Master thesis : Dynamics and control of a future off-shore wind power hub

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Dynamics and control of a future offshore wind power Hub

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Abstract

In the past decades, the increased carbon dioxide released by burning fossil fuels has been urging the demand for decarbonisation of our society. However, even if local renewable solutions are necessary, mass-scale production and management will soon be of crucial interest if fossil energies have to be replaced in due course and efficiently. In that context, it is very likely that offshore wind turbines will become an important electricity provider. Nevertheless, nowadays, technical obstacles remain and prevent the global implementation of such technologies. Indeed, the substitution of the classical synchronous machine by converter-based technologies induces a lack of inertia in the network, rendering the system more vulnerable to disturbances and source-outage. The present work aims at highlighting a possible transition technology : the Synchronous Condenser.

This project is drawn within the context of a large scale and international study: the North Sea Wind Power Hub. The principal idea is to connect onshore network from several countries with an artificial island collecting wind power. Mainly, the efficiency of a Synchronous Condenser to handle the power balance and the voltage control on the island is investigated. Two study cases are performed: a single DC link model and a five link system. Our leading aim is to propose a preliminary tuning of the parameters involved in the VSC controllers and specifically the control of active and reactive power on the island. The control of the active power is based on the rotor speed of the Synchronous Condenser and a Hub Coordinator used to synchronise all DC links together.

A first approach of the design is conducted through a linear study on the single link system. The poles location allows to determine the required value of the gains to fit specific dynamic constraints. Afterwards, a nonlinear analysis enables to impose additional complementary constraints on the gains. Thanks to those two analyses, the control of the VSC is entirely designed. The main conclusion of this chapter concerns the stability of the system. Indeed, a wide range of values for each gain is determined. Those ranges provide space for the tuning of the gains to fit desired dynamics constraints.

The final chapter, dedicated to the five link system, focuses on advanced analyses such as $n-1$ criterion or the operating point. The parameters study of the Synchronous Condenser highlights the large possibility in term of size and nominal power to ensure stability.

The general conclusion of this work is the feasibility of the Synchronous Condenser implementation and the strong stability of the system. It is viable to tune the gains to provide expected behaviours. Therefore, a Synchronous Condenser may be considered as a solution to sustain the current power transition and especially while awaiting the improvement of grid-forming technologies.

Figure 1 represent the model used in chapter 4 with 5 DC lines.

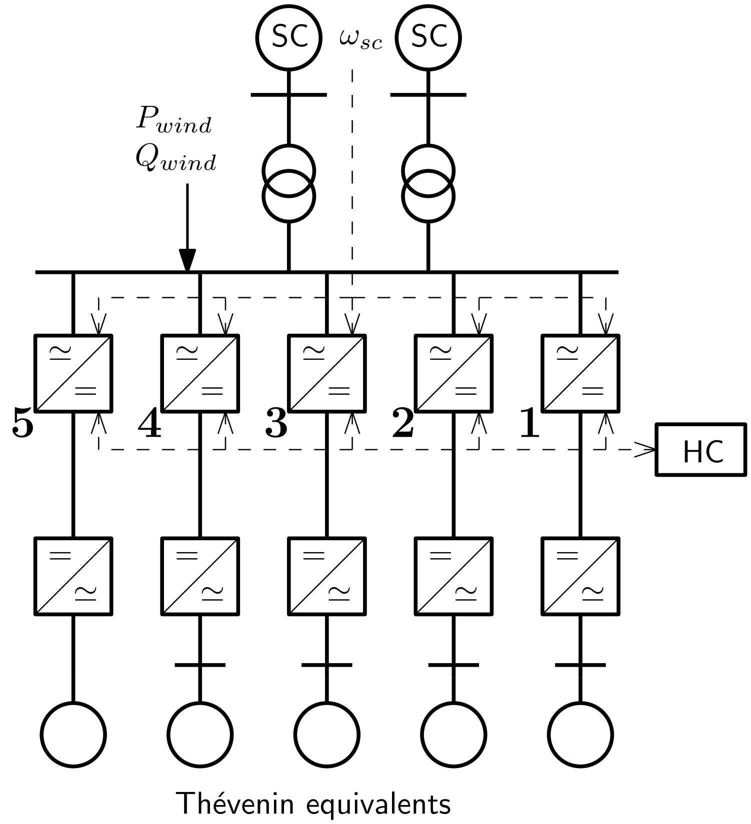

Figure 1 – Model of 5 DC lines