

POWER SYSTEM ENGINEERING AND SOFTWARE



Power System Analysis Software

# DIGSILENT PowerFactory



TRANSMISSION | DISTRIBUTION | INDUSTRIAL | DISTRIBUTED GENERATION | WIND POWER

# DIGSILENT

## Power System Analysis Software

DIGSILENT has set standards and trends in power system modelling, analysis and simulation for more than 20 years. The proven advantages of PowerFactory software are its overall functional integration, its applicability to the modelling of generation, transmission-, distribution- and industrial networks and its comprehensive user interface. PowerFactory is the ideal tool for studying the grid integration of new generation-technologies.

## PowerFactory Applications

### POWER TRANSMISSION

PowerFactory offers a complete suite of functions for studying large interconnected power systems integrating new technologies for power generation and transmission such as wind generation, virtual power plants, HVDC-VSC or FACTS. The fast and robust load flow algorithm can be applied to any AC or DC network topology. It uses highly accurate models including various types of MW and Mvar-controllers. PowerFactory's functions can be applied to improve the security, stability and economics of complex power transmission systems.

#### Typically required functions include:

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Load flow/Contingency analysis/OPF

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Nodal price and marginal cost indices

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Short circuit analysis (IEC 60909, ANSI C37, multiple fault analysis)

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Reliability assessment

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Integrated stability and transient (EMT) simulation

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Small signal stability analysis, also for very large networks

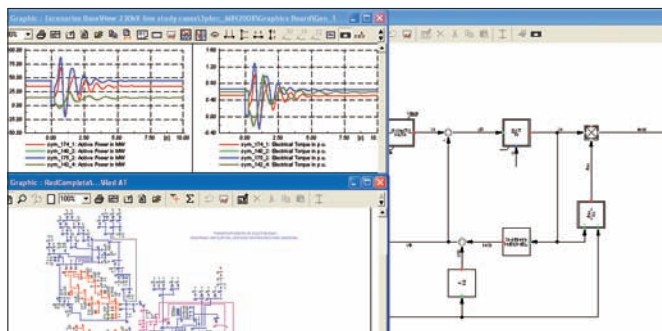
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Transmission system protection coordination and simulation

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Interfaces to SCADA/Energy Management Systems

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### POWER DISTRIBUTION

Different phasing technologies, such as single-wire earth return, two-phase, bi-phase or classical three-phase systems, have created a need for multi-phase distribution system modelling. PowerFactory provides the most comprehensive modelling features for studying all kinds of phasing technologies, meshed or radial topologies and railway supply systems connected to public distribution systems. In order to reduce network unbalance, improve quality of supply and optimize distribution networks, PowerFactory offers a large variety of functions, such as multi-phase load flow analysis, short circuit analysis (IEC 60909, ANSI C37 and multiple fault analysis), harmonic analysis, time-domain simulation and reliability assessment. Other standard features include the modelling of distributed generation and virtual power plants, voltage drop analysis, branch loading calculation, daily load curves and the consideration of LV load diversity. This is complemented by an easy-to-use protection coordination wizard.



#### Other important aspects are:

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Open tie optimisation

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Optimal capacitor placement

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Cable reinforcement strategies

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Quality of Supply Analysis

- Geographic Information Systems (GIS)
- Network Control Systems (SCADA)

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## INDUSTRIAL SYSTEMS

Industrial power systems supplying refineries, paper-mills, car factories or other plants with high power quality requirements benefit from high precision PowerFactory load flow algorithms, short circuit calculation features, 4-wire modelling, harmonics-analysis and filter design options.

**Other relevant functions include:**

Motor starting, voltage sag analysis and plant re-acceleration

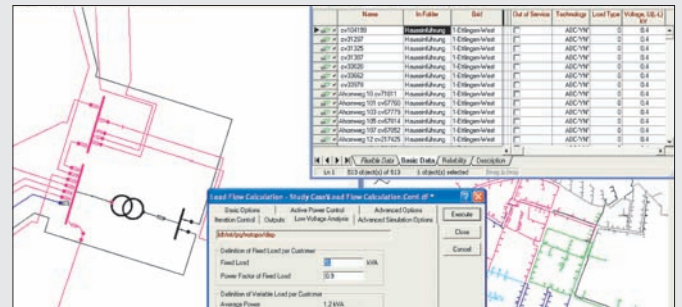
Protection coordination and settings verification

Stability analysis and electromagnetic transients

## DISTRIBUTED GENERATION

Generation at distribution levels defines entirely new challenges for distribution planning engineers due to reverse power flows, voltage drops and extreme variations in equipment loading. Various generation technologies are possible, such as synchronous and asynchronous cogeneration units, PV-cells, wind turbines, fuel cells and micro-turbines. Typical studies include steady-state and dynamic analyses, taking into consideration time-varying correlated or un-correlated energy sources.

PowerFactory is the ideal tool for analyzing the impact of distributed generation on the network. It combines classical distribution system analysis functions such as voltage drop calculation, unbalanced network, load and generation modelling, selectivity analysis, etc. with the power of a highly modern analysis tool featuring dynamic simulation functions and reliability analysis. Full support is available for developing and analysing the impact of virtual power plants and new control techniques on distribution networks.



## WIND GENERATION

Complex studies for the integration of wind generation into distribution and transmission networks are becoming increasingly important. PowerFactory, the de-facto standard in wind generation modelling, combines extensive modelling capabilities with advanced solution algorithms, providing the analyst with tools to undertake the full range of studies required for grid connection and grid impact analysis. The modelling capabilities of PowerFactory allow the inclusion of complex control dynamics, new generator technologies, blade control and wind turbulence.



Detailed wind turbine models

- Doubly-fed induction generator models (DFIG)
- Converter driven synchronous machine models (CDSG)
- Squirrel-cage induction generator models
- Manufacturer-specific high precision model with built-in control code

Power electronic devices and grid harmonic analysis

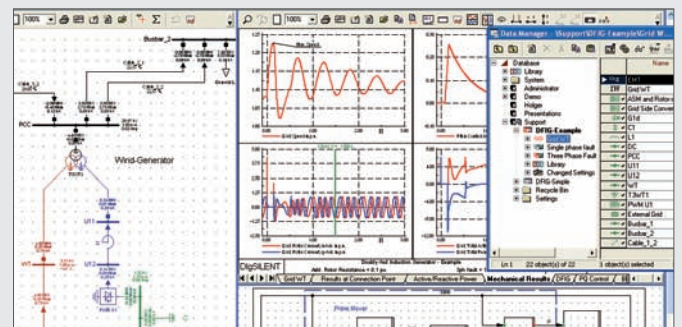
Generator protection and Crow Bar modelling

Blade control

Wind turbulence and gust models

Stability and EMT analysis

Integrated modelling of large wind parks



## PowerFactory Features

### Basic Functionality

#### Data Organization and Access

Single-user<sup>1</sup> and Multi-user<sup>2</sup> database  
 User accounting and user roles  
 Parameter characteristics on any parameter  
 User-friendly Data Manager  
 Non-redundant data modelling  
 Data versioning and data sharing  
 Management of multi-user data editing  
 Time stamped model variations  
 Highly flexible Study Case management and  
 Operation Scenario administration

#### Interfaces

Standard data formats, e.g. UCTE  
 Flexible DGS interface (ASCII, CSV, ODBC)  
 OPC and RPC Client- / Server support

#### Scripting

DPL-DIGSILENT Programming Language  
 C++ Interface for DPL scripts  
 Parameter variation studies

#### Network Diagrams

Schematic and semi-geographical diagrams  
 Overview single line diagrams  
 Classical single line diagrams  
 Design diagrams/Switch diagrams  
 Integration of overview and substation diagrams

#### Results and Reporting

Text and spreadsheet reports  
 Reporting in network diagrams  
 Around 30 diagrams for result visualisation  
 Specific diagrams for protection, harmonics, stability  
 and transients

#### Models

Support of any kind of meshed / radial 1-, 2-, 3- and  
 4 wire AC and DC networks  
 Synchronous and induction machines  
 Network branches (cables, OHLs, transformers, etc.)  
 Line routes and sections  
 Shunt and filter elements  
 FACTS and HVDC systems  
 AC/DC voltage and current sources  
 Virtual power plants  
 Doubly-fed induction machine  
 Wind generators, PV, fuel cell, micro- turbines  
 VSC, thyristor converters  
 Diodes, thyristors and transistors

#### Power Flow

AC and DC load flow algorithms  
 SVC, shunt and tap controllers  
 Generator capability curves  
 Station- and network control features  
 Secondary and primary control  
 Inertial response  
 Accurate induction machine models  
 Voltage dependent load models  
 Sensitivity analysis

#### Contingency Analysis

AC or DC load flow analysis  
 Fast contingency screening  
 Modelling of multiple time phases  
 Fault case management  
 Event-based post-fault actions  
 Tracing of individual contingency cases

#### Fault Analysis

IEC 60909, ANSI C37 and VDE 0102/0103  
 Complete superposition method  
 Multiple fault analysis

#### Integrated Functions

Network reduction  
 Voltage stability (PV curves, dV/dQ)  
 OHL parameter calculation  
 Cable loading (IEC 364)  
 Cable parameter calculation  
 Asynchronous machine identification  
 Comprehensive DPL script library

#### Optimal Power Flow (OPF)

AC optimization (interior point method)  
 DC optimization (linear programming)  
 • Contingency constraints (DC only)  
 Various objective functions such as:  
 • Minimization of losses  
 • Fuel costs

Various controls such as:

- Generator P and Q
- Transformer and shunt taps

Flexible constraints such as:

- Branch flows and voltage limits
- Generator active / reactive power limits
- Active/reactive power reserve
- Boundary flows

#### Time Domain Simulation and Small Signal Analysis

##### Dynamic Modelling

Graphical Editor for block diagram definition  
 Library of IEEE standard models  
 DSL - DIGSILENT Simulation Language  
 High precision built-in macros & functions  
 Multi-level dynamic modelling environment  
 MatLab/Simulink and C++ Interfaces  
 OPC interface for real-time applications

##### Stability Functions

Multi-phase AC networks  
 DC-networks  
 Fast, adaptive step-size algorithm  
 A-stable numerical integration algorithms  
 High precision event handling  
 Simulation of any kind of fault or event  
 Support of all protection library relays  
 Small signal analysis  
 Selective Eigenvalue analysis

##### Electromagnetic Transients (EMT)

Fast, adaptive step-size algorithm  
 Constant and frequency-dependent distributed  
 parameter cable/OHL models  
 Non-linear elements and saturation characteristics  
 Surge arrester models  
 Stochastic switching analysis  
 Impulse voltage & current source for lightning  
 surge analysis  
 Discrete R-L-C elements  
 FFT and user-defined models via DSL  
 Ferro resonance, SSR and TRV  
 COMTRADE-file support  
 Combined RMS/EMT simulation

##### Protection Functions

Comprehensive relay library with detailed static and  
 dynamic relay models  
 Transient / steady state response checks  
 Synchronization with StationWare

#### Overcurrent-time protection

Fuses and low-voltage circuit breakers  
 Cable and transformer damage curves  
 Coordination Wizard for settings calculation  
 CT verification according to IEC 60044

#### Distance protection

Comprehensive relay library  
 Electromechanical, static & digital relays  
 Any relay characteristic (MHO, polygonal)  
 R-X diagrams  
 Automatic time-distance diagrams

#### Harmonic Analysis

Harmonic load flow  
 Harmonic voltage and current indices  
 Continuous frequency sweep  
 Multi-phase or positive sequence model  
 Harmonic current and voltage sources  
 Unbalanced harmonic sources  
 Non-characteristic harmonics  
 Inter-harmonics  
 Frequency-dependent R and X values  
 Various filter models & filter sizing  
 Ripple control analysis

#### Reliability

Fast and accurate state enumeration  
 Failure models:  
 • Line, transformer, generator, busbar and circuit breaker failures  
 • Common mode failures  
 • Double earth faults  
 • Protection/circuit breaker failures  
 Maintenance schedules  
 Network Analysis:  
 • Connectivity analysis  
 • Power flow analysis  
 Failure effect analysis (FEA):  
 • Automatic protection-based fault clearing  
 • System restoration  
 • Sectionalizing  
 • Overload alleviation  
 • Undervoltage load-shedding  
 Tracing of individual cases  
 Calculation of all common indices  
 Components' contributions to reliability indices

#### Distribution Network Optimization

Optimal capacitor placement  
 Open tie optimization  
 Cable reinforcement optimization

#### Low Voltage Network Analysis

Line loads and load unbalances  
 Consideration of simultaneity factors  
 Voltage drop and cable loading analysis  
 Feeder plots and feeder scaling

#### State Estimation

P, Q, I and V-measurements  
 Observability and bad data checking  
 Pseudo measurements  
 Consideration of load flow constraints  
 Support of OPC

<sup>1</sup> Workstation Edition with local hardlock

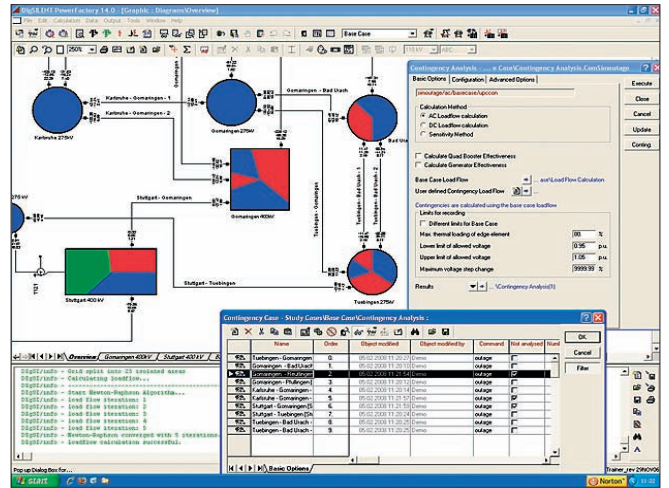
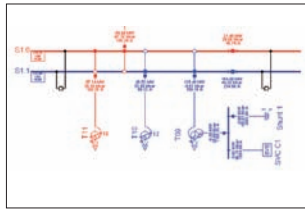
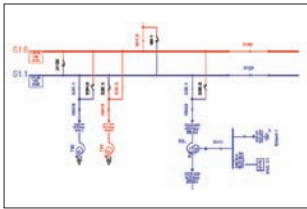
<sup>2</sup> Server Edition incl. license server and driver for ORACLE and MS-SQL

# DigSILENT PowerFactory Version 14

PowerFactory V14 continues with the successful concepts of the PowerFactory software while adding powerful new features improving the business processes of network planners, network operators, consultants and researchers.

## The focus of PowerFactory V14 is on:

- Highly efficient data management
- Powerful graphical capabilities
- Ultra-fast and accurate analysis algorithms
- New and improved models



## SOME OF THE HIGHLIGHTS ARE:

PowerFactory V14 perfectly supports teams working on the same power system model. The introduction of Master Project Management, Project Versioning and Project Deriving along with Project Compare- and Merge tools, make concurrent model building and data entry very easy.

The new "Roll Back" function allows the retrieval of any past state of a PowerFactory Project. Hence, lost data or unintended model changes are definitely history.

The idea of a "model" extends into the dimension of time. A PowerFactory V14 model may span a period of months or even years considering all network expansions, planned outages and other system events. This is possible using the new time-stamping mechanisms of PowerFactory and the corresponding tools for managing time-stamped model variations.

Operational libraries organize operational scenarios and can be combined with any time-state of the model. The independent management of model variations and operational scenarios adds a high degree of flexibility to the study case administration. Besides improved data management functionality,

Power-Factory V14 comes with new algorithms, models and graphical capabilities. Some important developments are:

### Substation models with unrestricted flexibility

Single-line diagrams with different levels of detail:

- Overview diagrams with nodes and branches
- Detailed bus-bar and switch representation
- Simplified bus-bar and switch representation
- Integration of overview and substation diagrams

Fast and flexible contingency analysis considering time phases and post-fault actions

New network reduction algorithm

Improvements to the "Complete Short Circuit Method"

DC-Loadflow

Contingency constraint economic dispatch

Coordination Wizard for automatic settings calculation

CT verification according to IEC 60044

Reliability: New failure models and improved failure effect analysis (e.g. sectionalizing, station access times)

Static Generator model for PV-cells, fuel cells, batteries

Virtual power plant model

Flexible, voltage-dependent generator capability curve

And many more "nice to have" features

# DIGSILENT GmbH

## Company Profile



**DIGSILENT GmbH** is a consulting and software company providing engineering services in the field of electrical power systems for transmission, distribution, generation and industrial plants.

**DIGSILENT GmbH** was founded in 1985 and is a fully independent, privately owned company located in Gomarigen/Tübingen, Germany, where the new offices have been in operation since early 2002. DIGSILENT continued expansion by establishing offices in Australia, South Africa, Italy and Chile, thereby facilitating improved service following the world-wide increased use of its software products and services. DIGSILENT has established a strong partner network in many countries such as Mexico, Malaysia, UK, Spain, Switzerland, Colombia, Brazil, Peru, Argentina, Iran and Venezuela. DIGSILENT services and software installations have been conducted in more than 110 countries.

### **DIGSILENT PowerFactory**

DIGSILENT develops the leading integrated power system analysis software PowerFactory, which covers the full range of functionality from standard features to highly sophisticated and advanced applications including wind power, dispersed generation, real-time simulation and performance monitoring for system testing and supervision. For wind power applications, Power Factory has become the power industry's de-facto standard tool, due to PowerFactory models and algorithms providing unmet accuracy and performance.

**DIGSILENT StationWare** is a reliable central protection settings database and management system for the complete power system substation data, based on latest .NET technology. StationWare stores and records all settings in a central database, allows modelling of relevant workflow sequences, provides quick access to relay manuals,

interfaces with manufacturer specific relay settings software, and integrates with PowerFactory software, allowing for powerful and easy-to-use settings co-ordination studies.

### **DIGSILENT Consulting**

DIGSILENT GmbH is staffed with experts of various disciplines relevant for performing consulting services, research activities, user training, educational programs and software developments. Highly specialized expertise is available in many fields of electrical engineering applicable to liberalized power markets and to the latest developments in power generation technologies such as wind power and dispersed generation. DIGSILENT has provided expert consulting services to several prominent wind-grid integration studies.

**PowerFactory Monitor** is a flexible performance recording and monitoring system that copes easily and efficiently with the special requirements for system test implementation, system performance supervision and the determination and supervision of connection characteristics. Numerous Monitoring Systems installed at various grid locations can be integrated to a Wide-Area-Measurement-System (WAMS). The PowerFactory Monitor fully integrates with the PowerFactory software.



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