

Training Content

Power Transmission with HVDC

DAY 1

MODULE 1: HVDC-LCC – Fundamentals and steady state operation

Line commutated converters - Overview and principle of operation 1 1/2 h

Basics of power electronics and line-commutated converters (LCCs).

LCC operation principles. LCC technologies for HVDC.

Coffee break

Exercises: Analysis of six-pulse thyristor bridge using *PowerFactory* 1 1/2 h

Introduction to the thyristor-based rectifier model, effect of thyristor gate controls load flow analysis.

Q&A session

Lunch break

Steady-state analysis of HVDC-LCC 1 1/2 h

HVDC configurations and components.

Steady-state behaviour, ideal and real commutation, selection of commutation reactance.

Reactive power demand and compensation.

HVDC-LCC harmonics and harmonic cancellation.

Coffee break

Exercise: Steady-state model of HVDC-LCC in *PowerFactory* 1 1/2 h

Implementation of an HVDC-LCC model, power flow setpoints, load flow analysis, reactive power compensation, functions for power flow optimisation in a transmission network.

Q&A session

DAY 2

MODULE 2: HVDC-LCC – Dynamic Simulation

DC-Link Controls and Dynamics

1 1/2 h

Control schemes for rectifiers and inverters. Implementation in *PowerFactory*, firing angle and extinction angle control.

Coffee break

Exercise: Power System Analysis

1 1/2 h

DC link power control and re-dispatch, response to AC-system faults.

Q&A session

Lunch break

Exercise: Power System Analysis (continued)

3/4 h

DC link power control and re-dispatch, response to AC-system faults.

HVDC LCC - Interactions with AC Systems

3/4 h

AC System Strength, Steady-state stability, Dynamic Stability, Screening and Analysis methods for Sub-Synchronous Oscillations (SSO)

Coffee break

MODULE 3: HVDC-VSC – Steady-state Analysis

Introduction to VSC/MMC

1 1/2 h

Voltage-sourced converter (VSC), modular multi-level converter (MMC), MMC with half-bridge or full-bridge submodules, point-to-point HVDC links, multi-terminal HVDC systems, operation principles, applications, steady-state control strategies.

Q&A session

DAY 3

HVDC VSC/MMC - Models in *PowerFactory*

3/4 h

Built-in components for HVDC VSC/MMC. Global library template models: DIgSILENT/Manufacturer specific. Available variants for different configurations and applications.

Exercise: Steady-state studies

3/4 h

Implementation of MMC-HVDC links into AC network models, application: embedded link in 50 Hz grid; load flow analysis, different control strategies.

Coffee break

Exercise: Steady-state studies (continued)

3/4 h

Implementation of MMC-HVDC links into AC network models, application: embedded link in 50 Hz grid; load flow analysis, different control strategies.

MODULE 4: HVDC-VSC – Dynamic Analysis

Dynamic behaviour (I)

3/4 h

Dynamic control strategies (control for islanded and non-islanded operation), upper level controls.

Lunch break

Dynamic behaviour (II)

3/4 h

Lower level controls, modulation techniques, protection schemes (power setpoint adaptation, DC chopper, converter blocking), behaviour during network faults.

Exercise: Dynamic behaviour

3/4 h

HVDC link to offshore wind park: dynamics under normal operating conditions, response to network disturbances and DC overvoltage mitigation.

Coffee break

Exercise: Dynamic behaviour (continued)

1 1/2 h

Dynamics under normal operating conditions, response to network disturbances, DC overvoltage mitigation in offshore HVDC links.

Q&A session

DAY 4 (half-day)

Exercise: Power system analysis

1 1/2 h

Practical use case examples of power system analysis with HVDC systems.

Coffee break

Faults in the DC link

3/4 h

Response of half- and full-bridge MMC HVDC systems to DC link faults.

Small signal analysis and power quality aspects

3/4 h

HVDC VSC/MMC System small signal stability analysis.

Power quality of HVDC VSC/MMC

Q&A session

Time Schedule (Central European Time)

Full-Day	Time
First 90 minutes block	9:00
Coffee break	10:30
Second 90 minutes block	10:45
Q&A session	12:15
Lunch break	12:30
Third 90 minutes block	13:30
Coffee break	15:00
Fourth 90 minutes block	15:15
Q&A session	16:45
End of the training day	17:00

Half-Day	Time
First 90 minutes block	9:00
Coffee break	10:30
Second 90 minutes block	10:45
Q&A session	12:15
End of the training day	12:30



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