

Grid Connection of Renewable Generation

MODULE 1: Introduction to Grid Connection of Renewable Generation (Estimated Time: 1.5 h)

Grid Connection of Renewable Generation

General introduction into the field of grid connection studies for power parks.

Exercise: Building a power park model

Configuring a 50 MW power park with inverter based resources (IBR). Getting acquainted with the existing power park network. Definition of the PQ capability of a single generation unit.

MODULE 2: Reactive Power Capability (Estimated Time: 2.5 h)

Reactive Power Capability Requirements

Overview of the typical grid code requirements specified for renewable generation with regard to reactive power capability at the Point of Connection (PoC).

Exercise: Reactive Power Capability

Grid code compliance in terms of reactive power provision at the PoC. Identification of the P-Q power park capability and comparison with given grid code requirements. Design the reactive power compensation unit so that regulatory compliance is achieved.

MODULE 3: Short-Circuit Analysis (Estimated Time: 1.5 h)

Short-Circuit Analysis

Learn about the options *PowerFactory* offers to consider short-circuit contribution from IBR according to different standards and with focus on IEC 60909 and the proprietary *Complete Method*.

Exercise: Short-Circuit in a Power Park

Verification of equipment ratings using the IEC 60909 method (worst case/planning stage behaviour). Verification of thermal ratings of a MV cable.

MODULE 4: Power Quality Assessment (Estimated Time: 2.5 h)

Power Quality Assessment

Fundamentals. Harmonic Load Flow according to IEC 61000-3-6. Overview of the calculation procedure. Definition of IEC harmonic sources and Harmonic Load Flow handling in *PowerFactory*.

Exercise: Power Quality Assessment acc. to IEC 61400-21

Evaluate the power quality of a power park according to IEC 61400-21, including calculation of voltage distortion due to harmonic injections in the power park.

MODULE 5: Dynamic LVRT Simulation of Wind Generators (Estimated Time: 4 h)

Dynamic LVRT Simulation of Wind Turbines and Introduction of the Dynamic Model of a WT with fully rated converter

Dynamic Simulation Fundamentals. Handling in *PowerFactory*. Get familiar with the *PowerFactory* dynamic models designed for fully rated converter WTs, with focus on IEC models, their structure, control block diagrams and supported functionality

FRT Grid Code Requirements

Learn about typical grid code requirements for FRT (fault ride through) capability of renewable generation.

Exercise: WT with fully rated Converter

Use a WECC type 4 model (fully rated converter based) to perform a dynamic short-circuit study according to the German VDE-AR-N 41xx or the ENTSO-E regulations. Learn how to test dynamic controllers and apply different controller settings (e.g. K factor for LVRT).

MODULE 6: Dynamic LFSM Simulation of Wind Generators (Estimated Time: 2.5 h)

FSM/LFSM Grid Code Requirements and Simulation

Overview of typical grid code requirements regarding frequency power control. Introduction to the simulation of overfrequency and underfrequency events in *PowerFactory*.

Exercise: LFSM Simulation with IEC Type 3 WTG

In this exercise, you will analyse the LFSM behavior of an aggregated wind farm model using a preconfigured *PowerFactory* project. Voltage and frequency profiles are provided via a measurement file, enabling simulation of specific grid events. The goal is to evaluate the system's response during under- and over-frequency scenarios.

MODULE 7: Photovoltaic (PV) Systems (Estimated Time: 2.5 h)

Photovoltaic (PV) Systems

Fundamental introduction to photovoltaic systems. Load Flow models for PV systems. The “Photovoltaic System” built-in model for steady-state analysis. Introduction into the tool “Park Energy Analysis” and into the “Quasi-Dynamic Simulation”.

Exercise: Calculation of the energy yield of a large PV park

Learn how to use the Power Park Energy Analysis tool using time series data. Study the steady-state voltage profile of the feeder. Adapt PV system data and apply various operational settings.



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