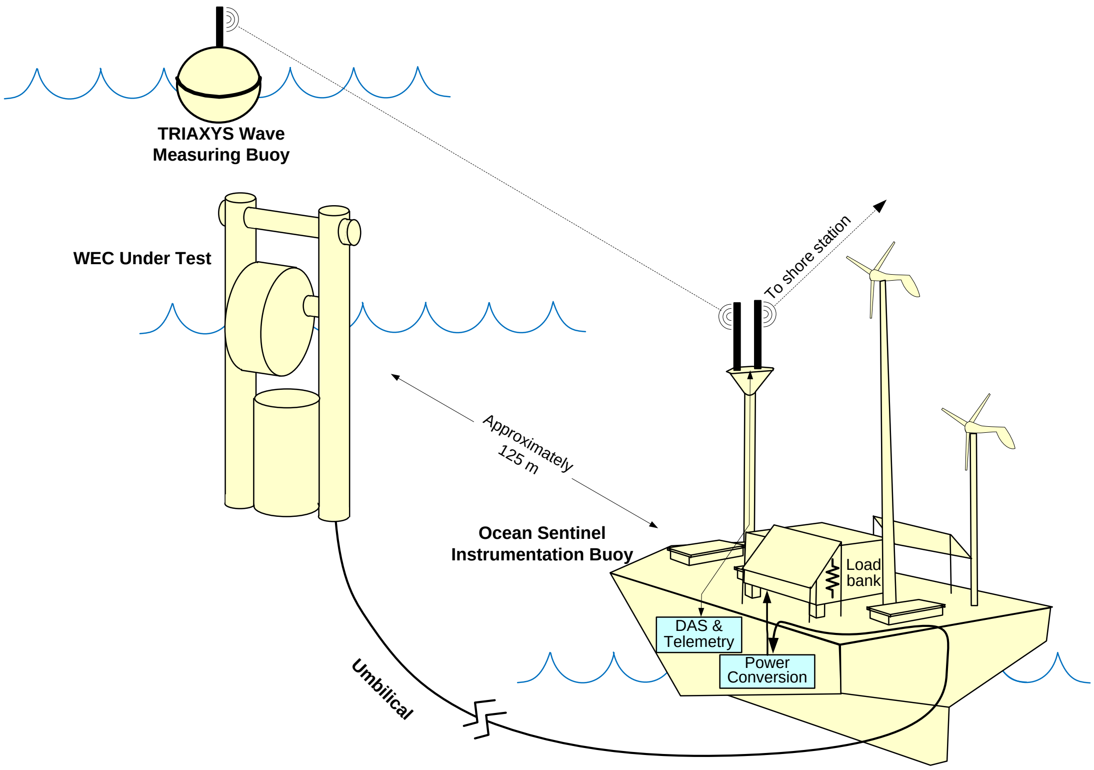

Figure 1. WEC Testing with the Ocean Sentinel instrumentation buoy

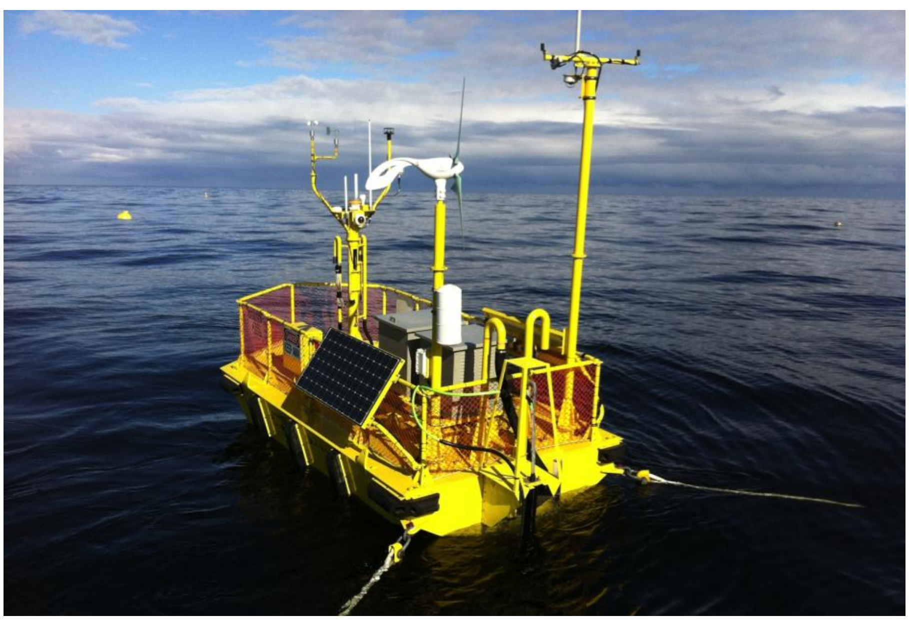

Figure 2. Ocean Sentinel instrumentation buoy on station

WECs under test are moored approximately 125 meters from the instrumentation buoy and connected by an umbilical cable. Power generated by the WEC is controlled by switchgear and power conversion equipment located on-board the instrumentation buoy and dissipated in an on-board load bank. Wave data recorded by a wave measuring buoy is also transmitted to the Ocean Sentinel, via wireless telemetry.

The primary functions of the Ocean Sentinel instrumentation buoy are as follows:

1. Provide stand-alone electrical loading and power conversion for the WEC under test.
2. Measure and record WEC power output.
3. Collect and store data transmitted from the TRIAXYS wave measuring buoy moored nearby.
4. Transmit collected data to a shore station via a wireless telemetry system.
5. Conduct environmental monitoring.

The Ocean Sentinel power conversion and load bank system provides a stand-alone load for the WEC under test. This system provides generator control for WECs in early stages of development that do not include onboard generator power conversion. A switchgear enclosure that includes the contactors along with an electrical disconnect, current and voltage sensors, and fuses is installed below deck in the forward compartment of the Ocean Sentinel, together with the power converter. Two 50 kW, air-cooled load banks are installed above deck. This system is controlled by a National Instruments CompactRIO based data acquisition system developed by NNMREC, which is also used to record WEC power and measured wave data.

Because NNMREC anticipates testing WECs with different power outputs and generator configurations, the Ocean Sentinel loading system has been designed for a high degree of flexibility and is reconfigurable via terminations in the switchgear enclosure. The air cooled load bank can be reconnected for different voltage and power levels, and can be controlled by either contactor switching, converter control, or a combination of the two. WECs with output current to 125 A continuous can be accommodated, for a power capability of 100 kW at 460 V or 50 kW at 230 V.

An on-board power system developed by AXYS Technologies can supply up to 400W of 24 Vdc and 120 Vac power to the instrumentation and power conversion equipment installed on the Ocean Sentinel, and to the WEC via the umbilical. Primary power is provided by 40x sealed lead acid batteries (2000 Amp-hours at 24V), which are maintained through the use of a 1 kW wind generator, 2x 210 W solar panels and a 3.2 kW standby diesel generator. The system can provide 400 W throughout a 3 month deployment period without refueling. This power system is controlled and monitored by a Watchman 500 data acquisition and control system.

Two independent cellular telemetry systems are used between the Ocean Sentinel and shore, one for the Watchman 500 that controls and monitors the power system, and the other for the CompactRIO system that provides control and data acquisition for WEC testing.

Deployment of the Ocean Sentinel Instrumentation Buoy

The Ocean Sentinel was deployed for the first time in August 2012 for the testing of a half-scale WEC, the WET-NZ device, which is the acronym for “Wave Energy Technology-New Zealand”. The Ocean Sentinel and WEC were moored at NNMREC’s open-ocean test site north of Newport, OR for a six week period while the testing was performed. The WET-NZ device, shown in Figure 3, is a self reacting WEC that generates power through the rotation of an active float relative to a large submerged spar. The Ocean Sentinel power converter was used to control the electrical generator on board the WET-NZ device via the umbilical cable throughout these tests. This allowed WEC performance to be characterized while operating in several different control regimes and under a variety of sea conditions. The final paper will detail the deployment, testing and data analysis process.

Figure 3. Deployment of the umbilical cable connecting the WET-NZ device under test to the Ocean Sentinel at NNMREC's open-ocean test site north of Newport, OR.

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