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Coordinated control for wind turbine and VSC-HVDC transmission to enhance FRT capability

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Abstract

The integration of large-scale offshore wind farms into electricity networks without causing stability hazards is one of the future challenges for interconnecting large offshore wind farms into national grids. This paper presents enhanced control strategies for offshore wind farm arrays interconnected via an HVDC link. To improve fault ride-through capabilities of the HVDC link and wind farms, a frequency controller is proposed and the third harmonic injection technique is applied as a means to improve the reliability of the offshore arrays. This new controller can easily coordinate the power flow from different sources (i.e. large-scale wind farms and conventional power stations). The power production from the offshore wind farms will depend upon the type of wind turbines installed. Thus, the performance of wind farms based on DFIG and FRC wint turbines is compared aiming to give a better understanding and to identify areas where control improvements can be introduced to optimise offshore wind power transmission.

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Keywords: Offshore wind farms, cluster collection platforms, offshore network connection, HVDC single point connection.

1. Introduction-----

Due mainly to European CO_2 targets for 2020 and 2030 offshore wind energy has become a key area in future energy production. Increasing energy production from individual turbines and the installation of large scale offshore wind farms should bring onshore a high amount of energy which should help to meet these targets [1].

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Thereby, in recent years installation of variable-speed wind turbines in deep waters has become a primary concern, as wind speed is steadier and there is less turbulence. However, the controllability and reliability of large offshore wind farms and their cluster platforms are challenging. To increase their reliability and achieve power transfer HVDC transmission is seen as a key element. There are two HVDC transmission configurations: the classical Line-Commutated Converter-HVDC (LCC-HVDC), which can transmit high amounts of power and the second option, the Voltage Source Converter (VSC-HVDC) technology [2-5], which has higher flexibility [6, 7], and allows faster control during normal operation or large transients [8, 9].

The aim of this research is to evaluate and to compare performances of VSC-HVDC for Doubly Fed Induction Generator (DFIG) and Fully Rated Converter (FRC) wind farms (WFs) during large transients. Control strategies that balance the active and reactive power transferred and the dc power during large transients are proposed and explored. Finally, this paper also evaluates the VSC control performance (flexibility and reliability) and fault ride-through capability of a proposed ac star wind farm layout during large transients, shown in Fig. 1.

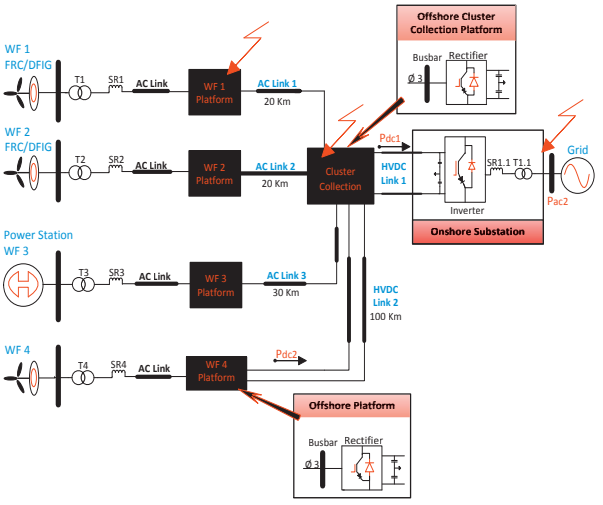

Fig. 1. Test system.

In the test system shown in Fig. 1 the DFIG/FRC wind farms are connected to the cluster collection platform through ac cables. To maintain the offshore system reference ac voltage and frequency, a synchronous generator has been added to the offshore scheme. Then this generator has been linked to the cluster by ac cables. Finally, an extra wind farm is connected to the cluster by dc cables and the HVDC system is connected onshore through a point-to-point connection.

2. VSC Control Strategy

The introduction of self-commutating IGBT in VSC converters has radically boosted their installation in industrial operation. The IGBT has improved performance of the controlled system during normal and/or abnormal operation improving power transmission through HVDC connection [10-12].