Investigation of DC Collection Networks for Offshore Wind Farms

The possibility to connect offshore wind turbines with a collection network based on Direct Current (DC), instead of Alternating Current (AC), gained attention in the scientific and industrial environment. There are many promising properties of DC components that could be beneficial such as: smaller dimensions, less weight, fewer conductors, no reactive power considerations, and less overall losses due to the absence of proximity and skin effects. On the other hand, challenges arise due to low grid impedance, high input and output current ripple of DC/DC converters, and high fault currents in case of an incident. To provide a solid foundation for a DC collection network simulation, intensive research of electrical representations of components was performed, and suitable models were identified and implemented in the transient simulation program PSCAD. By utilizing this tool, transient effects and fault scenarios in wind turbine converters, cables, and in the High Voltage Direct Current (HVDC) link, were studied. The steady-state simulations of the system showed high ripple current due to the low grid impedance and the high input and output ripple of the converter. Three different solutions have been proposed to reduce the ripple. In general, the proposed DC grid shows a good transient response to disturbances, and steady-state conditions are regained after the faults. As expected, peak current and voltages during fault conditions reached high magnitudes up to 15 times the nominal value. Additionally, each model of the DC grid has been evaluated regarding losses, and an overall efficiency of the DC collection network was found to be 94.9%.

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