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Improvement of power system stability by using a VSC-HVdc ☆

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ABSTRACT

The capabilities of a VSC-HVdc to improve the stability in power systems are analyzed in this paper. The analysis considers a power system which has the need for increasing the transmission capacity. Two options are analyzed: connection of a new ac transmission line or connection of a VSC-HVdc link. Different disturbances are applied in the system in order to analyze the dynamic response of the system. Supplementary control is included in the control of the VSC-HVdc. The control strategies in the supplementary control are based on nonlinear and linear theory. Furthermore, remote and local information are used as input signals in the control strategies. Simulation results clearly showed the benefits of VSC-HVdc in the improvement of power system stability.

1. Introduction

Steady state stability, lack of reactive power supply, voltage stability, electromechanical oscillations and transient stability are common problems that can occur in networks that transmit large amount of power over long distance transmission corridors. If these long corridors are used in the interconnection of power systems, poor damping of low frequency interarea oscillations and load flow problems are also very likely to happen.

The increase of both transmission capability and flexibility in these type of grids with conventional ac options is a challenge [1]. Voltage or transient stability, increase of short circuit levels and unaccepted network loop flows often limits the expansion with ac transmission lines [2].

Thanks to the capacity of independent control of active and reactive power, the use of VSC-HVdc systems in ac networks have shown to be an advantageous solution in these cases. By having embedded VSC-HVdcs in ac grids it is possible to enhance the stability in power systems and have a higher control of power flow [3,4].

The objective of this paper is to analyze the impact of connecting either a new ac line or a new VSC-HVdc link on the stability in a power system. The analysis is done by comparing the dynamic response of a test power system under different fault cases. The control of the VSC-HVdc includes a supplementary control to enhance the stability of the system by modulating the active power. Two control strategies based on different theory frame are also compared. Moreover local and remote information in the input of the control strategies are also analyzed.

1.1. VSC-HVdc

VSCs are based on valves that can be switched on and off by a control signal. By choice of the switching instant it is possible to generate any desired wave shape. With higher switching frequency components it is possible to use Pulse Width Modulation (PWM) technology to re-create the ac voltage with any phase angle or voltage amplitude (within certain limit). Thus, PWM offers the possibility to control both active and reactive power independently. The control of the voltage magnitude and the phase angle of the converters makes the use of separate control for active and reactive power possible. The active power loop can be set to control either the active power or the dc-side voltage. In a dc link, one station will then be selected to control the active power while the other must be set to control the dc-side voltage. The reactive power control loop can be set to control either the reactive power or the ac-side voltage. Either of these two modes can be selected independently at either end of the dc link [5].

In the research, the open model of the trademark HVDC-Light available in the software of simulation [6,7] is used. Fig. 1 shows a block diagram of the control of the VSC.

In the figure, the inputs ΔP_c, ΔQ_c and ΔU_{ac-c} are intended for supplementary control. In this paper only the input ΔP_c is used to improve damping and stability.

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