March Deliverables Report

Establish best practices for data processing, system identification, and parameter estimation of the MHK energy device data using marine energy resource data, field test data, and simulation data to develop power flow dynamic models and their parameters in PSS®E.

I. Deliverable 5.2.1

Open-source PSS®E dynamic model of selected MHK device(s) with model agreement within 80% target for similarity performance metrics.

A. Introduction

- Clarification of original deliverable goals (PSS®E dynamic model).
- Current implementation using PowerDynamics.jl (Julia-based) instead of PSS®E.
- Definition of "model agreement" for comparing the developed PowerDynamics.jl model to shuv's Simulink model.

To support this deliverable, the capabilities of the Julia-based PowerDynamics.jl package are being extended to process raw time series field data.

Dynamic Models

Linear PTO WEC Model: The Linear Power Take-Off (PTO) model developed as part of deliverable 5.1.1 serves as the interface between the hydrodynamic motion of a Wave Energy Converter and its interaction with the power grid.

A brief overview of the dynamic PTO model development… The dynamic WEC integration is modeled in two stages: The Hydrodynamic Simulation (WEC-SIM) and then Grid Integration (PowerDynamics.jl). Using WEC-SIM, the WEC's motion is simulated using the Reference Model 3 (RM3), a two-body point absorber. WEC-SIM outputs key mechanical parameters, including Relative displacement (X_{rel}) between the float and spar, Relative velocity ($\dot{X}_{rel}$), representing the rate of change of displacement and Time-series wave elevation data.

The PTO model is built ontop of PowerDynamics' VSIMinimal inverter model, allowing the simulation to use real-time relative displacement and velocity as inputs.

The WEC-SIM outputs are post-processed and initialized with the dynamic PTO model, which is part of the larger dynamic power system model in PowerDynamics.jl. With our fork on PowerDynamics, the simulator integrates the WEC (or PTO) using the relative values to produce our generation. The simulation workflow, shown in Figure 1, illustrates the entire processing pipeline from wave simulation parameters to grid simulations.

A detailed breakdown of the PTO model equations, control strategy, and stability analysis is provided in Deliverable 5.1.1.

Simulink WEC Dynamic Model: Description of the WEC Simulink model developed by Shuv.

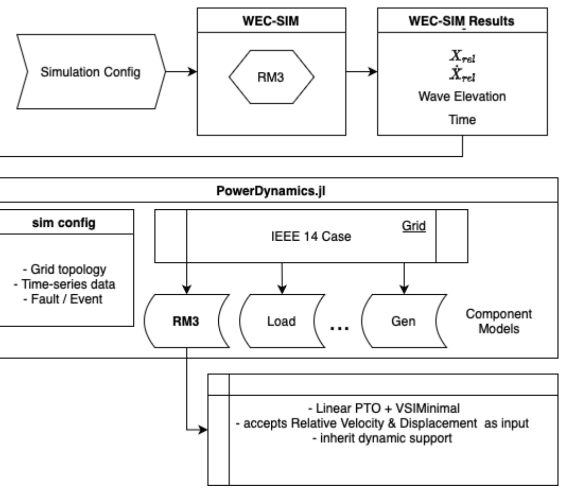

Fig. 1. Simulation framework integrating WEC-SIM with PowerDynamics.jl for grid simulation.

PowerDynamics.jl - IEEE14: The IEEE 14-bus system serves as the testbed for evaluating and comparing WEC integration into a power grid. We used a modified version of IEEE14 in deliverable 5.1.1 provided by PowerDynamics.jl with some additional modifications such as an additional WEC bus.

The default PowerDynamics.jl IEEE14 bus case is a PU ... need to describe how PowerDynamics implements their dynamic IEE14 model

We reused the default IEEE14 for this deliverable with some modifications to compare with the Simulink / power factor version ... need to describe how we will potentially update the default model so we can compare in the next section

With the discussed model parameter updates, this allows for a direct evaluation of how WEC integration impacts grid stability, frequency response, and power flow between both the Linear PTO and Simulink dynamics models.

Simulink or PowerFactory - IEEE14: placeholder

Simulation

Set-up:

- Simulation length: 5 minutes.
- Time step resolution: 0.02 seconds.
- Load scenario: Constant load conditions.
- Wave conditions: 2.5-meter height, 8-second period.
- Additional agreed-upon initial conditions.

output: maybe here we can talk a little about our different outputs and how we plan to try to compare them. any assumptions too.

Comparison Analysis (Performance Metrics of 80%)

I'm a bit confused about what the 80% means.

compare wec dynamics:

compare grid dynamics:

analysis: difference in how the grids responded.

II. DELIVERABLE 5.3.1

Report on a test system microgrid stability study with the developed power converter and system fault-protection model.

We are currently developing a low-voltage ride-through (LVRT) mechanism for converters and a fault protection model for the Wave-to-Grid (W2G) system. The LVRT capability has been implemented in the grid-side converter (GSC) to handle symmetrical three-phase grid faults. The W2G model has been integrated into a simplified three-bus power system to evaluate its performance within a microgrid environment, as shown in Fig.[YC1] 8. Additionally, efforts were made to connect and assess the stability of the developed W2G system with LVRT capability in the IEEE 13-bus standard test case. However, the desired performance was not achieved due to the unbalanced nature of the original IEEE 13-bus system. Work is currently underway to modify the test case and achieve a balanced configuration. Ongoing efforts are focused on developing an effective control strategy for the W2G system to facilitate its integration into the target microgrid and conduct comprehensive stability tests.