



Control and power management of DRU HVDC based offshore WPP

Assessment of existing solutions, proposition of enhanced grid forming control and umbilical cable free black start strategy

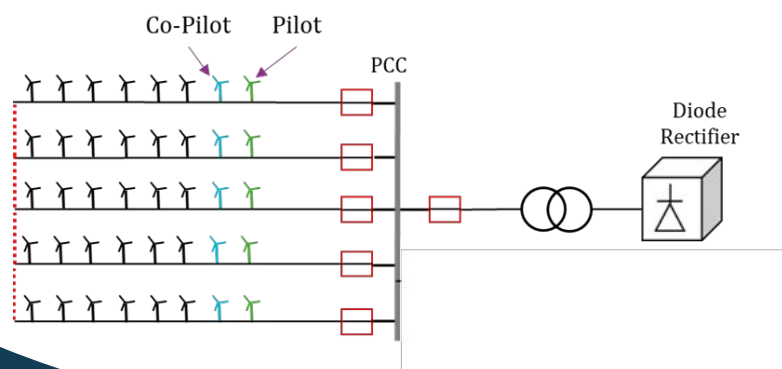
CONTEXT

Trends are now to build large power (> 1 GW) and far from shore offshore wind farms (OWF). HVDC transmission is seen as an efficient way to connect such OWF to onshore PCC. VSC MMC based HVDC transmission is today the classic solution implemented in several projects. However, this solution can incur high CAPEX (need for costly large offshore platform) and OPEX (converter losses and maintenance). A new solution has been proposed recently to lower such costs (30% overall cost reduction) and is claimed as a game changer. This solution relies on the replacement of the MMC by a series arrangement of Diode Rectifier Units localized in "small" distributed platforms.

The DRU being a passive and unidirectional device, it cannot play the roles of the VSC MMC converter in classical solution, which are to ensure black-start of the wind farm and AC collector grid forming (control of AC voltage magnitude and frequency). In the DRU based solution, it is proposed to implement a medium voltage umbilical AC cable and modify the control of wind turbine generator (WTG) side converters as well to manage black start and AC collector grid forming. However, implementing such an MVAC cable increases the cost of the solution.

TECHNOLOGY DESCRIPTION

An extensive review and assessment of existing grid forming solutions are done, implementing some of them in EMT models. This review is completed by an in depth analysis and understanding of the physical behavior of the OWF in both islanding (DRU not conducting) and connected operation modes. An enhanced grid forming solution is proposed, concatenating some principles proposed in existing solutions. It consists in the modification of the WTG grid side converter control to achieve active power control by managing AC collector magnitude and to regulate the AC collector frequency through a distributed reactive power Q/f droop control (all WTGs participating to frequency regulation). This solution does not need any measurement of the voltage phase at the WTG grid side converter output through a phase lock loop (PLL). A new black start strategy is proposed and implemented. This strategy relies on using local energy storage systems (ESS) at some WTG locations and as much as possible wind energy for full energization of the OWF. A discrete event system (DES) based supervisor is implemented to manage the different sequences of the OWF black start. This supervisor is able to deal with normal and fault operations during the black start sequences.



APPLICATION DOMAIN

DRU HVDC based offshore WPP

ADVANTAGES

- Cost reduction by removing the umbilical MVAC cable
- An extensive review and assessment of existing grid forming solutions
- An enhanced and robust (no need for voltage phase measurement with PLL) grid forming solution
- A black start solution using as much as possible wind energy

TRL SCALE



DELIVERABLES

- PhD report
- EMT simulation models developed in Matlab SPS

SCIENTIFIC REFERENCE

- PhD report
- 2 EPE papers (2018 and 2019)

