Wave Energy Conversion Systems Designed for Sensor Buoys

By Jeannette Gouin
Electro Standards Laboratories
36 Western Industrial Drive
Cranston, RI 02921

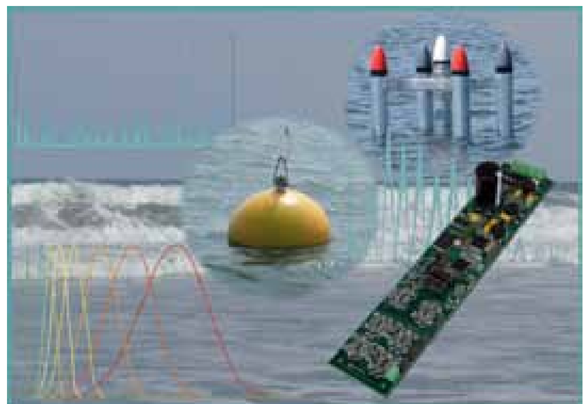
Telephone: 1-401-943-1164
Fax: 1-401-946-5790
E-mail: eslab@electrostandards.com
Web: www.ElectroStandards.com

Introduction

The ocean is in constant motion and the effects of sea states are enormous. Ocean energy has a profound impact on the development of storm systems; shipping safety and shipping routes; recreational boating, surfing and swimming; and fishing and other methods of obtaining seafood. Wind-driven currents on the ocean surface extrapolate down into the ocean depths. Data from Sensor Buoys can provide critical information regarding ocean properties such as: color, sea height, temperature, currents, and pollution.

Power Problem

Existing power systems for remote sensor buoys and other remote ocean platforms often include solar panels and batteries. These systems would benefit from major improvement or replacement. Problems include: poor performance in cold and/or dark latitudes, insufficient power to operate the latest electronic equipment, high maintenance costs, high replacement costs, loss due to theft and vandalism, and battery disposal. Power harvesting from ambient ocean wave energy is a natural option to augment or replace any of these electrical-power-providing systems.



Electro Standards Laboratories

Research Participants

Electro Standards Laboratories (ESL), an engineering and manufacturing company located in Cranston, RI, is working on solving the issues of powering sensor buoys. The company is a manufacturer of data communication products and data acquisition products as well as an R&D consulting company with a specialty in motor control and power systems. This combination of skills enables the company to readily bring together its experience in data communications, data acquisition and its extensive R&D expertise in motor control and power systems to forward the technology of self-powered sensor buoys. The company's close proximity to the ocean, Narragansett Bay in particular, gives it the added advantage of being able to test its systems to power sensor buoys locally.

The company's ocean wave energy harvesting systems capabilities are further enhanced by its partnership with the University of Rhode Island (URI). URI's Graduate School of Oceanography is recognized worldwide in the development of ocean science. Their interests include marine geology and geophysics, biology, atmospheric and ocean chemistry and physics. The University is situated on the shores of Narragansett Bay, a natural laboratory for their studies.

The scientists at ESL and in the Ocean Engineering Department at URI have combined expertise in marine hydrodynamics, electrical generators, advanced controls and dynamics. This team has worked collaboratively to improve the design and performance of wave energy harvesting devices.

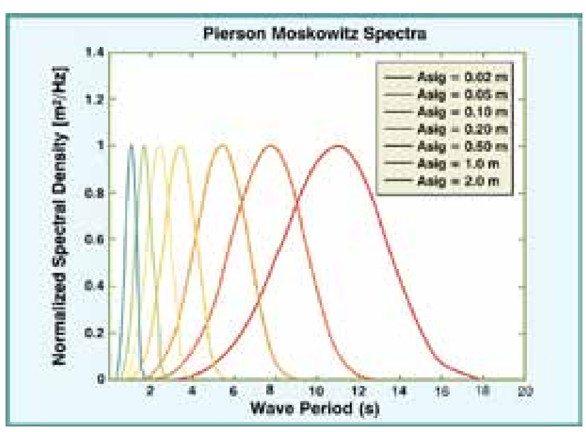
Ocean Wave Energy Harvesting Systems

Ocean wave energy harvesting systems designed for sensor buoys convert wave motion into electricity to allow operation under all weather conditions. These new systems will enable enhanced functionality, higher performance and continuous operation. Such systems generate and accumulate energy that can be used to indefinitely power remote buoys equipped with sensor arrays as well as electronics for processing and communications. These power sources can be integrated with buoy systems to minimize the size of batteries, or to eliminate the need for batteries if super-capacitors are used. The goal is to store accumulated energy and form a completely self-contained, persistent, energy source platform suitable for a variety of sensor payloads.

Obviously there are many challenges. The systems need to provide automatic wave energy harvesting and work with both drifting and moored buoys. The systems need to function at a low acoustic noise level and provide stealthy acoustic and visual operation plus a wide band response to the wave period. The elimination of batteries is the ultimate goal along with enhanced functionality, higher performance and continuous operation.

Research Sponsors

There are numerous organizations interested in this technology. Some of the organizations that have provided funding to ESL include: the Office of Naval Research, the Space and Naval Warfare Systems Command, and a Rhode Island Collaborative Research Grant from the Rhode Island Science and Technology Council. Projects investigated by the company include the development of a small spar buoy, a direct drive system and a resonant drive system.



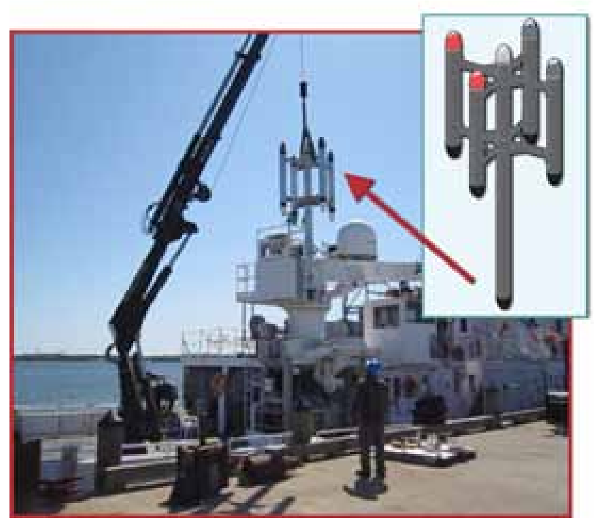
Small Spar Buoy

This project was to devise a means of energy harvesting for a small diameter buoy free floating on the ocean surface. The buoy would contain an antenna on the upper portion and electronics for remote communications and sensing. The design would ensure that the buoy produce enough energy so that more than 4 milliwatts of power would be available at an instance. The required battery storage capacity would be at least 60 joules. Energy storage could include the use of a rechargeable battery. The ESL-URI team greatly extended both design concepts and theoretical analyses typically proposed for such systems and performed detailed numerical modeling that featured a wave-to-wire model of the power generation system in ocean sea states. For more details, review a report entitled Ocean Wave Energy Harvesting Buoy for Sensors by Steven P. Bastien and Raymond B. Sepe, Jr., of ESL and Annette R. Grilli, Stephan T. Grilli and Malcolm L. Spaulding of URI.

Direct Drive System

The Direct Drive System developed by ESL and URI employs small electric generators that are directly driven via a surface buoy's wave-induced heave motion. This system provides power from the differential motion between the buoy float and a submerged resistant plate. This configuration provides reliable operation without the need for additional gearing and has the ability to harness electrical power in the 1 to 10 Watt range in small sea states (WMO Sea State 1: Calm). The buoy response in the Direct Drive System is designed to match a wide range of expected ocean wave spectra based on the deployment location. Direct Drive of the system with wave motion results in broad band response with high efficiency. Other benefits of this system include low acoustic noise and stealthy operation.

Resonant Drive System



The Resonant Drive System developed by ESL and URI employs small electric generators that are resonantly driven via a surface buoy's wave-induced heave motion. This system amplifies the generator's armature motion at the peak period of the sea state (WMO Sea State 1: Calm). The buoy response in the Resonant Drive System is designed to match the expected ocean wave spectrum based on the deployment location. The benefits of the resonant system include enhanced functionality, higher performance and continuous operation. The buoy is completely sealed with no external moving parts.

Scale Model Testing

Scale model testing of the Direct Drive and Resonant Drive Systems has been performed in the URI Department of Ocean Engineering wave tank as well as at the mouth of Rhode Island's Narragansett Bay. ESL's model simulations have shown good agreement with the scale model tests. This small buoy sensor system generates and accumulates energy that can be used to indefinitely power remote buoys equipped with sensor arrays as well as electronics for processing and communications. This power source can be used to minimize the size of batteries or to eliminate the need for batteries if supercapacitors are used. The buoy system design is customized and scalable (1-250 W) and can be suited to moored or drifting applications.

Furthering the Science

The company is also seeking organizations with applications for this technology, or with an interest in furthering this scientific study, or who are interested in commercializing this technology.

Targeted applications for this technology include:

- Recharging stations for unmanned underwater vehicles
- Replacement or augmentation for solar power
- Elimination of batteries
- Sonar listening stations
- Weather monitoring buoys
- Wave monitoring buoys
- Tsunami warning stations
- Port monitoring buoys.

The goal of the programs is to develop wave energy converters that can operate in all environmental conditions and augment or replace any of the currently used battery/solar power systems with efficient, low-cost, ambient ocean wave energy systems.

For More Information

Dr. Raymond Sepe, Jr., is the program's lead scientist at ESL. For more information on Ocean Wave Energy opportunities with ESL, visit http://www.electrostandards.com/Research-Development/, call 401-943-1164, or email eslab@electrostandards.com.