

Operational Planning of Electric Power System with Multi-terminal VSC-HVDC



Ph.D. student: Wang Feng

Supervisor and Examiner: Prof. Lina Bertling

Co-supervisor: Tuan Le (Chalmers)

Anders Mannikoff (SP)

Anders Bergman (SP)

Financial support: Chalmers Energy Initiative (CEI)

Partners: Chalmers University of technology,

SP Technical Research Institute of Sweden



2011-12-02

Chalmers Energy Initiative

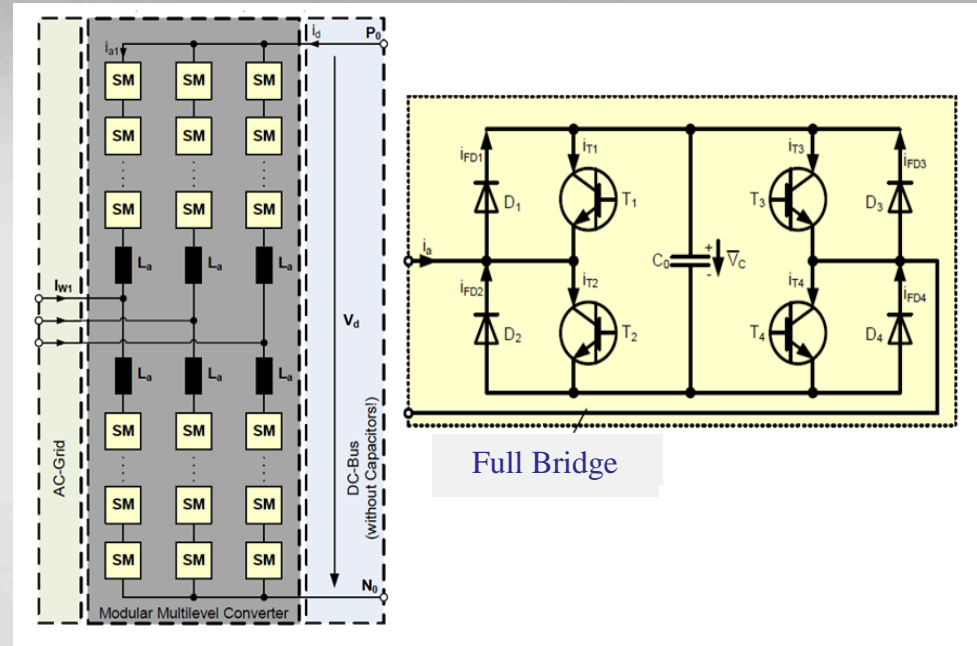
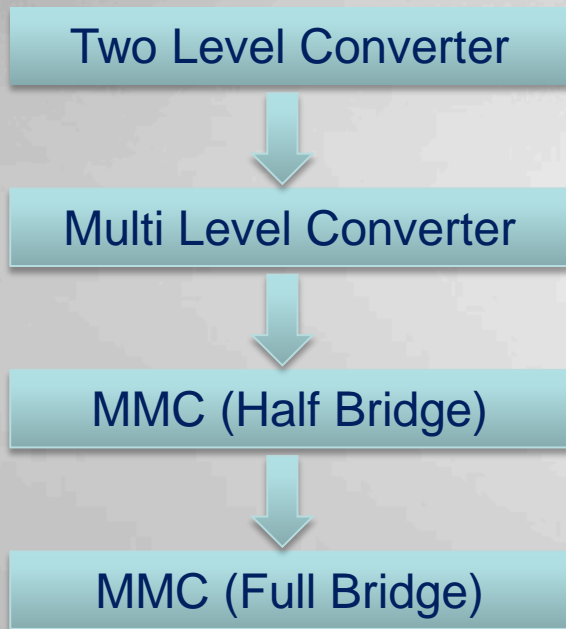
Outline

- State-of-the-art of VSC-HVDC
 - VSC Topologies
 - Modeling and Control
- Project examples
- Potential applications
- Summary from literature review

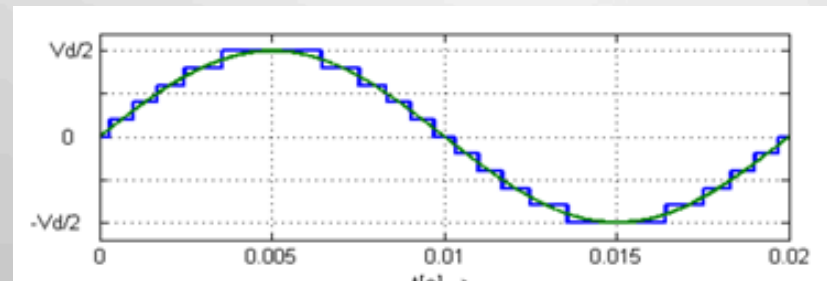
- Example results
- Further work



State-of-the-art of VSC HVDC: VSC Topologies



Modular Multilevel Converter (MMC) **

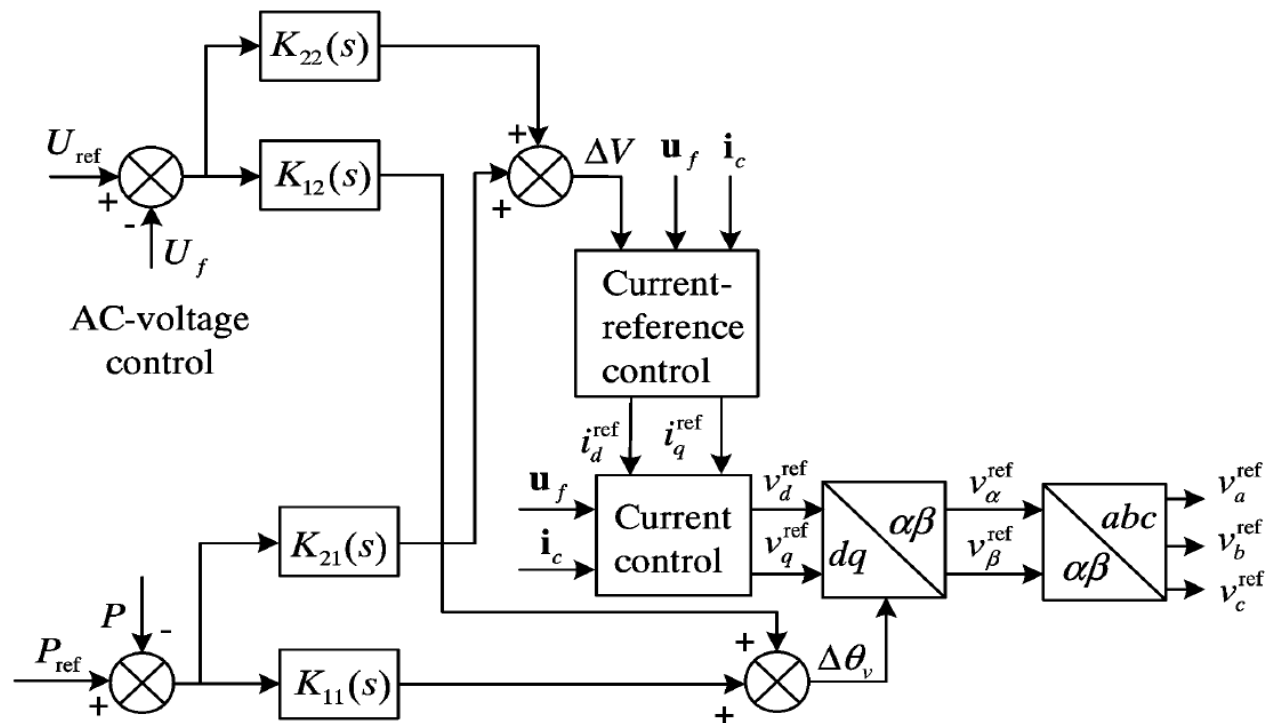


** R. Marquardt, "Modular Multilevel Converter: An universal concept for HVDC-Networks and extended DC-Bus-applications," in *Power Electronics Conference (IPEC), 2010 International*, 2010.



State-of-the-art of VSC HVDC: Modeling and Control

Power-Synchronization controller in synchronous frame **



** Z. Lidong, L. Harnefors, and H. P. Nee, "Interconnection of Two Very Weak AC Systems by VSC-HVDC Links Using Power-Synchronization Control," *Power Systems*, IEEE Transactions on, vol. 26, pp. 344-355, 2011.

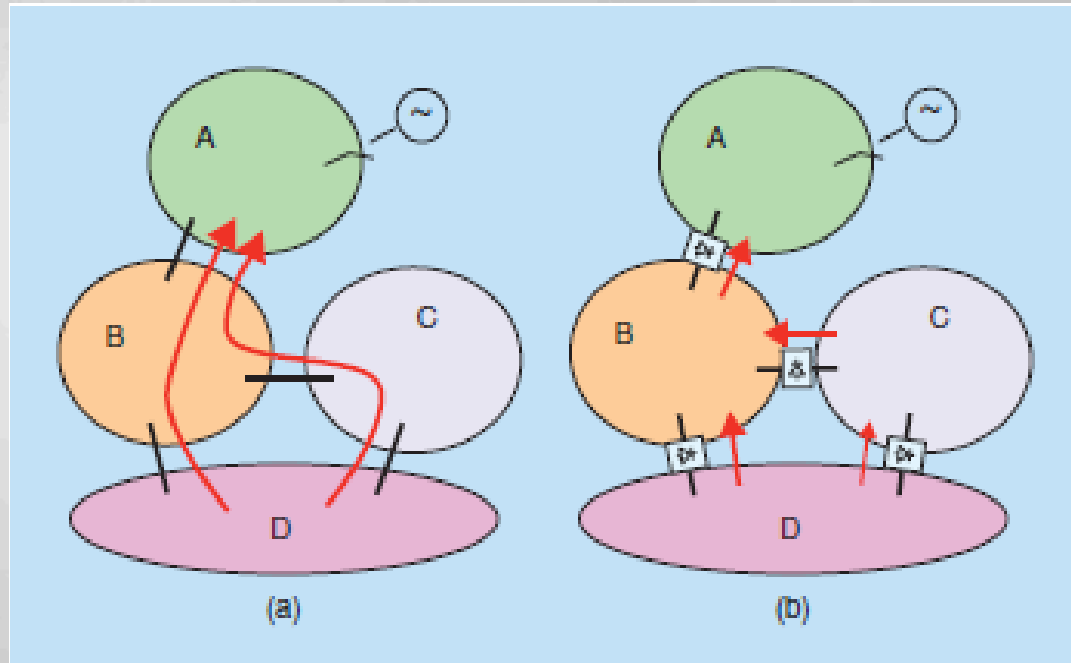
Example Projects

Project Name	South West link, Sweden/Norway
Year of Commissioning	South part 2014 West part 2016 (Scheduled)
Power Rating	South part: 2x600 MW
DC Voltage	± 300 kV
Remarkable: The first multi-terminal VSC HVDC system	



Potential Applications

- Multi-terminal VSC-HVDC
- Hybrid System of CSC and VSC
- Segmentation of AC Grid
- Meshed DC grid



Segmentation of ac grid using VSC-HVDC ⁴

4. H. Clark, A. A. Edris, M. El-Gasseir, K. Epp, A. Isaacs, and D. Woodford, "Softening the Blow of Disturbances" (Power and Energy Magazine, IEEE, vol. 6, 2008, pages 30-41).

Summary from Literature Review

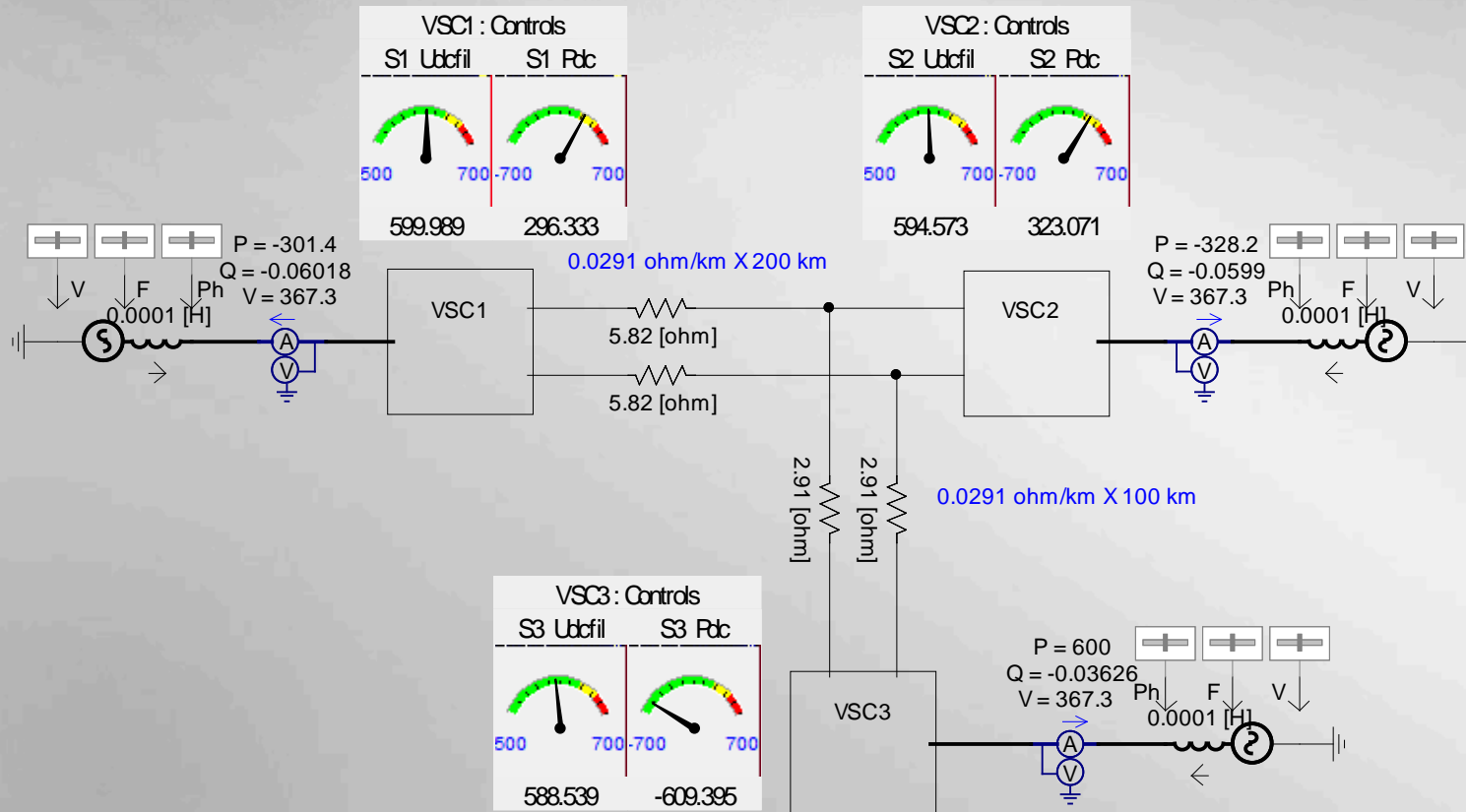
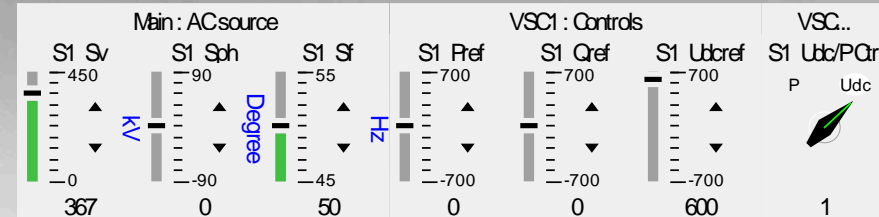
The most important aspects concerning this technology include:

- Applications of MMC in HVDC
- New modelling and control methods of VSC
- Future applications of VSC will be multi-terminal VSC HVDC and/or DC grid
- Research studies on operations of mixed DC and AC grid at the system level will be more demanding.



Example Results

Three-terminal VSC-HVDC model (preliminary) in PSCAD/EMTDC



Further work

- Steady state study
 - Joint AC and DC load flow calculation
 - Optimal operation study in steady state condition
- Dynamic study
 - VSC model simplification for dynamic studies in the system level
 - Multi-terminal VSC-HVDC system development using simplified VSC model in the system dynamic study platform
 - Interaction study between AC and DC system





**Questions or
comments?**

Thank you!



Contact Information

Wang Feng

Electric Power Engineering
Energy and Environment Department
Chalmers University of Technology
SE-412 96 Gothenburg, Sweden

+46 73 658 6258

feng.wang@chalmers.se

<http://www.chalmers.se>

<http://www.chalmers.se/ee/EN/research/research-divisions/epe>

