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# Design of Experimental Setup of a Wind Energy Conversion System Using a Power Split Device in Industrial Wind Turbines

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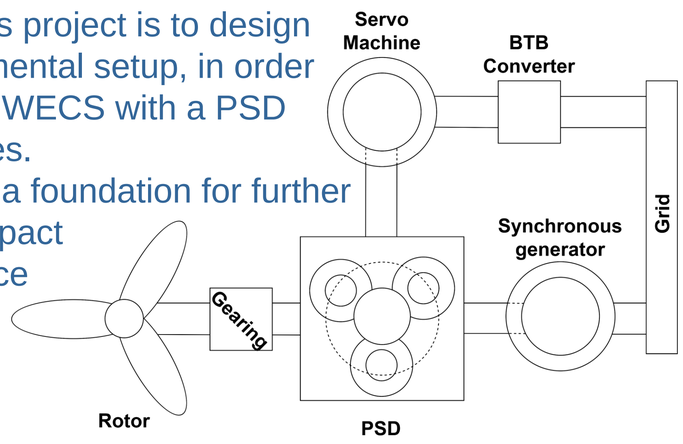
## 1. Introduction

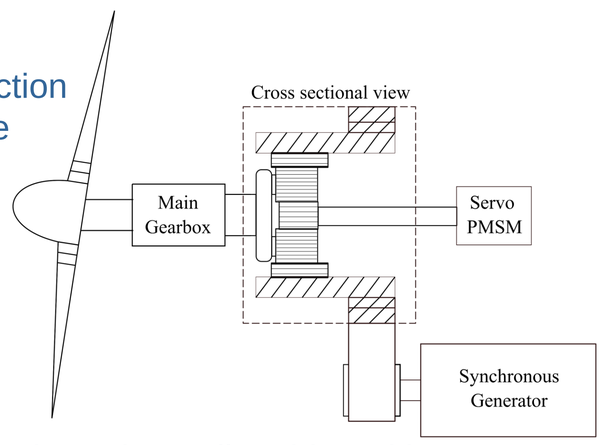
This project investigates a concept for industrial wind energy conversion systems (WECS) using a power split device (PSD). The principle of the concept is to use a PSD to split the power from the wind turbine's rotor between a synchronous generator (SG) and a servo machine. The servo machine is controlled to keep the SG at grid frequency. An illustration of the concept is seen below.

The main objective of this project is to design and construct an experimental setup, in order to test the feasibility of a WECS with a PSD for industrial wind turbines.
This is done to establish a foundation for further research, such as the impact on grid compliances, since research in this area is lacking.

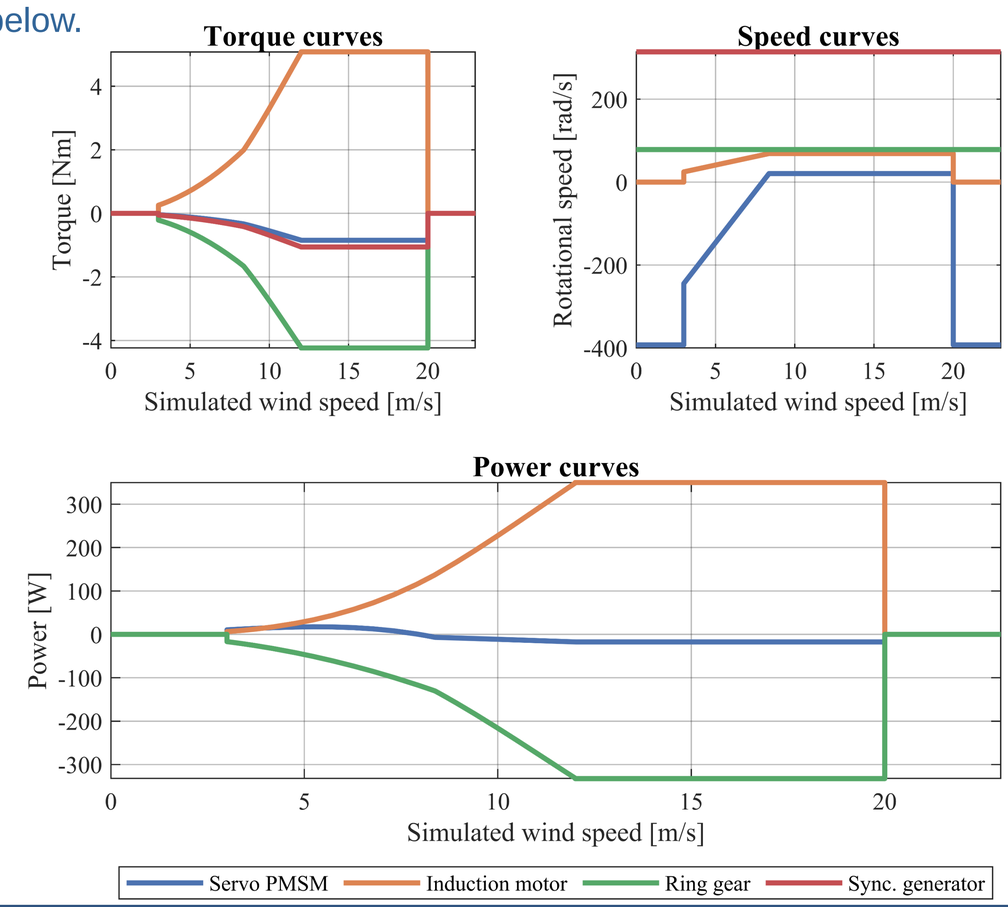



## 2. Experimental setup

The PSD is chosen to be of the planetary gearset type. An induction motor is utilised to represent the rotor of a wind turbine and the main gearbox. It is connected to the carrier of the planetary gearbox. A servo permanent magnet synchronous machine (PMSM) is selected and connected to the sun gear. The SG is connected to the ring gear through a pulley drive with a gear ratio of 1:4.

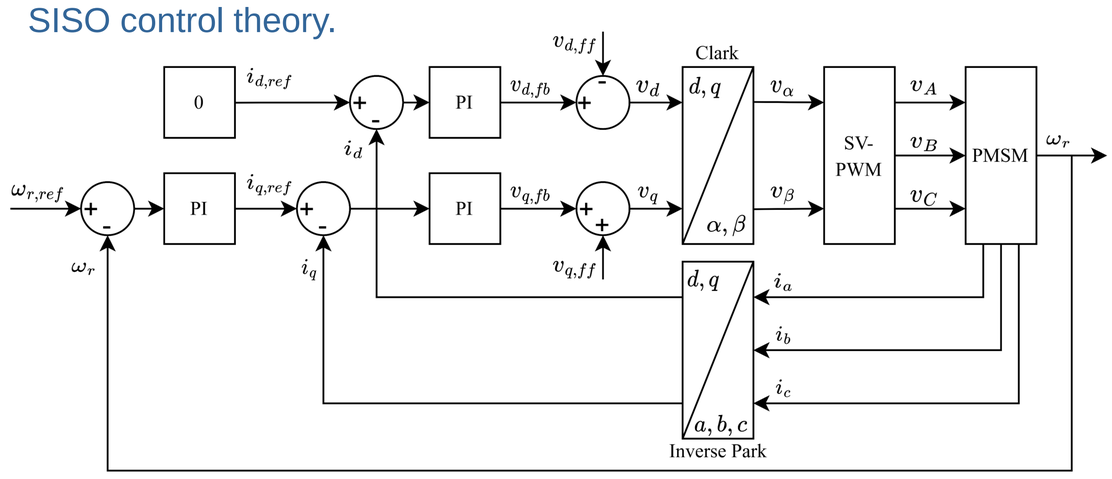



To determine the requirements for the operation of the setup, a scaled wind turbine power curve is utilised to calculate the torques, speeds, and power for the components. These are plotted as seen below.

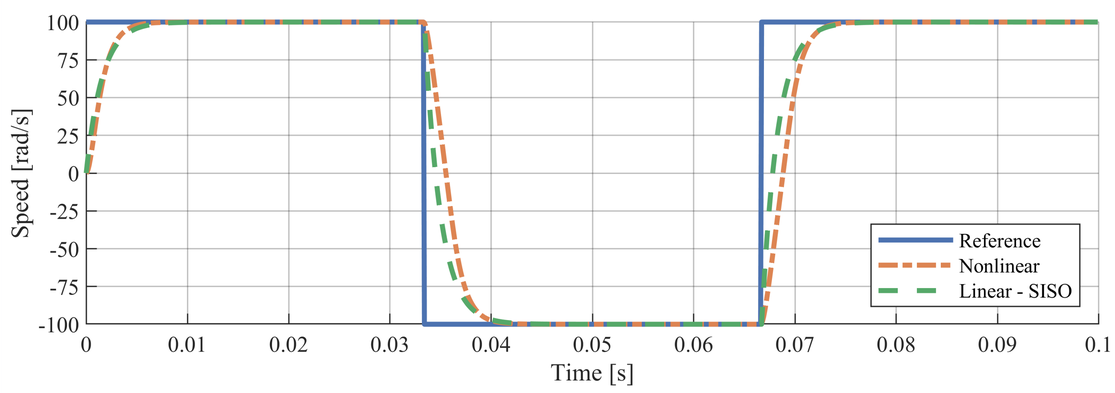



## 3. Control and Modelling of PMSM

The PMSM is modelled by transforming the three $a$, $b$, and $c$ phases to the $d$ and $q$ reference frame. This results in a nonlinear coupled system of differential equations. A field oriented control (FOC) scheme is implemented.
To linearise the system a feedforward compensation is added to the model, eliminating the nonlinear coupling terms, enabling the use of SISO control theory.

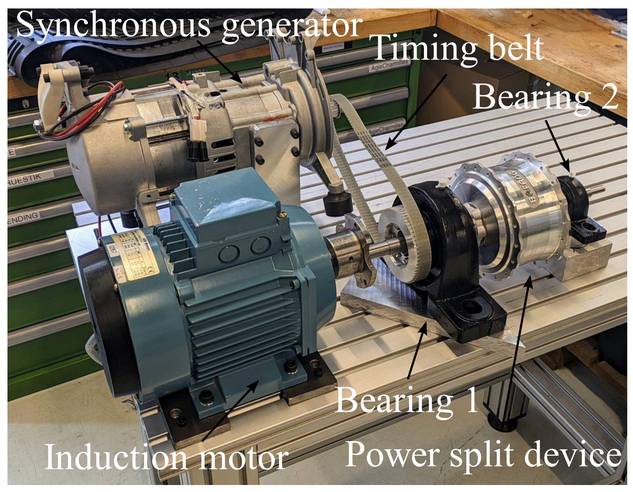



FOC consists of an inner current loop and an outer speed loop, controlled using PI controllers. The inner current loop is designed to have a bandwidth five times that of the outer speed loop. A square wave reference response is shown in the figure below. Where the linear response assumes perfect decoupling by the feedforward compensation.




## 4. Conclusions

In conclusion, an experimental setup is successfully designed and constructed to test the feasibility of a WECS utilising a PSD, based on a scaled wind turbine model. The constructed experimental setup without the PMSM and electrical components is seen to the right. Control of the setup is implemented using a micro-controller and space vector pulse width modulation. An FOC scheme is designed for the setup based on the modelling of a PMSM.

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