Dynamic Series Compensation and DC circuits for the Reinforcement of Network Connections with High Wind Penetration

JC Nambo-Martinez [1*], Kamila Nieradzinska[2], Olimpo Anaya-Lara[3]

e-mail: juan.nambo-martinez@strath.ac.uk, kamila.nieradzinska@strath.ac.uk, olimpo.anaya-lara@eee.strath.c.uk

[1,2,3]Department of Electronic and Electrical Engineering, Institute of Energy and Environment, University of Strathclyde, Royal College Building, 204, George Street, G1 1XW Glasgow, UK, Phone +44 (0) 141 552 44 00

Abstract

The targets set by the EU leaders in March 2007, known as the "20-20-20" targets, have the main objective of reducing 20% of EU greenhouse gas emissions compared to the levels from 1990.

Therefore, the UK Government issued plans to build around 40GW of renewable power generation for 2050, most of which derives from new offshore wind farms constructed around the British mainland. In order to connect such amounts of power to the UK mainland network, the reinforcement of existent AC transmission lines becomes a necessity along with the development of new transmission paths.

In current times VSC-HVDC is the preferred technology used to deliver high amounts of new power generation, this because of the several benefits that this DC circuits can provide to the system. However, VSC-HVDC technologies are not used in parallel circuits with AC lines because this configuration could cause the system to experience power oscillations.

Thyristor Controlled Series Capacitors (TCSC) are series compensation devices capable of providing variable reactive series compensation, a feature that can be used to increase the transmission capacity of AC transmission lines, to contribute to the reduction of power oscillations, and to improve system stability.

This paper explores the use of TCSC technologies as a possibility for allowing the interaction between AC lines and VSC-HVDC links working in tandem, with the purpose to reinforce transmission paths which will facilitate the integration of new wind generation and analyses the benefits that the interaction of both devices can provide to the system.

Methodology

This study compares two versions of a system with an AC transmission line connected in parallel with a VSC-HVDC link. In the first model (figure 1) the AC transmission line does not have any source of reactive compensation, while, in the second model (figure 2) a TCSC provides reactive series compensation to the AC transmission line.

This study analyses the system response to different changes of power delivered by the HVDC connection to the receiving end of the circuit.

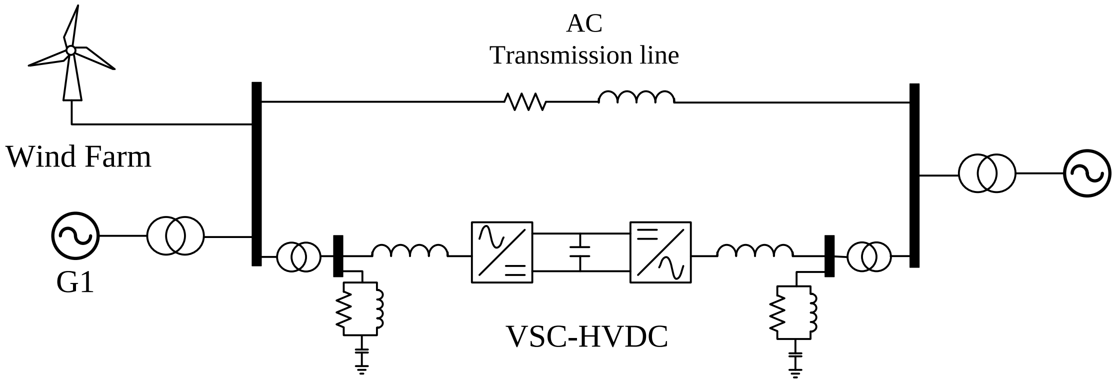

Figure 1. DC link in parallel with a non-compensated AC transmission line.

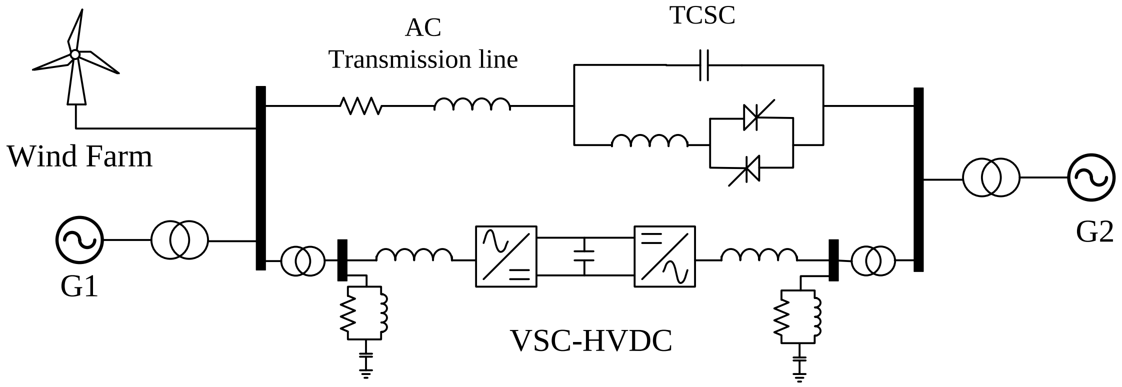

Figure 2. DC link in parallel with an AC transmission line with variable series compensation (TCSC).

Results

The results show how a TCSC besides increasing the power transmission capabilities of the AC transmission lines, also contributes to the reduction of the power oscillations that may be caused by the parallel connection between AC lines and HVDC links, without affecting the system stability.

At the same time it is shown that with the use of the AC voltage control, the HVDC link is capable to maintain the AC voltage at both PCC's close to 1pu.

Furthermore, it is expected that the study will show how the use of TCSC devices allow the AC lines to transport the totality or a fraction of the power delivered by the HVDC link, while the power angle remains close to the original value which benefits the system stability, in case that one of the HVDC links has to be taken out of operation.