Integrated Wind and Wave Power System Comprising State-of-the-Art Linear and Rotary Generators

...

Presentation by Natalie Gardner and Noah Sharrott

Development of highly efficient, cost effective wave energy conversion system

Oregon Institute of Technology

➢ Project objectives

- Create a workspace for research, simulation, and analysis of modern wave power generations systems at Oregon Institute of Technology (OIT).
- Design, build and integrate into these systems a state-of-the-art highly efficient direct-driven linear generator.
- Equip the generation system with rectifier, energy storage, pulse-width-modulated inverter, dc link, and data acquisition system.
- Construct a physical environment wave simulation.
- Prepare laboratory manuals for undergraduate and graduate students, as well as attractive presentations for high school students visiting Oregon Institute of Technology.

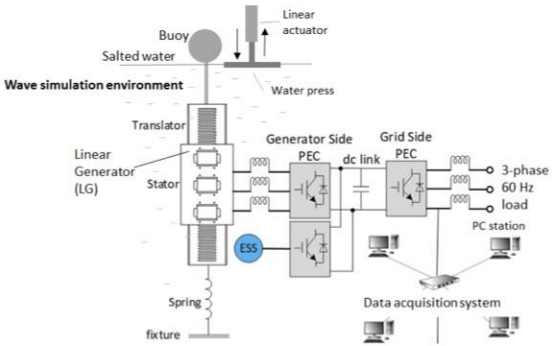


Fig. 1. Schematics of the proposed integrated wind and wave energy laboratory

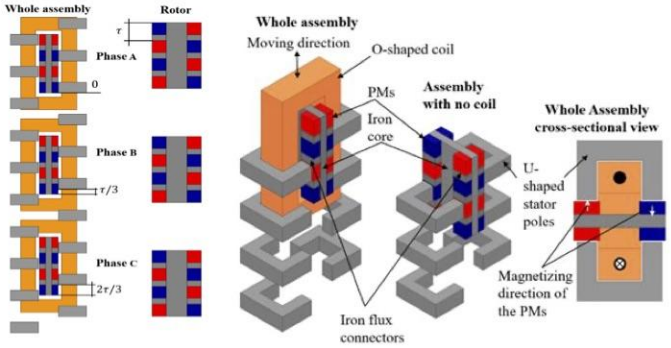


Fig. 2. Direct-drive transverse-flux linear generator for wave energy conversion

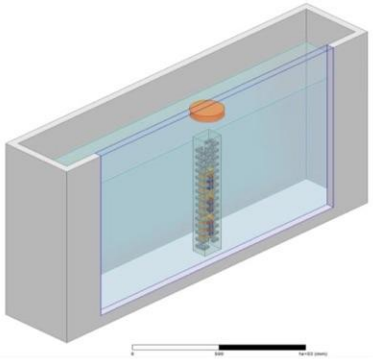


Fig. 3. Tank view with the submerged generator

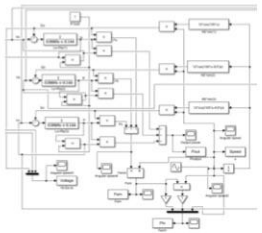


Fig. 4. Dynamic model of the generator

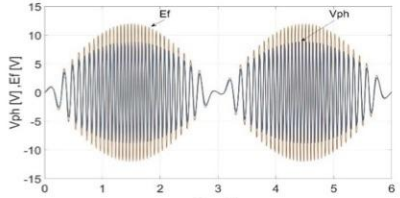


Fig. 5. Induced voltage of the generator at sinusoidal speed of the buoy

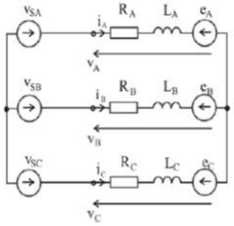


Fig. 6. Equivalent circuit of the generator

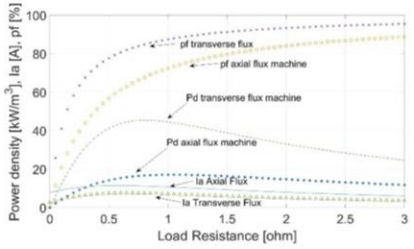


Fig. 7. Steady-state characteristics of the transverse flux generator compared to the conventional axial flux generator

Overview

A team of students lead by Dr. Dobzhanskyi and Dr. Yang from Oregon Institute of Technology (Oregon Tech) are working on an integrated wind and wave power system to use as a laboratory space. The students are designing the system and will begin building it once the university reopens. This laboratory will be used by the students for many years to conduct research at undergraduate and graduate levels.

Education

The wave generator is being designed as a learning tool for current and future students. There is a clear casing around the generator that will allow students to observe the moving components. There will be a variable wave creating machine which will, in theory, allow us to be able to change the speed and amplitude of the waves in order to observe the difference in power produced by the wave power system. The system will be used for classes, labs and potentially senior projects.

Educational Approach

This project was designed to give the students involved reign over decisions about the system. Students split themselves into teams which focused on specific design aspects of the wave power system. These teams were working independently from each other in order to focus on their goal, such as generator team focusing on creating a practical and functional design of the linear generator, and the power electronics team focusing on designing a power electronics system that can have any erratic and unstable power input and a predictable and stable output. The students involved have been in charge of designing the system and will be responsible for building and testing the system.

Remote Work

Due to COVID-19 causing our campus to temporarily close, the majority of the work has been be paused since the project requires students to be physically on site to build the system and conduct tests on the system. Students were advised to continue thinking about, and researching ways to improve the project, and to contact Dr. Dobzhanski with questions, and to contact your teammates with any ideas. Many teams began communicating largely through email or video chat in order to continue brainstorming or show results of simulations.

Learning Outcomes

Since this was many students first “real” engineering project, all students learned a great deal about the engineering and design process. Many of the skills learned were:

- Working within various groups with a focused goal
- Working remotely to accomplish as much as possible given the circumstances.
- Identifying weak-points in a design in order to fix, or redesign the system prior to building the prototypes.
- How to get parts quotes from industrial businesses and find the most cost-effective yet high quality parts.
- The engineering process/cycle of taking a concept, drawing it out in AutoCad or paper, simulating the design to test theoretical functionality, finally prototyping to test “real-world” functionality, and decide if it needs to be redesigned, simulated, and tested as part of the engineering process/cycle.

Learning Outcomes - Tank Team

The tank team is in charge of finding a tank to house the generator which is able to house an ocean-like environment, be aesthetically pleasing, withstand years of use, and stay within a tight budget.

Some things they learned were:

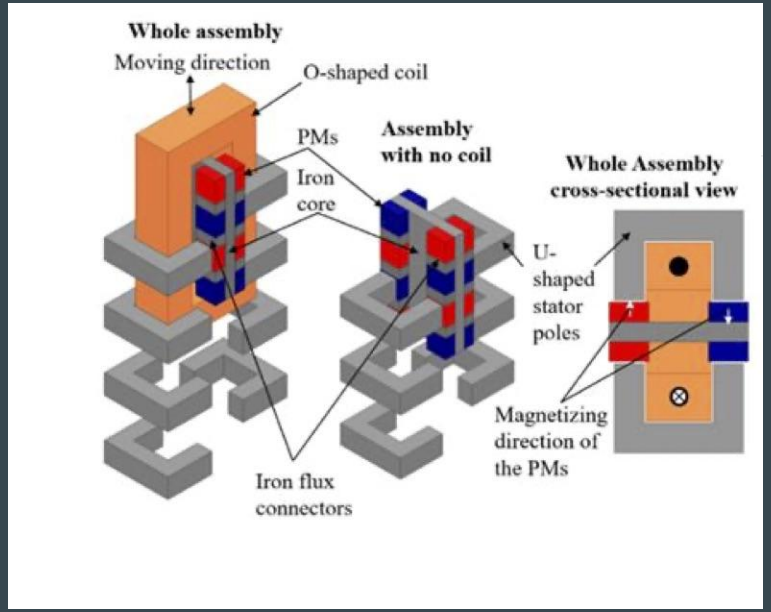
- How to manage a budget for a large project
- Requesting and sorting quotes for fabricated tanks
- How to apply for grants to expand project possibilities
- Researching many options for various tank designs
- Designing creative ways of mechanically creating waves within the tank

Learning Outcomes - Generator Team

The generator team is in charge of designing and building the generator.

Some things they learned were:

- Requesting and sorting quotes for material
- Designing a system in AutoCad
- Simulating and modeling the design in MatLab and FEMM allowing circuit and magnetic field calculations respectively.
- Problem-solving techniques with regards to redesigning around identified weak-points within the system.

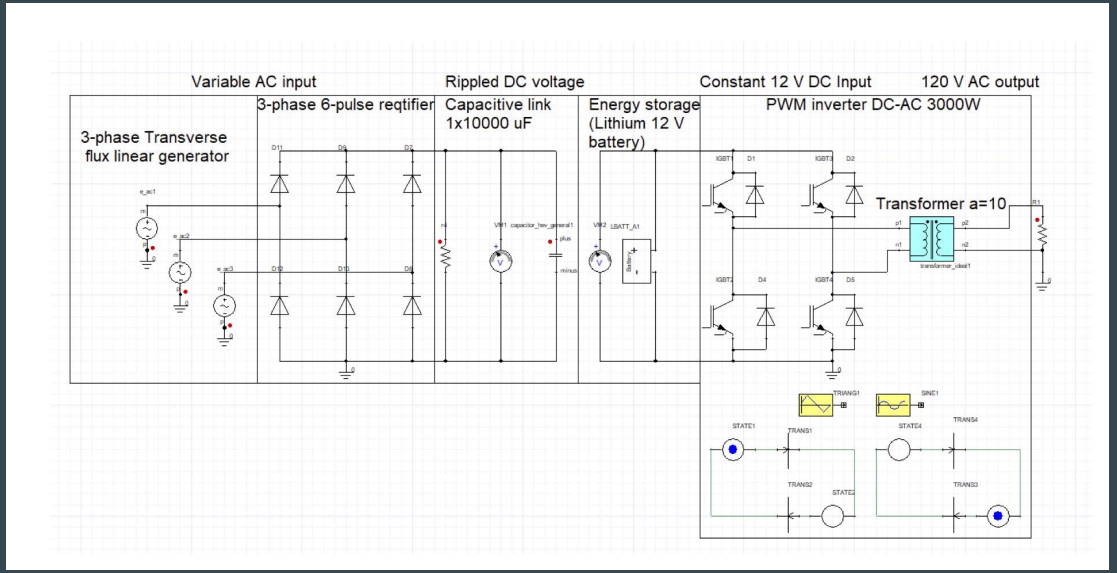


Learning Outcomes - Power Electronics Team

The power electronics team is in charge of designing the electronics between the generator and other equipment.

Some things they learned were:

- Online design and simulation software
- Converting an erratic, unstable power input into a predictable, stable power output.



Educational Impacts

The wave generator will be around for many years and will be used extensively for students to study and get hands-on experience with wave energy hundreds of miles away from the ocean. They will be able to alter the speed and amplitude of the waves to see the impact on power generation as well as study the power electronics design to better understand ways of creating stable power sources for other applications. The fundamental skills learned by students during this project and learned by future students studying the system are very important and applicable to all sources of renewable energy. These concepts will help students think of their own designs involving renewable energy and may inspire future senior projects.

Future Plans

Once COVID-19 restrictions are lifted, the teams will be able to meet back at Oregon Tech to finish building and testing the system.

After the wave generator is completed, students will design a small wind turbine to collect energy. This will provide a model for various forms of renewable energy which each can have erratic, unstable power generation and will demonstrate important engineering skills students will need when designing, simulating, and building their own systems.

Questions?

For questions, please email Natalie Gardner at natalie.gardner@oit.edu or Noah Sharrott at noah.sharrott@oit.edu.

Thank You!