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 ½ 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 ½ 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 ½ 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 ½ 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 ½ h

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

Coffee break

Exercise: Power System Analysis — 1 ½ h

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

Q&A session

Lunch break

Exercise: Power System Analysis (continued) — ¾ h

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

HVDC LCC - Interactions with AC Systems — ¾ 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 ½ h

Application cases, point-to-point HVDC links, multi-terminal HVDC systems; voltage-sourced converter (VSC), modular multi-level converter (MMC), MMC with half-bridge or full-bridge submodules, operation principles, modulation techniques; steady-state control strategies.

Q&A session

DAY 3

HVDC VSC/MMC - Models in *PowerFactory* — 1 ½ h

Modelling aspects, *PowerFactory*'s built-in components for HVDC VSC/MMC, model templates in the global *DIgSILENT* library, available variants for different configurations and applications.

Coffee break

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Exercise: Steady-state studies **1 ½ h**

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

Lunch break

MODULE 4: HVDC-VSC – Dynamic Analysis

Controls and dynamic behaviour **1 ½ h**

Dynamic control strategies (control for islanded and non-islanded operation), upper level controls, lower level controls, protection schemes (power setpoint adaption, DC chopper, converter blocking), behaviour during network faults.

Coffee break

Exercise: Dynamic behaviour **1 ½ h**

HVDC link to offshore wind park: dynamics under normal operating conditions, response to AC network faults, DC overvoltage mitigation in the offshore HVDC link.

Q&A session

DAY 4 (half-day)

Exercise: Power system analysis **1 ½ h**

Practical use case examples of power system analysis with an HVDC system: 50 Hz/60 Hz HVDC internconnector, response to frequency events (frequency sensitive mode), contribution to power oscillation damping.

Coffee break

Faults in the DC link **¾ h**

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

Small signal analysis and power quality aspects **¾ h**

HVDC VSC/MMC system small signal stability analysis in the frequency-domain.

Aspects for power quality assessment of power systems with HVDC VSC/MMC.

Q&A session

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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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