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CONTROL STRATEGIES OF A WAVE ENERGY CONVERTER FOR THE WECFARM PROJECT

Background and introduction

Increasing energy consumption and exhaustible fossil fuels force people to shift to renewable energy sources [1]. One possible blue energy source is wave energy which is distributed over a wide range of frequencies [2]. The devices used to absorb this energy are **wave energy converters (WECs).** The WEC used within this study, also called the "Master WEC", is a heaving point absorber since its dimensions are small compared to the wavelength of the incident waves.

The current test rig for the Master WEC is shown in Figure 1. The WEC can be moved up and down due to the connection of the motor with the rack and pinion system. The motor and gear box connecting the WEC buoy to the Beckhoff Drive are located at the back of the depicted experimental set-up.

To capture sufficient energy, multiple WECs have to be combined in what is called a "WEC array". Within WEC arrays, both constructive and destructive WEC interferences take place [3].

Since wave absorption also means wave generation, radiated waves will occur due to the oscillating motion of the "Master WEC". The presence of the WECs under wave action will also cause a diffracted wave pattern since waves are hindered due to presence of the WECs.

New renewable energy sources become attractive when their **levelised cost of electricity** (**LCOE**) becomes competitive with that of other energy sources. To decrease LCOE, one aims to increase the energy absorption and decrease the overall costs. Power absorption can be increased by adapting the **power take-off (PTO)** of a WEC. This allows to limit the WEC size and to increase the energy absorption over a broad frequency range [2].

This research is part of the **WECfarm project** which is planned to be executed in the new Coastal and Ocean Basin (COB) in Ostend, early 2022. This experimental campaign will investigate the near-field and far-field interactions for different **WEC array geometric layouts and inter-WEC distances**. Within these tests, five WECs will be combined into one array. The outcome of the WECfarm tests will serve a database for validating a wide range of numerical models used for WEC array or WEC farm modelling [4].

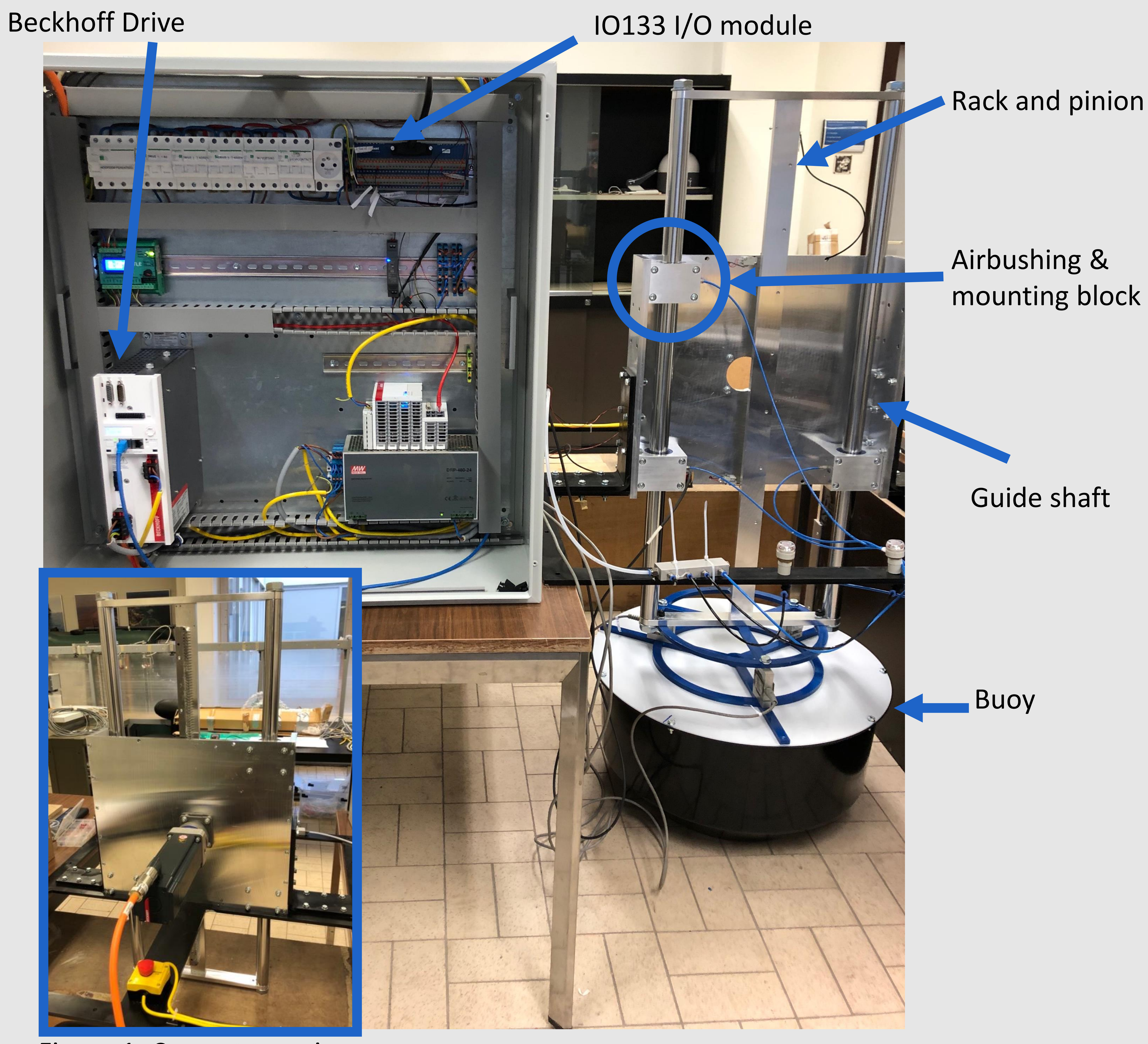

Figure 1: Current test rig

Research question

This research focusses on the influence of the **control strategy** on the total power absorption compared to the **passive damping** strategy. Within this passive damping, the PTO-force is proportional to the heave velocity of the WEC buoy. Other control strategies that will be investigated are the model predictive control (**MPC**) and the **latching** control [2][5]. The MPC strategy predicts the excitation force of the incoming waves to optimise the PTO-force. Within latching control, the WEC is hold in position for a certain time to increase its heaving velocity and such increase the power absorption.

Methodology

To validate the different PTO control strategies, these have to be implemented in the **MATLAB-Simulink software**. An overview of the employed procedure for Data Acquisition is illustrated in Figure 2. The MATLAB-Simulink model on the "Development laptop" is connected to Speedgoat Performance real-time target machine which allows real-time adaptation and monitoring of different parameters. To monitor the behaviour of the WEC, different sensors are applied to this model to allow real-time control and validation.

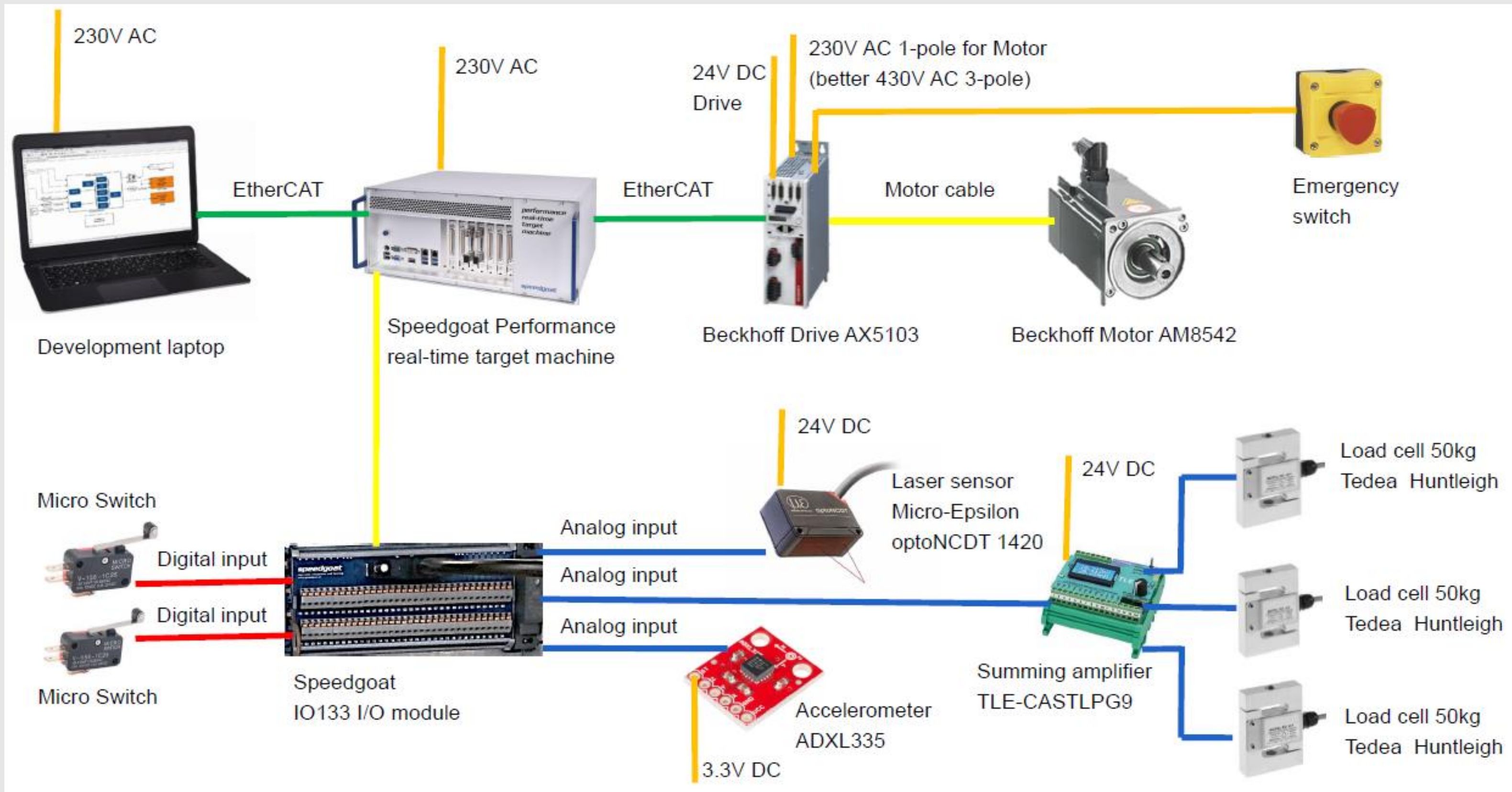

Figure 2: Data acquisition (DAQ) of the test rig

The accelerometer is used to determine the acceleration of the WEC where the laser sensor determines its position. The summing amplifier combines the three load cells on the test rig to determine the forces acting on the WEC.

For the selection of the PTO control strategy, one has to consider the later extension to an array of five WECs. Note that the selection of the control strategy has an influence on the optimal WEC array layout and inter-WEC distances between the WECs as identified in [3].

Results

A unique property of the tested "Master WEC" are the **airbushings** incorporated within the mounting blocks. A permanent layer of pressurised air creates a theoretical zero friction interface between the guide shafts and airbushings . Experimental tests are planned to determine the exact contribution of the friction to the equation of motion of the WEC. When the COVID-19 situation allows work-related trips, tests will be executed in the wave basin of the Aalborg University (Denmark). These tests are planned to determine the WEC power absorption for different PTO control strategies. A short term scientific mission (STSM) was awarded by the WECANet COST Action CA17105 and allows the execution of these tests. After executing the tests, the effect of different PTO control strategies and their effect on the WEC power absorption over a broad frequency range will be evaluated.

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