ELECTRIC DRIVES AND MACHINES INSTITUTE

TU Graz

Lehrveranstaltungsankündigung

LV 431.317 Selected Topics of Drive Systems (WS 2022)

High-Voltage DC Current Transmission Systems

(2 SWS / 3 ECTS)

Instructor

Prof. Maryam Saeedifard received the Ph.D. degree in electrical engineering from the University of Toronto, in 2008. Since January 2014, she has been with the School of Electrical and Computer Engineering at Georgia Institute of Technology, where she is currently holds a Dean's professorship position. Prior to joining Georgia Tech, she was an assistant professor at Purdue University and a research scientist with the Power Electronic Systems Group, ABB Corporate Research Center, Switzerland. Her research interests include power electronics and its applications in power systems and vehicular electrification.

Course description

High Voltage DC (HVDC) transmission is a long-standing technology with many installations around the world. Over the past few years, significant breakthroughs in the Voltage-Sourced Converter (VSC) technology along with their attractive features have made the HVDC technology even more promising in providing enhanced reliability and functionality and reducing cost and power losses. Concomitantly, significant changes in generation, transmission, and loads such as (i) integration and tapping renewable energy generation in remote areas, (ii) need for relocation or bypassing older conventional and/or nuclear power plants, (iii) increasing transmission capacity, and (iv) urbanization and the need to feed the large cities have emerged. These new trends have called for Multi-Terminal DC (MTDC) systems, which when embedded inside the AC grid, can enhance stability, reliability, and efficiency of the present power grid. This course provides a comprehensive description and overview of the MMC-HVDC systems. This course provides a comprehensive description and review on the most recent advances and contributions on the operational issues, modeling, control, protection, and operation of the MMC-HVDC transmission systems and multi-terminal HVDC grids.

Learning outcomes

1. Understand the principles of HVDC transmission systems and their differences with AC transmission.
2. Understand basics of operation, control and operational challenges of the state-of-the-art modular multilevel converter (MMC)-HVDC transmission systems.
   - Circulating current suppression
   - Capacitor voltage balancing
3. Develop various control strategies for proper operation of the MMC-HVDC systems.
   - Circulating current suppression
   - Capacitor voltage balancing
   - Closed-loop control
4. Understand the protection issue and develop several protection schemes against DC-side short circuit faults.
   - Fault detection
   - Dynamic of the MMC during the DC faults

- Calculation of the DC fault current and voltage stress
- Alternative MMCs with DC side fault handling
- Solid-state hybrid DC circuit breakers

5. Understand the control and protection of multi-terminal HVDC transmission grids
   - Droop control of various HVDC converter stations
   - Fault detection, primary and secondary protection
6. Stability and control challenges of HVDC-connected wind farms
   - Control interactions and source of instability
   - - Mitigation

General Competencies

1. Knowledge of semiconductor devices and control theory.
2. Knowledge of power electronics and basics of operation of inverters/rectifiers.
3. Ability to implement simulation models in the MATLAB/SIMULINK or PSCAD/EMTD software tools.

Course Topics

1. Introduction to HVDC transmission systems and various configurations and components.
2. Analysis and operation of LCC-based HVDC systems, basics of operation of LCCs, control aspects, harmonics, filtering, and faults.
3. Analysis and operation of voltage-sourced converter (VSC)-based HVDC systems, basics of operation of VSCs, semiconductor devices, control aspects, harmonics, filtering, and faults.
4. Multilevel VSCs, their basics of operations, salient features and operational challenges.
5. Fundamentals of operation of the state-of-the-art HVDC transmission systems based on Modular Multilevel Converters (MMCs), circuit topologies and submodule configurations, steady-state analysis, and component rating issues
6. Control aspects of the MMC-HVDC systems including internal dynamics, pulse-width modulation techniques and submodule capacitor voltage balancing strategies, circulating current control, and closed-loop current control, and operation under AC and DC faults and unbalanced conditions.
7. Analysis and protection of MMCs when subjected to DC-side faults, Hybrid solid-state DC circuit breakers, MMCs with embedded DC fault handling capabilities, analysis of fault current and calculation of peak fault current
8. Multi-terminal HVDC grids, architectures, droop control, and protection

References

1. Nilanjan Ray Chaudhuri, Balarko Chaudhuri, Rajat Majumder, and Amir Yazdani, Multi-terminal Direct-Current Grids, IEEE Press/ John Wiley, 2014.
2. Conference and Journal Papers