Investigation on Fault-ride Through Method for VSC-HVDC Connected Offshore Wind Farms: New Proposal

Wenye Sun*, Raymundo Enrique Torres-Olguin*+ & Olimpo Anaya-Lara*+

Norwegian University of Science and Technology* and SINTEF Energy Research+

Objective

This work proposes a novel fault-ride through method for VSC-HVDC connected to offshore wind farms. The proposed method initiates a controlled voltage drop at offshore grid to achieve a fast power reduction when an onshore fault occurs. Almost simultaneously, the individual wind turbine detects the voltage drop of offshore grid, then its controller decreases the power set-point to reduce the power output from each wind turbine.

Introduction

When a fault occurs at the ac grid, the onshore converter is unable to transmit all the active power to the ac grid, however OWF still inject active power to offshore converter. This results in power imbalance that will charge the capacitance in the dc-link. Without any actions, this will result in a fast increase of the dc voltage, which may damage the HVDC equipment.

Test System

Two OWFs with capacity of 300 MW and 200 MW connected to the onshore grid via VSC-HVDC is considered as the test system, shown in Figure 1.

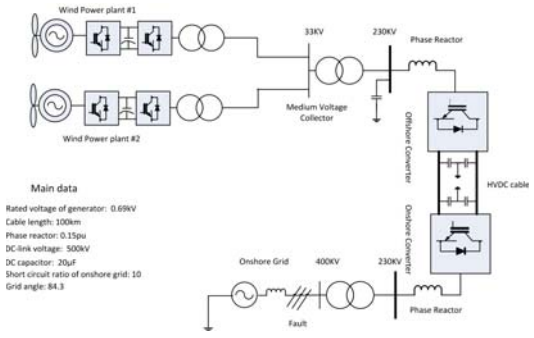

Figure 1: Figure caption

Control design for VSC-based HVDC

Since the wind turbines can control active power and reactive power by themselves, the basic function of the offshore converter controller is to maintain the ac voltage and frequency in the OWF grid. The block diagram of the controller is shown in Figure 2.

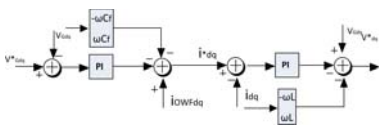

Figure 2: Figure caption

The control objective of onshore converter is to regulate the dc-link voltage. Additionally, the onshore converter can regulate the reactive power to provide voltage support. The controller is shown in Figure 3.

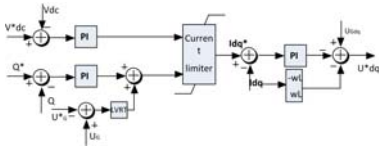

Figure 3: Figure caption

Proposed Fault Ride through Method

The overall control structure is shown in Figure 4. When an onshore fault occurs, the dc voltage at the offshore converter will increase. When the dc-link voltage exceeds its threshold value, it will activate the offshore converter controller to control offshore ac voltage magnitude based on (1). Almost at the same time, wind turbines detect the offshore ac voltage magnitude reduction. A power droop factor is generated and sent to wind turbine to de-load active power based on (2).

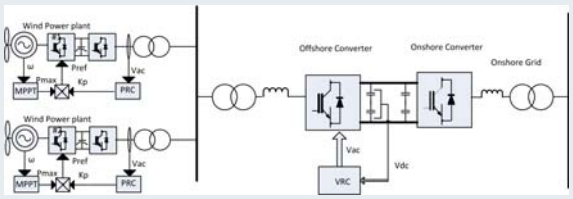

Figure 4: Control structure of the novel fault-ride through method

$$V_{ac} = V_{ac_{ref}} - k_v(V_{dc_{ref}} - V_{dc}) \quad (1)$$

$$K_p = \frac{V_{reduce}}{V_{rated}} \quad (2)$$

Simulation Results

The effectiveness of this method is verified by simulation in PSCAD. A three-phase-to-ground fault occurs at 10.5 s and last for 200 ms, and a small ground fault resistance is used.

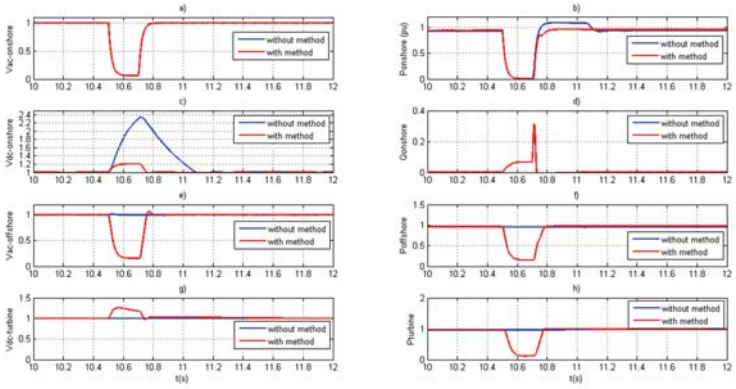

Figure 5: Three phase-to-ground fault without and with FRT

Conclusions

This paper proposed a novel FRT method for VSC-HVDC connected OWF system. There are four main advantages of this novel FRT method:

- Fast OWF power reduction by decreasing the offshore grid voltage and the output power from each wind turbine is also reduced.
- There is no communication delay.
- The wind turbine drive train does not suffer from large electrical stress.
- This method largely improves the control ability of HVDC over voltage and limits the dc voltage within safety value.

Contact email: wenye.sun@cn.abb.com