Electromagnetic Transient Analysis

PowerFactory 2024

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July 16th - 18th 2024

Online Training Course via Zoom

The course gives an overview of electromagnetic transients in power systems and the simulation techniques available in *PowerFactory* for their assessment. As such, it provides the participant with the necessary background to understand complex transient mechanisms in the power systems while emphasising the models required for EMT-type simulations.

The training introduces the different transient categories, from temporary, over switching up to lightning transients, in the sequence typically required for an insulation coordination study. Besides the review of the theoretical fundamentals, multiple hands-on exercises will assist the participant to familiarise with the EMT-simulation in *PowerFactory*.

WHO SHOULD ATTEND:

The course is intended for utility engineers, power system operators, project developers, manufacturers, consultants and electrical engineers in general, interested in the analysis of electrical transients in power systems.

Previous experience in *PowerFactory* basics and some experience in handing of *PowerFactory*'s time domain simulation functions, or attendance at the equivalent introductory courses ("Load Flow and Short Circuit Calculation" and "Time Domain Simulation"), is essential.

PRICE PER PARTICIPANT:

- € 1,848.00* (with valid maintenance contract)
- € 2,175.00* (without valid maintenance contract)
- € 654.00* (with valid student identification)

*Prices are exclusive of VAT

Training Content

Electromagnetic Transient Analysis

DAY 1

MODULE 1: Power System Transients

Presentation: Introduction to electromagnetic transients **1 h**

Transient phenomena in power systems. Classification of overvoltages acc. to IEC60071: temporary, slow-front, fast-front and very fast-front transient overvoltages. RMS versus EMT simulations. Handling: definition of simulation events and result variables. Visualisation of simulation results. Fast Fourier Transform analysis.

MODULE 2: Transformer Energisation

Presentation: Transformer energisation **1 h**

Fundamentals. Transformer inrush currents. Saturation characteristics. Residual flux. Harmonic content of inrush currents. Resonance and overvoltages excited by inrush currents.

Coffee break

Exercise: Transformer energisation **1 h**

Energisation of a transformer in a weak network. Determination of maximum inrush currents. Decaying DC component. Voltage dip during energisation. Assessment of typical grid code compliance. Mitigation of inrush currents. Conversion of RMS to peak values.

Q&A session

Lunch break

MODULE 3: Capacitor Switching

Presentation: Capacitor switching **1 ½ h**

Fundamentals. Inrush currents and switching overvoltages during energisation of capacitor banks. Back to back connections. Mitigation of inrush currents.

Coffee break

Exercise: Filter bank energisation **1 ½ h**

Natural oscillation frequencies. Simulation of inrush currents and maximum transient overvoltages in a filter bank. Back-to-back energisation of a second filter bank.

Q&A session

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DAY 2

MODULE 4: Transient Recovery Voltage (TRV) Analysis

Presentation: Transient recovery voltage (TRV) analysis — 1 ½ h

Fundamentals. Overview of abnormal switching transients, trapped energy and current chopping. Dielectric strength of circuit breaker after contact opening. Suppression (or chopping) and recovery overvoltages. Voltage escalation following abnormal switching.

Coffee break

Exercise: TRV analysis for shunt reactor drop out — 1 ½ h

Assessment of switching overvoltages due to reactor drop out. Circuit breaker capability curves. Current chopping. Mitigation using R-C surge suppressors.

Q&A session

Lunch break

MODULE 5: Overhead Line and Cable Models for EMT Simulations

Presentation: Overhead line and cable models — 1 ½ h

Geometric models for overhead lines and cable systems. Conductor types and frequency dependecy. Single core cable types and bonding options. Lumped and distributed parameter models. Travelling wave effects.

Coffee break

Exercise: Modelling of overhead lines and cable systems — 1 ½ h

Definition of double circuit overhead line and double circuit single core cable system. Analysis of coupling effects using EMT simulations. Line energisation with distributed parameter model. Travelling wave effects.

Q&A session

DAY 3

MODULE 6: Line Switching

Presentation: Line switching — 1 ½ h

Fundamentals. Line re-energisation. Distributed frequency dependent line models. Stochastic switching assessment. Mitigation measures.

Coffee break

Exercise: Switching overvoltages in a mixed OHL/cable system — 1 ½ h

Overhead line energisation and re-energisation. Cable energisation with missing zero-crossings. Maximum transient overvoltages based on deterministic and stochastic approaches. Modelling of surge arresters and pre-insertion resistors. Stochastic switching.

Q&A session

Lunch break

MODULE 7: Lightning Transients

Presentation: Lightning transients — 1 h

Fundamentals of transient phenomena and its interaction with the power system. Modelling of relevant power system components for lightning transient analysis: impulse sources, line/cable surge impedances, tower footing resistance, dielectric strength of isolators. Surge arresters.

Exercise: Model enhancement for lightning analysis — 1 h

Definition of the overhead line model for lightning analysis. Phase conductors and earth wires. Line couplings. Model of the footing resistance. Voltage controlled switches to represent the flashover. Impulse current sources.

Coffee break

Exercise: Assessment and mitigation of lightning overvoltages — 1 h

Determination of the lightning performance of a transmission line. Simulation of direct and earth wire strikes. Back flashover. Overvoltage mitigation: selection of surge arresters. Lightning protection characteristic. Energy duty. Lightning overvoltages under consideration of surge arresters.

Q&A session

Time Schedule (Central European Time)

	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

DIgSILENT GmbH
Heinrich-Hertz-Str. 9
72810 Gomaringen
Germany

T +49 7072 9186-0
F +49 7072 9168-88
mail@digsilent.de

www.digsilent.de