Modeling of Grid-Connected VSCs for Power System Small-Signal Stability Analysis in DC-Link Voltage Control Timescale

Abstract:

This paper presents With the increasing use of voltage source converters (VSCs) in power electronics dominated power systems, oscillation phenomena in DC-link voltage control (DVC) timescale (around 10Hz) among multiple VSCs have occurred. Several studies have tried to analyze these oscillation problems, but all associate with the single VSC situation. To consider the dynamic interactions between VSCs in DVC timescale, especially in the weak grid condition, this paper presents a small-signal model to understand VSC external characteristics based on motion equation concept also featured in synchronous generator (SG). Comparisons of time-domain simulation responses and Eigen values show the proposed model can hold the main behaviors of concern. The form of the model is very similar to the rotor motion equation in SG, with which power engineers have been very familiar.

Existing method:

The existing method describes the dynamics of power systems with large scale VSCs in DVC timescale, time domain simulation method and Eigen value analysis method based on the differential algebraic equation (DAE) and state-space equation, respectively, can also be used. Combing with these methods, the characteristics of VSCs and power network, which are two factors to determine the behaviors of such power systems, also need to be researched. While, the models like which contains the details of different control loops in VSC to reflect VSC’s characteristics, can be hardly used to understand the behaviors of power systems with a large amount of VSCs due to their complexity. The characteristics related with these control effects need to be abstracted and simplified. In addition, to consider the characteristics of VSCs and power network separately in power system analysis, VSC’s external characteristics are of more interest than its internal details.

Proposed method:
The proposed method proposes, a small-signal model of VSC is proposed to describe its external characteristics related with the dynamics of DC-link voltage and control actions in DVC timescale. This model synthetically considers the control effects in VSC and is established based on the motion equation concept that has gotten good applications in recent references. The form of the model is just like the rotor motion equation of synchronous generator (SG), which has been effectively used to analyze the rotor dynamics in conventional SG dominated power systems.

**Block diagram of proposed method:**

![Block diagram](image)

**Drawbacks of existing method:**

1. It can be hardly used to understand the behaviors of power systems with a large amount of VSCs due to their complexity.

**Advantages of proposed method:**

1. Synchronous generator (SG), which has been effectively used to analyze the rotor dynamics in conventional SG, dominated power systems.

**Applications:**

HVDC transmission and FACTS applications.