DIgSILENT *PowerFactory* Seminar

Power system Dynamic and Wind Power using DIgSILENT PowerFactory (Basic V14)

University of Cyprus, Nicosia-Cyprus. 24th-25th May 2011

Objective:

To provide a thorough and comprehensive introduction to the most important features of PowerFactory software.

The approach used in this course is learning-doing with a practical approach from the perspective of the power system modelling, analysis and simulation.

The topics to be covered during the seminar include: Overview of power system analysis function in DIgSILENT, RMS simulations for analysis of power system stability.

An introduction of the dynamic modelling with PowerFactory and its use for constant speed wind turbines is presented.

Pre-requisites:

- A good working knowledge of how to operate Windows, Windows Explorer and any normal Windows program (e.g. Word).
- A basic mathematical understanding of loadflow studies and fault calculations and very good mathematical knowledge of the basic techniques used in Control Theory.
- Good understanding of dynamic processes in power systems, previous experiences in time-domain simulations are desired.
- Participants should be familiar with the general handling of the PowerFactory software (Load flow and short-circuit calculation with PowerFactory)
- Background experience through the use of DIgSILENT PowerFactory - this will greatly enhance the participants; the handling of the RMS-simulations is highly desired.

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Course Program

Day 1: 24th May 2011

9:00 – 9:30	Registration
9:30 – 10:00	Welcome and introduction. Course overview
10:00 –10:30	**I. Introduction into DIgSILENT PowerFactory** ▸ Basic PowerFactory Concepts: o Functional Integration. o Vertical integration. o Database integration. ▸ The PowerFactory Project Environment: o Projects o Network Model, Libraries, Study cases o Type and Elements (*.ElmXXX y *.TypXXX)
10:30 – 10:45	▸ Structure and operation principles of DIgSILENT PowerFactory operation. ▸ Overview of main functionality. ▸ Project management. ▸ Populating the database / using the Data Manager. Using the Built in Library and creating a user library.
10:45 – 11:00	Coffee break
11:00 – 11:30	**II. Overview of Power System Analysis Functions** ▸ Overview of the DIgSILENT PowerFactory Power System Analysis Functions: o Load Flow Analysis o Short-Circuit Analysis o Harmonics Analysis o Stability and EMT Simulations o Modal Analysis / Eigenvalue Calculation
11:30 – 12:00	o Model Parameter Identification o Contingency Analysis o Reliability Assessment o Optimal Power Flow o Optimization Tools for Distribution Networks o Protection o Network Reduction o State Estimation
13:00 – 14:00	Lunch
14:00 – 15:00	**III. Load flow** ▸ Load-flow applications ▸ Examination of the models used for lines, cables, transformers, synchronous and induction machines, loads.
15:00 – 15:20	Coffee break
15:20 – 16:20	▸ Performing a loadflow and interpretation of error messages to debug the user data. ▸ Use of built in tools to analyze the load flow results.
16:20 – 17:20	**Exercises 1** ▸ Load Flow Analysis with PowerFactory o Execution of load flow calculations o Documentation of results and input data o Visualisation of data and results in the single line diagram

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Day 2: 25th May 2011

10:00 - 10:45	**IV. Power System Stability** ▸ Dynamic Processes in Power Systems o Time scales of dynamic phenomena in power systems o State space representation of power system: Differential-Algebraic-Equation (DAE) model o Power system dynamic simulation o Different Types of Simulation and Requirements for Accuracy o Simulation work and required modelling accuracy o Different types of simulation ▸ Introduction to Stability o Fundamentals of Power System Stability o Frequency stability o Voltage stability o Rotor angle stability ▸ Models for Dynamic Power System Analysis o Synchronous generators o Induction generators o Dynamic loads o Excitation systems o Turbine and governing systems
10:45 – 11:00	Coffee break
11:10 – 12:00	▸ Handling of Time Domain Simulations –Stability function- in PF ▸ RMS (Stability) vs. EMT-Simulations ▸ Initialisation ▸ Event Definition ▸ Result Visualisation, Plots **Exercises 2:** ▸ Rotor angle stability under large disturbances ▸ Modelling a one-machine system with PowerFactory ▸ Entering the network data ▸ Entering machine data ▸ Determination of critical fault clearing times
12:10 – 13:00	**V. Dynamic Modelling with PowerFactory** ▸ **Introduction to DSL (DIgSILENT Simulation Language)** o Frames and Composite Models o Block Diagram and Common Models o State Equations o Basic Modelling Blocks (Integrator, Lead-Lag, non-windup and windup limiters, etc.) o DSL overview o The standard DSL-macro library o Drawing block diagrams with PowerFactory **Exercise 3+4:** ▸ Simple Excitation System ▸ Entering the block diagram of a simple, static excitation system ▸ **Calculation of Initial Conditions** o Heuristic approach for model initialisation o Application to Exercise 3 o Systematic approach for model initialisation
13:00 – 14:00	Lunch
14:00 – 15:00	**Exercise 5:** ▸ Excitation System (AVR and PSS) ▸ Modelling of AVR and PSS in the one-machine-system ▸ Results of time-domain simulations

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15:00 – 15:30	**VI. Modelling of Wind Generation** ▸ **Wind Turbines – Basic Principles and Generator Concepts** o Generating Electrical Power from Mechanical Power o Energy conversion systems o Wind energy conversion, Betz law etc. o Wind turbine components o Status of technology
15:30 – 16:00	Coffee break
15:20 – 16:20	▸ **Basic of Wind Energy** ▸ **Generator concepts in PowerFactory** o Fixed speed induction machine o Induction generator with variable rotor resistance o Doubly- fed induction generator o Wind generator with fully rated converter ▸ **Reduced Order Model for Wind Turbines Modelling** o Model of a Constant-speed Wind Turbine ▪ Model structure and considerations ▪ Rotor model ▪ Shaft model ▪ Generator model ▸ **DSL Implementation of Constant-Speed Wind Turbine** o Aerodynamic, Mechanical and Electric systems: ▪ Frames and Composite Models ▪ Block Diagram and Common Models
16:20 – 17:20	**Exercise 6:** ▸ Simple Constant-Speed Wind Turbine ▸ Entering the block diagram of a Constant-Speed Wind Turbine **Exercise 7:** ▸ Calculating the initial conditions of a Constant-Speed Wind Turbine **Exercise 8:** ▸ Results of time-domain simulations: Dynamic behaviour of wind turbines technologies during short-circuit events

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