DIgSILENT

PowerFactory for Wind Power Applications

Introduction

DIgSILENT's network simulation program PowerFactory incorporates extensive modelling capabilities with advanced solution algorithms, to provide electrical engineers with tools to carry out power system studies – from easily manageable calculations to very advanced simulations of the highest complexity. With more than 25 years of experience, DIgSILENT provides state-of-the-art algorithms and models, as well as leading, innovative developments to meet the needs of the future. Especially in wind power applications, DIgSILENT PowerFactory has become the de-facto standard tool, providing all required models and simulation algorithms and achieving unrivalled accuracy and performance.

Power System Analysis Needs with Increasing Wind Power Generation

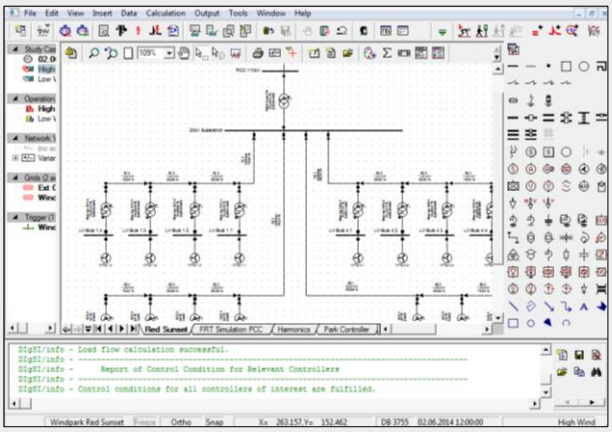
During recent years, the growth in worldwide installed wind power generation capacity has substantially changed transmission and distribution grid characteristics, introducing new engineering tasks in system planning and grid operations. The increasing size of wind turbines and wind parks has lead to some of the greatest challenges currently present in the field of Power Systems engineering:

Voltage changes, loadings, and losses are analyzed by using Load Flow calculations. To undertake detailed analysis of grid losses, power generation patterns and energy yields, wind time series covering periods of days, weeks, months, or even years have to be considered.

Synchronous generation, which has traditionally determined grid characteristics, is being replaced step by step by inverter fed generation systems. Such systems introduce completely new dynamic characteristics, influencing short-circuit currents and network stability.

Grid impact studies covering steady state, fault analysis as well as dynamic aspects (stability and EMT type studies), must consider the behaviour of inverter fed generation systems.

Grid codes determine the design and behaviour of wind turbine and wind farm controllers. Calculation of steady-state results and simulation of dynamic behaviour is essential for defining grid code rules, and for evaluating the behavior of wind turbines and wind farms according to grid code requirements.



Testing and validation of wind turbine simulation models on the basis of field tests, parameter identification and benchmark analysis is necessary to guarantee high model accuracy. Typical models cover fundamental frequency level (dynamic RMS / stability), or electromagnetic transient level (EMT), both including controllers and protection devices for fault-ride-through (FRT) simulations.

The increasing use of power electronics converters in grids, is leading to new challenges and new solutions in the field of power quality. Harmonic analysis and flicker evaluation including compliance studies according to IEC requirements in the planning process are becoming more and more important.

Non-dispatchable renewable generation with limited prediction accuracy requires new considerations in generation planning and grid expansion engineering:
In particular, the execution of comprehensive Capacity Credit studies considering stochastic modelling of the network including wind farms with stochastic wind models.

All wind power integration studies require specific power system analysis capabilities to allow for accurate, efficient and flexible project execution.
High precision wind generation models for any kind of wind generator technology are necessary.

PowerFactory Features to Support Wind Power Applications

DIgSILENT GmbH has given priority to wind power applications for more than 10 years. Design and grid integration studies of the world's first offshore wind park "Horns Rev" in Denmark were completed using PowerFactory.

Since then, DIgSILENT PowerFactory has been developed further, to satisfy the needs and requirements of power system planners, certification and research institutes, transmission and distribution utilities and wind turbine manufacturers. Among many unique PowerFactory features and capabilities, the following are most essential:

Modelling

Library of generic wind turbine models (generators connected via fully-rated converters, doubly-fed induction generators, induction generators with variable rotor resistance)

In addition, world-class manufacturers have their specific models (validated acc. German TR4) implemented in PowerFactory. These models may be requested from the manufacturer

Support of integrated single-phase and three-phase AC/DC grid modelling with balanced and unbalanced operating conditions

Numerous models of power electronic devices such as voltage-sourced converters (VSC), semiconductor valves for chopper applications, etc.

Doubly-fed induction generator models of varying complexity, including the capability of crowbar switching

A general "Static Generator" model representing all kinds of generators which are connected via fully-rated converter

Flexible modelling options for implementing any kind of dynamic model (e.g. device controller, prime mover, protection relay, coordination and supervising controller) including interfacing options with Matlab/Simulink

Injection of harmonics and existence of background harmonics - either phase-correct or defined only by magnitudes acc. to IEC 61400-21 / IEC 61000-3-6:
Ideal sources, Norton and Thevenin equivalent sources are available.

Analysis Functions

Steady-state load flow calculations considering voltage-dependent reactive power capability limits, wind farm controllers with setpoint characteristics, automatically adjustable shunts, etc.

Load flow time series analysis based on long-term measurements or synthetic signals via flexible scripting functions and comprehensive visual analysis features

Short-circuit calculation with options to include dynamic voltage support acc. to k-factor settings of wind turbines

Dynamic time-domain simulations with high-precision simulation kernel (A-stable) and adaptive step-size algorithm allowing fast, efficient, robust simulations – for example for fault-ride-through (FRT) simulations

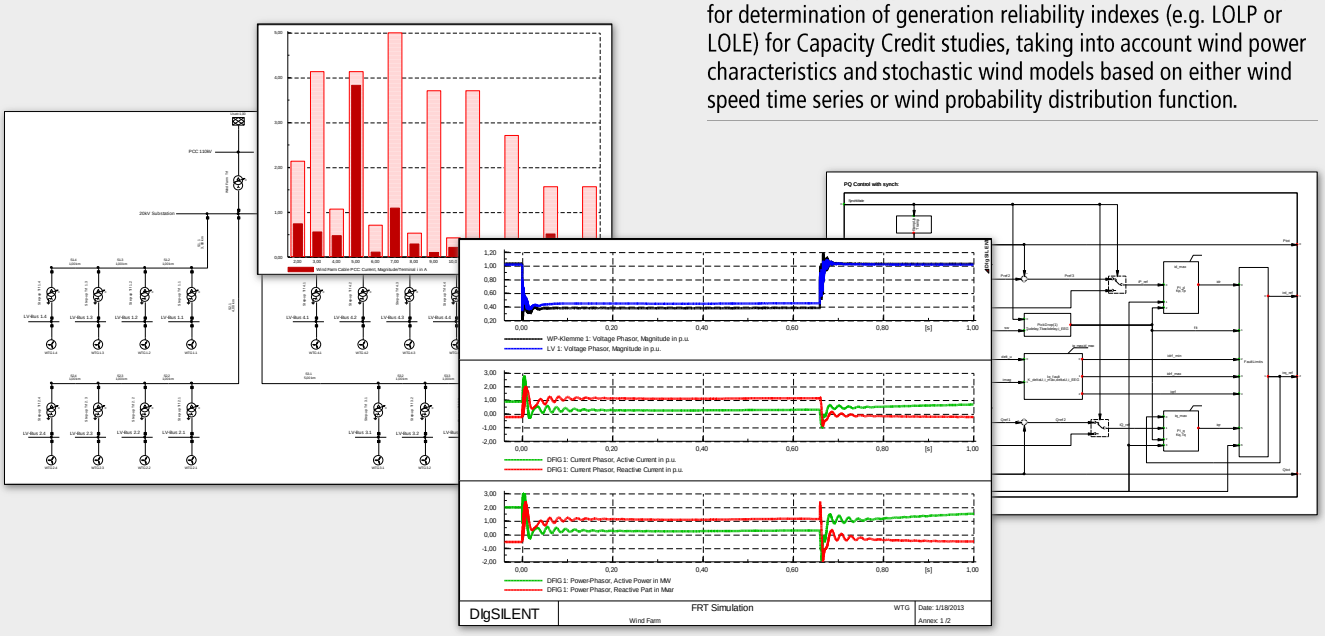
Small Signal Stability Analysis (eigenvalue analysis) of power system models having any kind of wind turbines, also considering HVDC systems, controller etc. Both the QR-method and the Arnoldi-Lanczos method are supported

Electromagnetic transients analysis (EMT) with balanced or unbalanced load flow initialization and adaptive step-size algorithm for simulating valve switching, transformer inrush, and so on

Flickermeter according to IEC 61000-4-15 for analyzing measured or simulated curves

Power quality assessment for harmonics and flicker propagation according to IEC 61000-3-6, IEC 61400-21

Generation adequacy assessment on basis of Monte Carlo Analysis for determination of generation reliability indexes (e.g. LOLP or LOLE) for Capacity Credit studies, taking into account wind power characteristics and stochastic wind models based on either wind speed time series or wind probability distribution function.



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