**Dynamic design of a novel inertial reaction mass wave energy converter: The SWINGO system**

As the impact of fossil fuels on the Earth's environment becomes increasingly apparent, governments worldwide are shifting their political focus towards reducing carbon emissions. In this context, renewable energy sources are considered the alternatives to traditional carbon-based energy. Among these sources, wave energy holds great promise as a clean and abundant resource, comparable to solar and wind power. However, to reach the commercialization stage and be economically competitive, significant advancements are still needed to achieve high-performance levels in wave energy conversion technology.

To achieve the goal of economically viable wave energy conversion, it is crucial to have suitable Wave Energy Converter (WEC) technology. This technology should enable efficient energy conversion while minimizing the overall cost of energy production. On this basis, the WEC should be designed to operate effectively across a wide range of sea conditions, ensuring reliable performance in varying wave environments. The vast majority of existing wave energy converter (WEC) technologies are designed to absorb wave power through a single mode of motion, often constraining the device on the remaining degrees-of-freedom (DoF) or neglecting their effects on the system dynamics and resulting power production.

Therefore, this manuscript focuses his attention on inertial reaction mass (IRM) Wave Energy Converter (WEC) systems, offer advantages such as the ability to incorporate electrical components within the floater. Additionally, inertial WEC systems are known for their adaptability to various characteristics associated with wave phenomena. This adaptability enables them to effectively harness wave energy in different sea conditions and wave directions.

Based on these considerations, it becomes evident that an accurate modeling approach is essential to capture the various modes of motion and ensure that none are neglected. Therefore, the impedance matching (IM) theory is extended to accommodate the multi-mode dynamics of WEC devices and develop a comprehensive control-informed modeling framework. Furthermore, The IM theory is utilized to investigate the dynamic characteristics of the system under controlled conditions, focusing on its power performance and emphasizing its key features. In this thesis, both analytical nonlinear equations and the control-oriented modeling computation are introduced and formulated in a general and adaptable manner suitable for multi-DoF systems.

This study presents a novel WEC technology that introduces the concept of omnidirectionality, combining the behaviors of both a pendulum and a gyroscope mechanism. This unique design allows for maximum wave power absorption, resulting in increased device efficiency, as it can operate effectively regardless of the incoming wave direction. By applying the impedance matching condition to the multi-DoF system, a control-informed model of the WEC device is derived, facilitating its design and optimization.

The proposed technology is evaluated in two different offshore locations: the Mediterranean Sea off the coast of Pantelleria island and the North Sea on the Danish shelf. The optimization process is conducted, and the resulting designs are compared. Furthermore, a comprehensive analysis is performed to investigate the nonlinear behavior of the system. A comparison is made between the full nonlinear model and its linearized counterpart, with a particular focus on the impact on device productivity.

Through this analysis, valuable insights are gained into the performance and behavior of the WEC technology. The differences between the nonlinear and linear models are assessed, shedding light on the system's response, and highlighting the importance of considering nonlinear effects. The study also emphasizes the impact of these nonlinearities on the device's productivity, providing valuable information for further design improvements and optimization efforts.