DEE-46006 HVDC - Power transmission

This is a post-graduate course, which carries 5 cr and is delivered over four days, as follows: 2-3.04.2020 and 16-17.04.2020. The course starts at 9:00 am each day. The venue is room K2115A in the Konetalo Building of the University of Tampere, Hervanta Campus.

The course is in two parts. Part 1 offers an overview of the HVDC technology, encompassing high-voltage power transmission, its role in power generation and in low-voltage distribution systems. It starts with an outline of the role of the HVDC technology within the electrical power sector – past, present and future. The physics and operational principles of the classical and modern semiconductors valves and converters are discussed. The role of the various converter bridges in HVDC transmission is covered, including multi-level VSC converters. Applications of HVDC links in power transmission, power generation and low voltage power distribution are addressed.

Day 1: 7 hours

1. **Background:** the power electronics industry in the electrical power sector. Early developments, current-status, future directives, challenges and areas of opportunity for the HVDC technology, installations. 3½ hr.

2. **Power transmission using classical HVDC:** basic principles, diodes and thyristor valves and bridges, HVDC transmission schemes. 3½ hr.

Day 2: 7 hours

3. **Power transmission using VSC-HVDC:** basic principles, GTOs and IGBTs valves and bridges, HVDC transmission schemes. 3½ hr.

4. **Application areas:** bulk power transmission; AC *vs* DC; HVDC in wind power; HVDC in PV solar power, HVDC in wave power, HVDC in low-voltage distribution systems. 3½ hr.

Part 2: Steady-state assessments of AC/DC power grids

Part 2 of the course offers a thorough grounding in the theory of power flows and its implementation in software, to carry out comprehensive power flow simulations. Advanced models of classic and modern HVDC links aimed at power flow solutions, are developed from first principles. Plenty of numerical examples and computer-based simulations are carried out to support and to illustrate the theory.

Day 3: 7 hours

5. **Support analysis tools:** Power flow theory and programming using Matlab scripting. 3½ hr.

6. **Modelling and simulation of classical HVDC:** thyristor-based HVDC link modelling and their inclusion in a power flow computer program, numerical exercises. 3½ hr.

Day 4: 7 hours

7. **Modelling and simulation of modern HVDC:** VSC-HVDC link modelling and their inclusion in a power flow computer program, numerical exercises. 3½ hr.

8. **Applications:** wind power, solar PV power and wave power. 3½ hr.

Assignment: an engineering-type project will be carried out using a power flow computer program written in MATLAB scripting, e.g. simulating an energy transaction scenario between two areas, a planning study to build an offshore windfarm.

Course assessment: the assessment will comprise two elements, namely, a two-hour exam and the assignment. The former will contribute 60% of the overall marks and assignment will contribute 40%.

Reading material: E. Acha et al (2019), *VSC-FACTS-HVDC: Analysis, modelling and simulations in power grids*, Wiley & Sons.