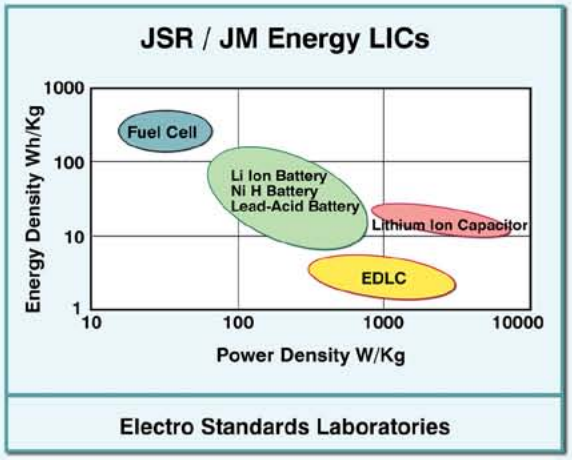
Energy storage with ULTIMO, Lithium Ion Capacitor (LIC) from JSR Micro



- **High cycle life, up to 1 million cycles**
- **Very low self discharge**
- **High energy density, 12Wh/kg or 20Wh/L**
- **High power density, 14kW/kg or 27kW/L**
- **Light weight and low volume**
- **High energy content (3300F cell)**
  ~1.5 amp-hr
  ~4.4 watt-hrs
  ~15.8kJ
- **High efficiency at low currents, over 99%**
- **High current capability, up to 1350A (1sec peak) or 200A continuous**
- **No thermal runway**
- **Low lithium content**
- **Environmentally safe**
- **Wide temperature performance (-30˚C to 70˚C)**
- **Quick charge times**
- **Low impedance**
- **Safe and reliable**
- **Power providing asymmetric design**

Electro Standards Laboratories & JSR Micro are co-exhibiting at the Energy Ocean International 10th Annual Conference & Exhibition in Rhode Island, June 10-12, 2013. www.energyocean.com

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Electro Standards Laboratories

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Electro Standards Laboratories
ADVANCED SYSTEMS DESIGN & SERVICES

Direct Drive Ocean Wave Energy Harvesting System Designed for Sensor Buoys

- Ocean Wave Energy Harvesting System developed by Electro Standards Laboratories and the University of Rhode Island
- Automatic Wave Energy Harvesting
- Drifting or Moored Operation
- Low Acoustic Noise
- Stealthy Operation (acoustic & visual)
- Wide Band Response to Wave Period
- Elimination of Batteries

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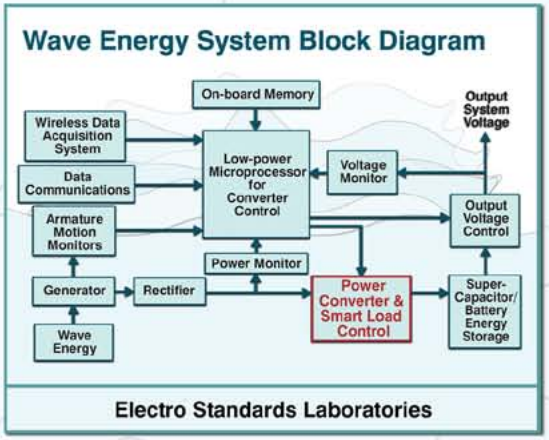
Electro Standards Laboratories Power Conversion Electronics

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 integrated with buoy systems to minimize the size of batteries, or to eliminate the need for batteries if supercapacitors are used.

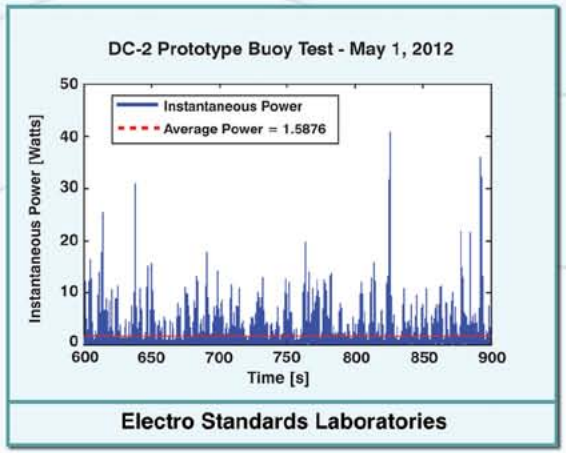


- **Power electronics to fit into slim buoy, 5 x 25 cm (2 x 9.8 in).**
- **Wave energy stored to JSR Lithium Ion supercapacitor.**
- **Output DC system voltage regulation.**
- **Onboard sensors and data acquisition.**
- **Data storage >256 MB flash.**
- **Wireless communications for setup and data transfer.**
- **Sleep modes and low power operation when fully active.**
- **Intelligent processor for easy and effective adaptation to custom applications.**

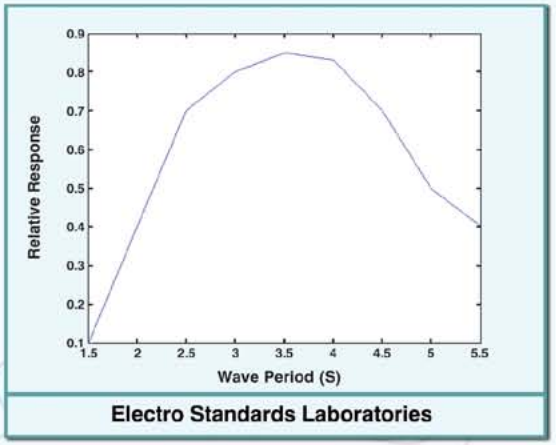
Deployed Energy Harvesting Buoy

This technology employs small electric generators that are directly driven via a surface buoy's wave-induced heave motion. 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 States 1: Calm)

Power Plot Example: (Sea State 1)

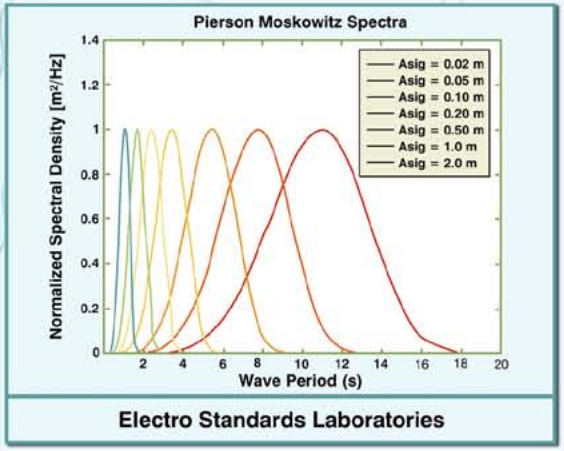


Wide Band Response to Wave Period



The graph above shows the wide band response to wave period. Buoy response is designed to match a wide range of expected ocean wave spectra (below) based on the deployment location. Direct Drive of the system with the wave motion results in broad band response with high efficiency.

Example Ocean Wave Spectra



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