ABSTRACT

Thesis Title: ***Implementation of DC Voltage Droop Control in Multi-Terminal VSC-HVDC Transmission for Offshore Wind Farms***.

Historical background of DC & AC power transmission goes way back to 1880s, at that time power transmission was only possible using Direct Current (DC) technology. First commercial power transmission was in Wall Street, New York. It was Sir Thomas Alva Edison, who pioneered DC technology. Later in that era, Sir Nicola Tesla purposed an AC power transmission system. Since then, the war of currents began. At that time, the battle was lost by DC transmission. But today in the 21st century, power system has become a complex structure. With significantly increasing population, the need of providing each and every one with basic necessities is of an utmost concern. One of the most basic need is electrical power. Today, the world is facing a situation where only having an energy source is not an ultimate priority, but having a clean energy source is of ultimate concern. Nowadays, not only the problem of increasing power demand is in our hands, but also the problem of secure and optimum power transmission is at the center of excessive concern. Although electrical power generation technology is a very mature technology, but when clean energy generation is concerned, only renewable energy resources comes into the picture rather than conventional power generation sources. The reason being, the impact of these conventional methods on the environment. Power generation among different renewable energy sources, if to be compared, then it can be stated that wind energy has the highest share in renewable energy power generation. Wind energy farms are located where the strong winds are available. Mostly wind farms are located onshore, i.e., land. But lately, offshore wind farm technology has been developed where wind farms are constructed offshore, i.e. in the sea bed. The advantage of this technology over existent one is that strong wind is available in the offshore region. Also, RoW which is an ultimate concern in onshore wind farm's construction, is not a point of major discussion in offshore wind farm technology. Now as the penetration of renewable sources of energy is increasing day by day, the point of power generation is moving far away from load centers. Therefore, a strong power grid is required to cope up with a large range of power transmission. Hence, there is an inherent need for long distance bulk power transmission. A detailed comparison has been carried out on High Voltage AC (HVAC) vs High Voltage DC (HVDC) systems. It can also be noted that after break-even distance, HVDC power transmission is more economical than HVAC transmission. Therefore, HVDC transmission system is preferred for transmitting power in renewable energy power systems, especially in offshore wind farm power generation. There are 2 available technologies in HVDC transmission: Voltage Source converter (VSC) HVDC and Line Commutated Converter (LCC) HVDC. Here VSC-HVDC technology is less matured technology as compared to LCC-HVDC technology. In VSC, both turn off and turn on can be controlled whereas in LCC only turn on can be controlled, for commutation of LCC valves line AC voltage is responsible. This thesis presents the design, control, and analysis of power transmission used in offshore wind farms. The main objective of this research is in VSC-HVDC power transmission technology than generation and construction of offshore wind farms. In this thesis, inclination for research towards VSC-HVDC systems for study over LCC-HVDC systems lies in nature of controllability of systems. This thesis discusses an overview of conventional LCC HVDC, and VSC-HVDC technologies based power transmission. Different control strategies for VSC-HVDC systems are studied, and their MATLAB/Simulink models are developed. Control strategies carried out here are: Active Power control, Reactive Power Control, DC Voltage Control, and DC Voltage Droop Control. A Two Terminal Point to Point Bipolar VSC-HVDC Test Grid and a Four Terminal VSC-MTDC Test Grid, are proposed in this thesis for power transmission in an offshore wind farm. In MTDC topology, Two VSCs are operated as the rectifiers, which are located at two different offshore wind farm regions, which are transmitting power to Two onshore VSCs operating as inverters and these VSCs are further connected to two different AC grids. Controller tuning, and operations are tested on VSC-HVDC systems against various parameters changes using developed models in Simulink. A detailed comparison is carried out for loss of converter operation in MTDC test grid (with, and without DC voltage droop control action).