PTO-Sim: Development of a Power Take Off Modeling Tool for Ocean Wave Energy Conversion

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Abstract

A collaborative effort between the Energy Systems group at Oregon State University (OSU) and Sandia National Laboratories (Sandia) has resulted in the development of PTO-Sim, an additional WEC-Sim library used to accurately model a device's PTO system (hydraulic or direct-drive). Sandia and the National Renewable Energy Laboratory (NREL) jointly developed the open-source Wave Energy Converter (WEC) modeling tool WEC-Sim, capable of running on a standard personal computer. Its main objective is to simulate WECs of arbitrary geometry subject to regular and irregular operational waves. However, WEC-Sim Version 1.0 models a power take-off (PTO) as a simple linear damper. Development of PTO-Sim makes WEC-Sim a wave-to-wire model by adding functionality that extends WEC-Sim capabilities. In PTO-Sim, a PTO model is easily created with drag and drop PTO-Sim library blocks used to simulate absorbed and electrical power.

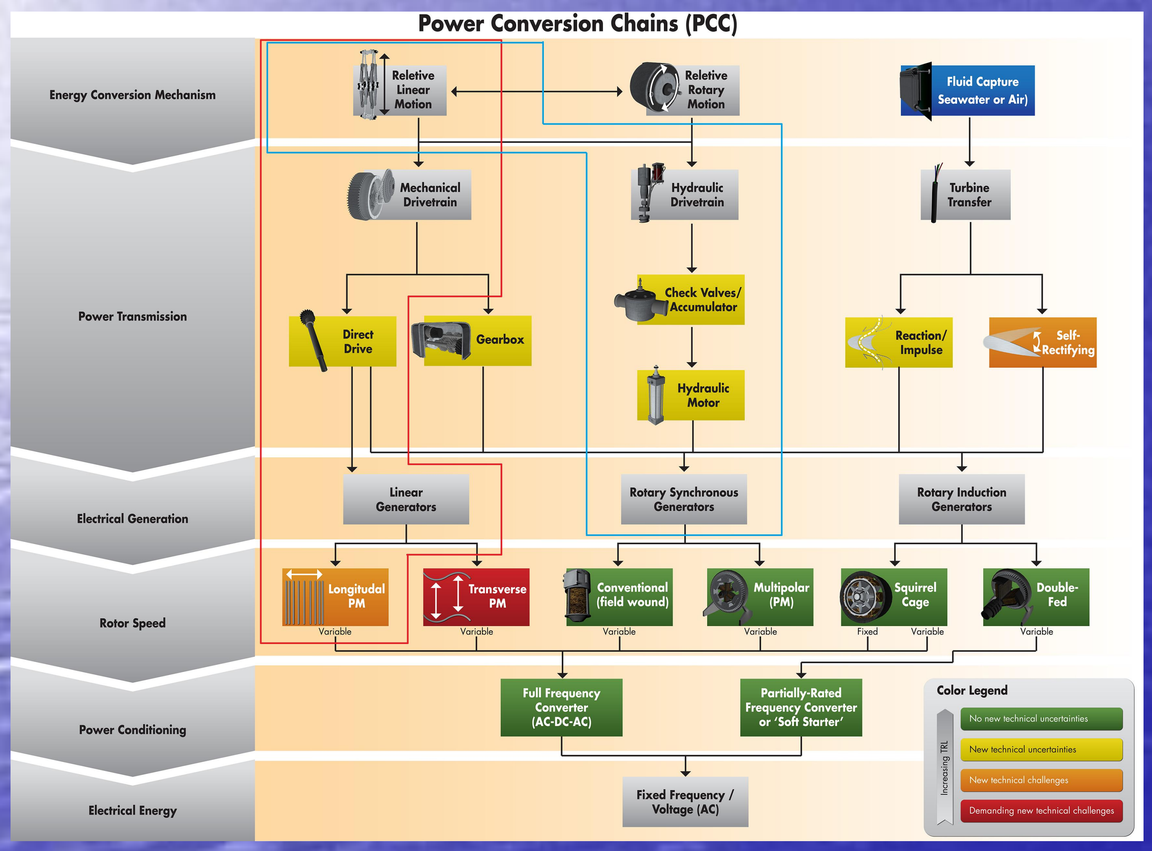

Figure 1. Power conversion chain from mechanical energy to electrical connection to grid. Lower TRLs are novel concepts and higher TRLs are more proven technology.

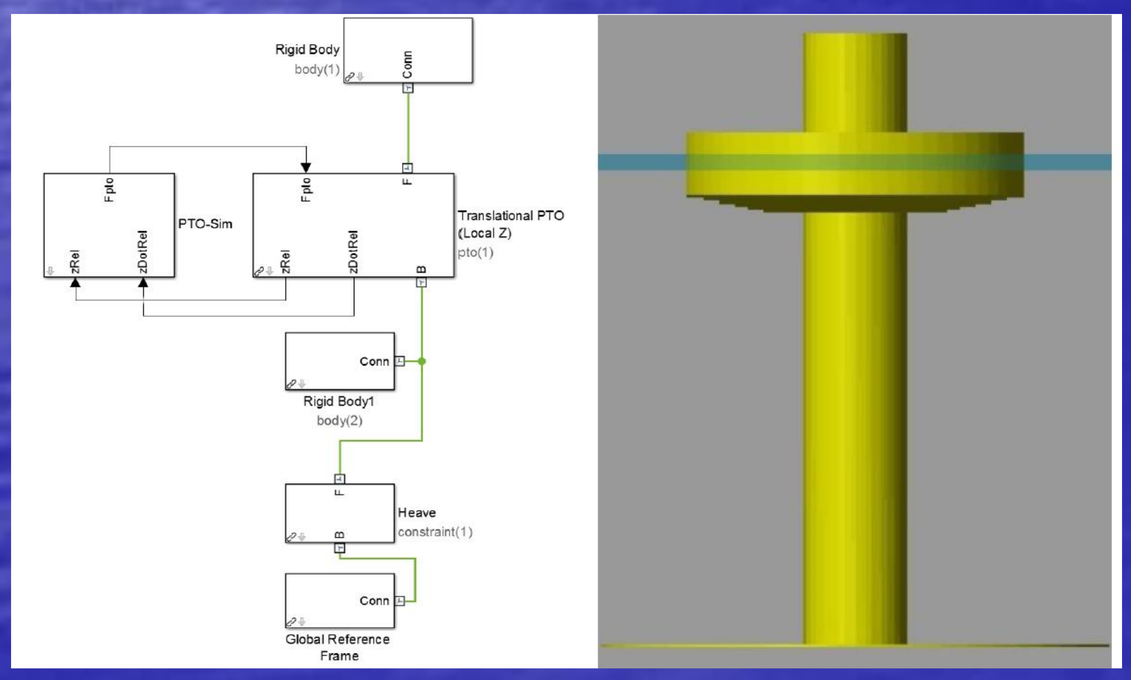

Figure 2. An example of a fully integrated PTO-Sim coupled with WEC-Sim simulations. RM3 model in WEC-Sim (left), and with the animation (right).

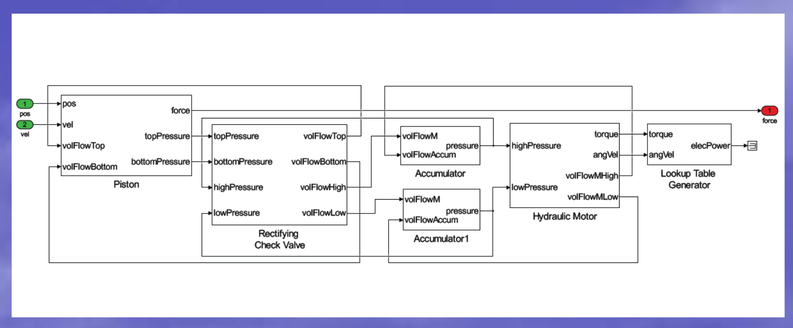

Figure 3. Simulink model of the hydraulic system.

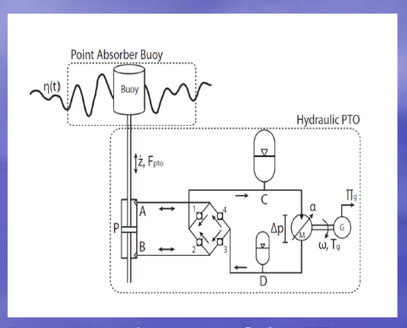

Figure 4. Schematic of the PTO-Sim hydraulic model.

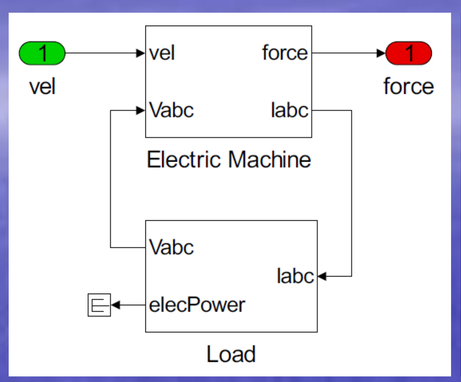

Figure 5. Simulink model of the direct drive system.

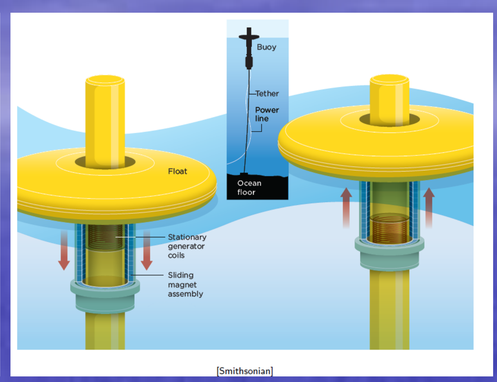

Figure 6. Direct Drive: OSU L10.

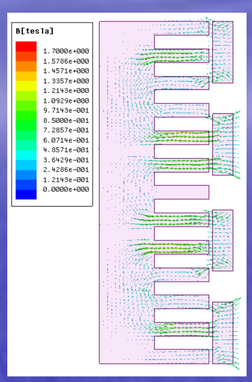

Figure 7. Cross section view of slots and magnets.

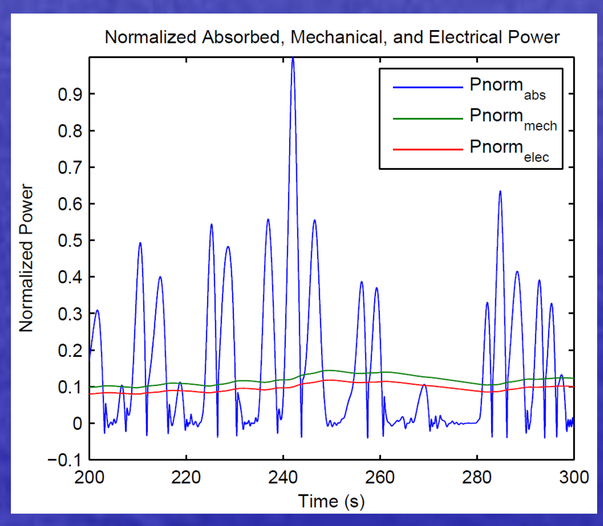

Figure 8. Absorbed, mechanical, and electrical power. Blue line is the power produced by the PTO. The green line is the power at the axle connecting the motor and generator. Red line is the electrical power at the output of the generator.

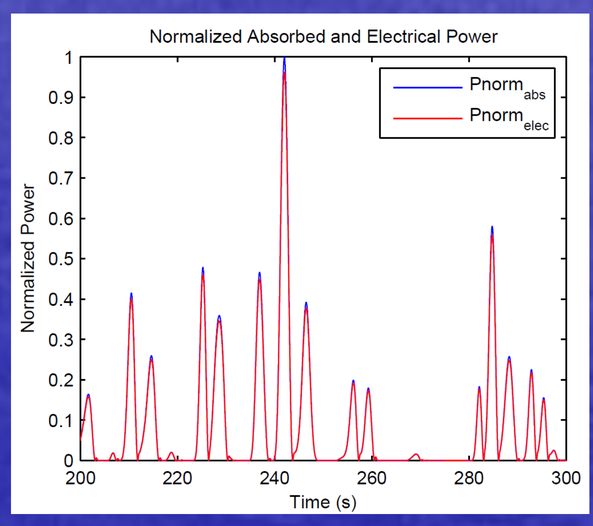

Figure 9. Absorbed and Electrical Power of the direct drive PTO. Blue line is the power produced by the PTO and the red line is the electrical power.

Conclusions

- **The development and application of PTO-Sim:**
  - **The WEC-Sim module responsible for accurately modeling WEC conversion of:**
    - **Mechanical power to electrical power through its PTO systems**
- **The usefulness of the PTO-Sim tool:**
  - **Comparing the results from two different architectures:**
    - **Hydraulic PTO**
      - **The native storage capability**
    - **Direct Drive PTO**
      - **A direct reflection of the incident sea state**
- **The goal of designing PTO-Sim:**
  - **To abstract the end-user from the details but to make the WEC more accessible**

Acknowledgements

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