VOLATILE

Voltage Control on the transmission grid using wind power at other voltage levels

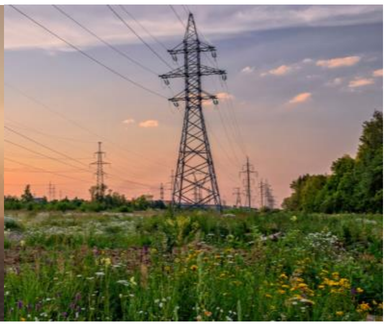
VOLATILE: Combining new advanced control methods for real grids for estimating challenges and possibilities with distributed reactive power support.

Wind power has grown strongly in recent years. For Sweden nuclear power will be phased out during the coming decades, which causes a need of new generators such as wind energy. In Denmark and other countries large amounts of wind power is currently in operation and it is expected that the amount will increase significantly.

In a power system there is a need to keep a good voltage. This is often done by using the synchronous generators in the power plants connected to the transmission system. With large amounts of solar and wind power enters the system, then the amount of these centrally power plants will decrease. The question is then how to keep the voltage.

The possibility to be studied here is to use wind power stations on other voltage levels to keep the voltage on the transmission level. Methods concerning controller design, communication and parameter setting will be combined with impact studies on real networks in order to estimate the possibility to implement this option.

The project combines the expert knowledge in control methods applied to power systems from KTH and DTU with the knowledge and experience of operation of real grids from Vattenfall.



Project Duration

01.02.2016 - 06.30.2018

Project Budget

Total Budget: € 825000

Funding: € 743000

Project Coordinator

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Project Partners

- KTH (Sweden)
- DTU (Denmark)
- Vattenfall (Sweden)

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Smart Grids Plus ERA-Net

This project has received funding in the framework of the joint programming initiative ERA-Net Smart Grids Plus, with support from the European Union's Horizon 2020 research and innovation programme.

Main Objectives

The aim of the project is to identify the possibilities to use voltage control in WTG:s located in sub-transmission and distribution systems in order to control the voltage in the transmission system. This includes several different sub-objectives as

Identification of suitable input signals: Controlling the voltage implies controlling the reactive power production/consumption in the windpower converters. In order to do so it is important to identify what inputs are needed for the control of these converters.

Identification of suitable control algorithms: Based on the input signals to the different controllers in WTG:s, SVC and transformer tap-changers, it is possible to identify different controllers that could control the target voltage in the best way.

Identify the need of reliable communication in order to make the controllers work properly and veriify that the controllers are robust and there will be no instabilities in the control set-up

Case studies in real systems:

Main Results

Distribution System Capabilities for Reactive Power Support

Before applying control strategies, boundaries of the system have to be identified to ensure reliable and stable operation of the distribution system. Future investments in the grid have to be directed to enhance their capability of satisfying reactive power needs of overlaying grids. For this reason, reactive power capability of the typical Swedish rural distribution grid with distributed wind power is assessed for different scenarios of development:

1. Exchange of overhead lines with underground cables
2. On-Load Tap Changer (OLTC) influence

For the first scenario, part of the grid consisting of overhead lines has been replaced with cables. The particular change resulted in 35% increase in reactive power bandwidth at the point of common coupling with the overlaying grid.

Second scenario asseses how the operation of OLTC influences the reactive support capability of the grid. In the reference case, OLTC was blocked meaning that it’s tap-ratio value was kept fixed on one. This is quite often done in distribution systems to avoid control interaction between OLTCs and other controllers which might lead to instabilities in the system. Then, OLTC was enabled allowing it to change the tap ratio

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value in order to optimize (maximize provision and consumption) the reactive power support to the overlaying grid. For two analysed utmost loading conditions, increase of reactive power bandwidth of 65% and 70% respectively has been achieved.

Final conclusons

Bigger penetration of cables in disitrubition systems as well as coordinated control of OLTCs with reactive power sources in the grid substantially enhances distribution grids' reactive power capabilities meaning that they can support reactive power to the overlaying grid in enlarged reactive power bandwidth.

Coordinated voltage control of wind power and combined AC/DC grid

Voltage source converter (VSC) based high voltage direct current (HVDC) has attracted a lot of attention for integrating offshore wind power due to its good controllability and cost efficiency for wind power plants (WPPs) far from the shore.

In order to ensure secure operation of the wind power plants and grid, it is important to maintain good voltage in the WPPs, DC grid and external alternate current (AC) grid. On the other hand, the voltage stability of the external AC grid is often compromised by the low voltage levels of the critical buses, e.g., load centers. Therefore, improving the voltage levels of the critical buses can increase the system-wide loadability and ensure the voltage stability, which will be a severe concern in the future power systems with high penetration of intermittent renewable energy.

The objective of this research is to develop a coordinated voltage control scheme for offshore WPPs connected through a multi-terminal DC (MTDC) grid (the offshore part) and the external AC grid (the onshore AC bus and its neiboughering load centers, i.e., the onshore part). A model predictive control (MPC) method will be employed for the coordinated voltage control of the offshore part and the onshore part. The simulation will be done in three stages. In the first stage, the voltage control of the offshore part will be studied by the MPC method. Two control modes, i.e., the corrective mode (pull the voltage levels back into the allowed range) and normal mode (to minimize losses), will be studied. The second stage is mainly focusing on the onshore part, which includes the onshore converters of the HVDC connections and the neiboughering load centers connected by OLTC equipped transformers. The voltage levels of the onshore part are maintained by the MPC method. In the third stage, the coordination between the onshore and offshore parts are done by a coordinated MPC method, where the offshore part will provide a reference voltage for the offshore part. So far, we are in the second stage.

Final conclusons

From the simulation results of first stage, it can be concluded that the MPC method can be employed for the voltage correction and voltage maintainence of the offshore WPPs. It has superior performance than the traditional methods, such as the propotional allocation method or the local voltage control based on a droop control.

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