Implementation and Enhancement of a New Control and Balancing Concept for MMC-HVDC Links in Rigid Bipolar Configuration

Master or Bachelor Thesis

High Voltage Direct Current (HVDC) transmission systems based on Voltage Source Converters (VSC) have become a promising solution for the integration of renewable energy sources into existing AC power grids as well as for the future grid extension. Especially, their efficiency and high controllability makes them a feasible option in many application cases, which require flexible bulk power transmission. As VSC-HVDC systems provide independent set points for active and reactive power injection on the AC side as well as stabilizing and decoupling capabilities, they are particularly used to interconnect weak and asynchronous AC nodes.

Up to today, most HVDC links are built as monopolar systems. However, due to the steadily growing power demand worldwide and the subsequently necessary raise of power ratings in the transmission systems (e.g. of transmission links which have to interconnect large scale wind power plants, hydropower, etc. with far distant load centers), a trend towards bipolar VSC-HVDC schemes is expected. Bipolar configurations can offer a higher transmission capacity due to a usage of two converters per station and therefore provide better redundancy than monopolar configurations. As indicated in Figure 1, two basic concepts of the Bipole exist. The first concept, the Symmetric Bipole, considers a Dedicated Metallic Return (DMR) in order to provide a current return path during single pole outages as well as to define the neutral bus potential of the ungrounded converter station during the system’s operation. While the Symmetric Bipole can be seen as the simplest bipolar configuration with regard to its protection and control system, the Rigid Bipole comes without a DMR. Therefore, an enhanced voltage balancing control is required to keep the neutral bus voltage between the positive and negative pole of the ungrounded Bipole within a suitable tolerance range (see Figure 1), in particular during contingencies. The main advantage of the Rigid Bipole is the saved DMR while the HVDC link still keeps part of its redundancy compared to monopolar HVDC configurations. Due to this, the Rigid Bipole may represent a feasible trade-off between investment costs and reliability for power system operators.

![Figure 1: Bipolar HVDC link scheme (floating neutral bus potential to be balanced is highlighted)](image-url)
Within this thesis, a proposed Rigid Bipole voltage control and balancing concept shall be implemented into an existing Modular Multilevel Converter (MMC) model in PSCAD\EMTDC\TM, where its functionality shall be tested and validated on a simulative basis. Subsequently, possible enhancements for this new concept should be identified and investigated. The objective is to achieve a reliable and robust functionality during different contingencies, e.g. severe transient faults that require a Fault Ride Through (FRT).

Goals and focus of the thesis:
Your focus and core tasks will be:

- Familiarization with
  - the MMC as the state of the art VSC-HVDC converter technology (Rigid Bipole with half and full bridge technology),
  - control theory with respect to the MMC converter,
  - *Electromagnetic Transient (EMT)* simulation with PSCAD\EMTDC\TM
- Literature search for balancing controls for the neutral bus voltage to reach a stable steady state of the ungrounded rigid bipolar converter station (see Figure 1)
- Implementation of a suitable balancing control
- Evaluation of the dynamic behavior and control parameter optimization
- Appropriate discussion of the results and documentation

Your profile:

- Interest in HVDC systems and control topics
- Basic skills in Matlab/Simulink\TM and PSCAD\EMTDC\TM advantageous

Other:

- The thesis can be written in either English or German.

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Focus

- HVDC converters
- Control
- Simulation