

POWER SYSTEM ANALYSIS SOFTWARE

DIGSILENT

# PowerFactory 15.2



# DlgSILENT

## PowerFactory Applications

DlgSILENT has set standards and trends in power system modelling, analysis and simulation for more than 25 years. The proven advantages of PowerFactory software are its overall functional integration, its applicability to the

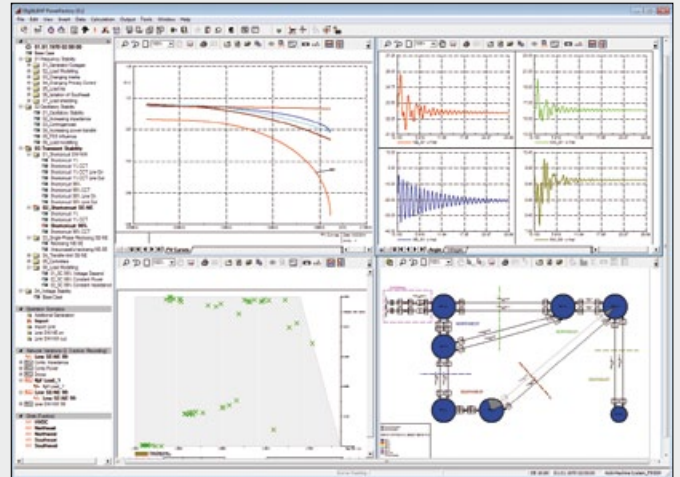


### POWER TRANSMISSION

The transmission grid is currently undergoing a major change to reliably accommodate increasing amounts of nondispatchable resources while maintaining operational efficiency and system-wide cost. The displacement of less flexible base-load generation by asynchronous wind and solar power generators imposes new challenges on the ability of the grid to maintain system stability.

PowerFactory offers a complete suite of functions for studying large interconnected power systems and addressing these emerging needs. Its fast and robust simulation algorithms can be applied to any AC or DC network topology and support the simulation of new technologies such as converter-based power generation, FACTS, voltage-sourced converters (VSC), HVDC cables and overhead lines, DC breakers, filters, and various types of MW- and Mvar-controllers and virtual power plants.

PowerFactory is also perfectly suited to transmission system operation planning. It integrates a comprehensive set of tools to support automatic and parallel grid safety analysis such as ENTSO-E D2CF/DACF/IDCF, and outage planning. Multiple interfaces (API, DGS, CIM) and flexible scripting languages (DPL, Python) enable smooth integration with existing systems.



### 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 power system modelling. PowerFactory provides comprehensive modelling features for studying all kinds of electrical networks with different 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 optimise 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, quasi dynamic simulation, time-domain simulation, optimal power restoration and reliability assessment.

Other standard features include the modelling of distributed generation and virtual power plants, voltage drop analysis, consideration of LV load diversity, daily load and generation profiles and easy-to-use protection coordination functionality.



#### OTHER IMPORTANT ASPECTS:

Tie open point optimisation

Optimal capacitor placement

Voltage profile optimisation for bi-directional power flows

Geographic diagrams (GPS-based) with background maps

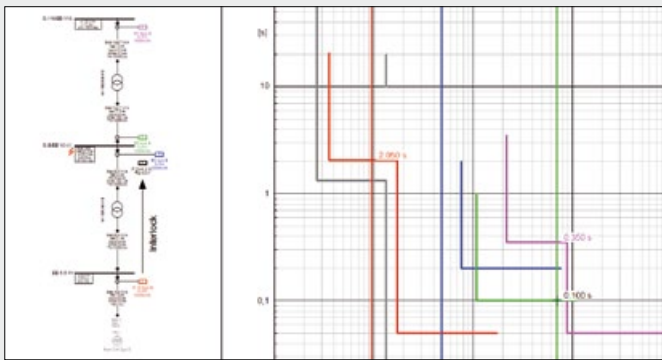
GIS and SCADA integration

modelling of generation, transmission, distribution and industrial grids and the analysis of their interactions. With its rich modelling capabilities, PowerFactory is perfectly suited for network planning and operation studies of increasingly smart grids.



## INDUSTRIAL SYSTEMS

To ensure continuity of production and the safety of personnel, the proper operation of industrial networks is of utmost importance. With high precision load flow algorithms, flexible short-circuit calculation features, 4-wire modelling, protection system modelling, harmonic analysis and filter design options, PowerFactory offers a vast array of functionality perfectly suited to the industrial user's needs. In addition, PowerFactory provides calculation accuracy, appropriate standards, clearly presented results, and a comprehensive and user-friendly interface.



### TYPICALLY REQUIRED STUDIES INCLUDE:

- Analysis of voltage drop and transformer and generator regulation using load flow functionality
- Short-circuit calculations according to IEC, ANSI and VDE standards
- HV & LV cable sizing according to IEC, NF and BS standards; ampacity, voltage drop, short-circuit capability
- Motor starting, re-acceleration and voltage drop analysis
- Protection scheme coordination (overcurrent, differential, distance and signalling)
- Harmonic distortion and resonance studies; filter sizing
- Network reliability analysis, scenarios and fault models
- Time domain simulation for stability analysis and examination of electromagnetic transients



## POWER GENERATION

Reliability and efficiency are mandatory properties of a power plant as it represents the core of any power system. PowerFactory offers tools for analysing all aspects of their electric components.



### POWERFACTORY CAPABILITIES:

- Models of generators, governors (steam, gas, diesel, water), automatic voltage regulators (AVRs) and power system stabilisers (PSSs)
- Voltage dependent PQ capability curves
- Models of motors, protection relays, power electronic converters and DC equipment
- Calculation of short-circuit currents
  - in AC grids according to IEC 60909 (VDE 0102) and ANSI
  - in DC auxiliary supply grids according to IEC 61660 and ANSI/IEEE 946
- Stability and EMT simulation
  - Behaviour during short-circuits and load changes
  - Frequency control
  - Transient stability
  - Sub-synchronous resonances
  - Transformer inrush

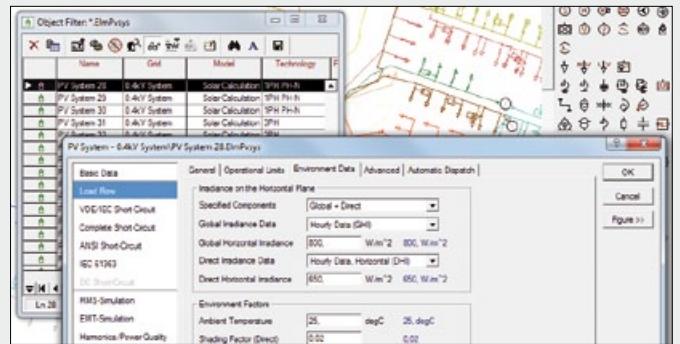


## DISTRIBUTED GENERATION

Power system phenomena such as reverse power flows, voltage dips and swells, varying fault levels and equipment loading are some of the challenges arising from distributed generation in electricity systems. Of particular note are the challenges of forecasting renewable energy generation with respect to the transfer capacity of distribution feeders under increasing deployment of smart grid technologies such as smart meters, demand side management and storage options.

PowerFactory is perfectly suited for the analysis of these challenges. It combines classical distribution system study functions such as voltage drop/rise calculation, unbalanced network assessment, fault level calculation and protection selectivity analysis with modern analysis tools featuring quasi-dynamic simulations, voltage plan optimisation, reliability analysis and power quality assessment.

The comprehensive model library in PowerFactory provides users with the ability to use ready-made objects for single and three-phase loads, consumption energy profiles, generators and converters, PV cells featuring integrated power calculation based on solar radiation, fuel cells, wind generators, micro-turbines and battery storage among others.



## WIND GENERATION

Complex studies for the integration of wind generation into distribution and transmission networks have become very important. PowerFactory, the de-facto standard in wind generation modelling, combines extensive modelling capabilities with advanced solution algorithms, thereby providing the analyst with tools to undertake the full range of studies required for grid connection and grid impact analysis:

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

Short-circuit calculation with optional inclusion of dynamic voltage support according to k-factor settings of wind turbines

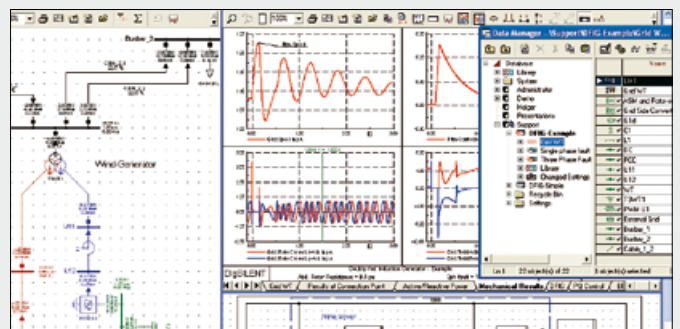
Power quality assessment according to IEC 61400-21

Stability and EMT analysis

Wind turbine models for all established generator/converter types

Additional wind power plant equipment such as controlled shunts and STATCOMs

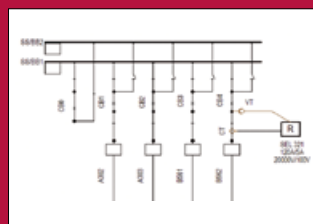
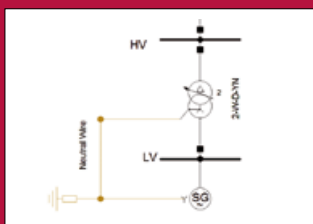
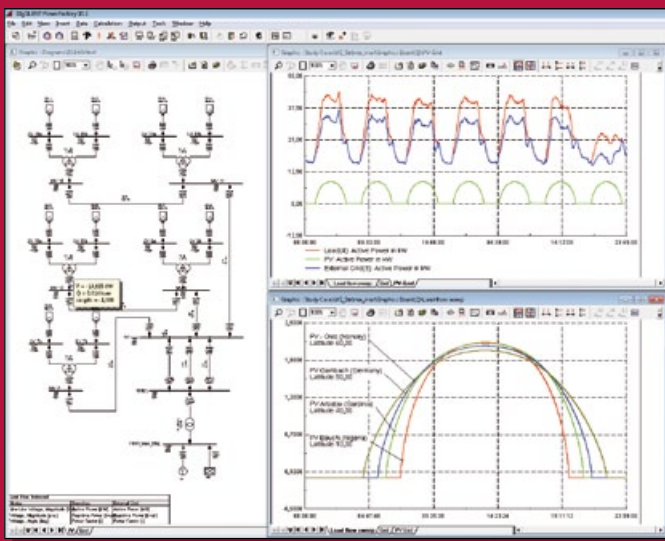
Stochastic wind models for generation adequacy studies





# DIgSILENT PowerFactory Highlights

PowerFactory is a leading power system analysis software application for use in analysing generation, transmission, distribution and industrial systems. It covers the full range of functionality from standard features to highly sophisticated and advanced applications including windpower, distributed generation, real-time simulation and performance monitoring for system testing and supervision. PowerFactory is easy to use, fully Windows compatible and combines reliable and flexible system modelling capabilities with state-of-the-art algorithms and a unique database concept.



## SOME HIGHLIGHTS:

Economical all-in-one solution with broad coverage of state-of-the-art power system applications

Extensive and flexible modelling capabilities with rich suite of power equipment models and libraries

Supports all network representations and phase technologies, i.e. any kind of radial or meshed 1-,2-,3- and 4-wire (combined) AC and DC networks

Powerful network diagrams and graphic/visualisation features

Single- and multi-user environment with full support of team-working, user accounting, profiles and flexible customisation

Unique data management concept including project versioning and archiving mechanisms, master/derived concepts with compare and merge tools

Unlimited opportunities in process optimisation based on integrated scripting functionality

Rich interfacing and system integration options (e.g. GIS, SCADA, EMS)

Professional support via customer portal or hotline, as well as continuous product maintenance and development

# DIgSILENT PowerFactory 15.2

## Base Package

### LOAD FLOW ANALYSIS

- Balanced and unbalanced load flow for coupled AC and DC grids
- Meshed DC supergrid load flow analysis
- SVC, shunt and tap controllers
- Station- and network control features, incl. Q(U)-, cosphi(P)-, Q(P)-, and droop characteristics
- Local- and remote control options
- Consideration of generator capability curves
- Secondary and primary control, inertial response
- Distributed slack by load and generation, including grid interchange schedules
- Accurate modelling of induction machines
- Voltage dependent load models
- Simple load/generation scaling, as well as automated feeder load scaling
- Determination of "power at risk"
- Consideration of temperature dependency
- DPL scripts for time sweeps, ATC, penalty factor calculation, etc.

### SHORT-CIRCUIT ANALYSIS

- Support of IEC 60909, IEEE 141/ANSI C37, VDE 0102/0103, G74 and IEC 61363 norms and methods
- Calculation of short-circuit currents in DC grids according to IEC 61660 and ANSI/IEEE 946
- Complete superposition method, including dynamic voltage support of generators connected via power electronics
- Multiple fault analysis of any kind of fault incl. single-phase interruption, inter-circuit faults, etc.

### CONTINGENCY ANALYSIS

- AC or DC and combined AC/DC load flow analysis
- Fast contingency screening
- Single and multiple time phase consideration
- Event-based post-fault actions
- Substation automation via switching schemes
- Automatic time sweep contingency analysis of a 24 hour time period incl. parallelisation
- Generator effectiveness and quad booster effectiveness
- Enhanced Fault Case management
- Comprehensive spreadsheet reporting features incl. graphical visualisation of critical cases
- Tracing of individual contingency cases
- Contingency comparison mode
- Grid/multiple-CPU computing support

### QUASI-DYNAMIC SIMULATION

- Medium- to long-term simulations based on steady-state analysis
- Time and Time-Profile characteristics for simplified modelling of (recurrent) time series
- Consideration of planned outages, network Variations and Expansion Stages
- Simulation plots and tabular reports including statistical analysis

### NETWORK REDUCTION

- Flexible definition of boundaries
- Calculation of load flow and short-circuit equivalent
- Support of load, Ward and extended Ward equivalents
- Capturing of reduction via Variation for convenient toggling between original and equivalent grid

### LOAD FLOW SENSITIVITIES

- Voltage sensitivities and branch flow sensitivities
- Transformer and booster sensitivities
- Modal analysis for identifying strong and weak parts of the network

### ASYNCHRONOUS MACHINE PARAMETER IDENTIFICATION

### OVERHEAD LINE & CABLE PARAMETER CALCULATION

### BASIC MV/LV NETWORK ANALYSIS

- Feeder analysis tools incl. voltage profile plots and feeder load scaling for simple and meshed feeders
- Automated schematic visualisation of feeder topology
- Radial feeder tools incl. voltage and phase technology change tools and auto-balancing tool
- Backbone calculation determining the main connections between meshed feeders
- LV network analysis functions
- Stochastic load modelling

### TECHNO-ECONOMICAL ANALYSIS

- Economic assessment of network expansion strategies
- Net Present Value method considering costs of losses, investment costs, economic impact of failure rates (only with Reliability Analysis functions), and project schedules
- Efficiency ratio evaluation to determine optimal year of investment

### RESULTS AND REPORTING

- Extremely rich set of calculation quantities
- Text and interactive spreadsheet reports
- Configurable Flexible Data pages
- Comprehensive reporting in network diagrams
- Numerous interactive plots for result visualisation (differential and time-over current protection, harmonics, stability and transients, eigenvalue analysis, etc.)
- Powerful result comparison mode

### NETWORK DIAGRAMS AND GRAPHIC FEATURES

- Simplified single line diagrams for schematic and design views
- Detailed single line diagrams showing full switch & component model including primary and secondary equipment
- Intelligent Overview Diagrams supporting node & branch views
- Geographic Diagrams (GPS-based) with background maps
- **Background Maps representation automated via mapping server interface (e.g. Open Street Map, Google Maps<sup>1</sup> ©, Esri ArcGIS<sup>1</sup> ©) NEW**
- Annotation layers for enriched visualisation options
- Single line diagram handling across Variations and Expansion Stages
- Automated drawing of Substation Diagrams
- Auto-assistant for diagram drawing based on grid data
- User-definable symbols and composite graphics
- Global template libraries (e.g. for substation configurations, WTGs, PV systems)
- Numerous diagram colouring and result visualisation modes
- **Flexible Heatmap background colouring scheme NEW**
- **Navigation pane facility NEW**

### NETWORK REPRESENTATION

- Support of any kind of meshed/radial 1-, 2-, 3- and 4-wire AC and DC networks with combined AC and DC modelling for all available analysis functions
- Single-phase, two-phase, bi-phase and three-phase technology with/without neutral
- Detailed primary and secondary substation models (single/double busbars w/o tie breaker, 1-1/2 busbar, bypass busbar), extendable for user-specific busbar configurations incl. protection schemes
- Switches and substation equipment such as CB, fuse, disconnecter, load break switch, grounding switch, NEC/NER, surge arrester, CT, VT, CVT, etc.
- Running arrangements and switching rules for substation automation

<sup>1</sup> Upon request: additional license agreements with map service providers apply

## POWER EQUIPMENT MODELS

- Large and comprehensive Equipment Type Library
- Synchronous and asynchronous motor/generator
- Doubly-fed induction machines
- Static generator for modelling wind- and PV-generators, fuel cells, micro-turbines, etc.
- PV system with integrated power calculation based on solar radiation
- External grids, AC and DC voltage and current sources
- Simple and complex load model, special MV and LV load models, including input based on yearly energy values and load profiles **NEW**
- Static var compensation (SVC) and shunt/filter models
- Network branches (OHL, cable, branches, line couplings, tower geometries, cable systems, 2-winding transformer and auto transformer, 3-winding transformer and auto transformer, booster transformer, reactor, series capacitor, common impedance, etc.)
- DC/DC converter, inductive DC-coupling
- Battery and DC machine models
- Power electronic devices (thyristor/diode, VSC, DC valve, soft starter, etc.)
- FACTS and HVDC systems
- Controller objects such as station & secondary controller, transformer tap controller, virtual power plants, capability curves
- Explicit modelling of neutral wiring
- Protection devices with over 30 basic function blocks
- Protection device library (static/dynamic functions)
- Fourier source, harmonic source, impulse current source, FFT, clock, S&H, etc.
- Composite models for branch and node models, incl. template library for handling composite models
- Parameter characteristics (**scaling factor NEW**, vector, matrix, files) for modelling of load profiles, wind/PV infeed, temperature dependencies, etc.
- Grid organisation and element grouping (zones, areas, boundaries, circuits, routes, feeders, operators, owners, etc.)

## DATA MANAGEMENT

### Single-User Database Licence

- User-friendly and powerful Data and Object Manager
- Grid Variations management with time-stamped grid Expansion Stages
- Highly flexible Study Case concept with definable Operation Scenarios, Variations, Grids and Triggers
- **Project Overview window with extended functionality for simplified management of Study Case configuration NEW**
- Flexible parameter characteristics
- Master- and Derived Projects with Merge Tools
- Project versioning
- Database Undo and Rollback function
- User profiles with customisable toolbars, dialogs and context menus

### Multiple-User Database Licence

- Includes all Single-User Database Licence features
- Concurrent multi-user operation and teamworking
- User accounting, data access and function access rights
- Database housekeeping mechanisms
- Project archiving
- Offline Mode via locally cached database and possibility for synchronisation with multi-user database when connected to the network (requires Network Licence with Floating Licence)

## EXTERNAL DATA FORMAT SUPPORT

- Import filters for PSS/E, PSS/U, PSS/Adept, UCTE/ENTSO-E, Neplan (v4/v5), Integral, Elektra, ISU, NETCAL, NEPS, ReticMaster
- Bi-directional, flexible DGS interface (ASCII, XML, CSV, ODBC) supporting GIS and SCADA interfacing
- Optional: PSS/E Export, CIM (ENTSO-E Profile), PRAO

## GENERAL SOFTWARE INFORMATION

- Functional integration for all power system applications incl. T&D, industry, renewables, smart grids, etc.
- Various interfaces for communication and data exchange with third-party systems
- Fully compatible with MS Windows 32- and 64-bit versions

## SCRIPTING AND AUTOMATION

- Integration of Python as programming language with full PowerFactory data model access and rich function suite
- DPL: DlgSILENT Programming Language; C-like syntax supporting unlimited access to PowerFactory objects, parameters and their functionality
- Extendable function scope of DPL via C-Interface, thus allowing access to external data and applications
- PowerFactory C++ API (Application Interface) for full external automation of PowerFactory
- StationWare interface

## GIS AND SCADA INTEGRATION

- Support of various interfacing options incl. bi-directional data exchange with GIS and/or API utilisation
- Online reading of dynamic SCADA data as well as import of static data; engine integration with SCADA systems
- Optional interfaces: OPC (SCADA interoperability standard), A/D signal interfacing

# Advanced Functions

## PROTECTION FUNCTIONS

- Comprehensive relay library with relay models suitable for steady-state, RMS and EMT calculations
- Synchronisation with StationWare
- Highly-detailed relay settings spreadsheet reports
- Graphical visualisation and editing of fuses, relays, CTs and VTs

### Time-Overcurrent Protection

- Overcurrent-time diagram with drag & drop functionality including auto-generated graphical legend
- Cable and transformer damage curves
- Motor starting curves
- Automatic display of measured currents
- Steady-state response checks
- Steady-state short-circuit simulation with tracing of individual steps
- Steady-state tripping times for transient or sub-transient current/voltage values
- Transient response checks (requires Stability Analysis functions (RMS) or Electromagnetic Transients functions (EMT))
- Protection model features
  - Fuses and low-voltage circuit breakers
  - Positive-, negative-, zero-sequence inverse and definite time characteristics
  - Thermal overload characteristics
  - Directional elements supporting cross-, self- and memory polarising, Wattmetric method
  - Differential unit with harmonic blocking for multiple harmonic orders
  - Generic and detailed manufacturer-specific recloser units
  - Signal transmission between relays, inter-tripping, interlocking schemes
  - Detailed CT, VT and CVT models including saturation
  - Over-, under-voltage inverse and definite time characteristics
  - Programmable logic unit
  - Over-, under-frequency and df/dt inverse and definite time characteristics (requires Stability Analysis functions (RMS))

### Distance Protection

- Includes time-overcurrent protection
- R-X diagrams supporting the display of measured impedance trace
- Time-distance diagrams, with metric or calculated display of zone reach in forward and reverse direction
- Assistant for automated distance protection coordination
- Protection model features
  - Generic and detailed manufacturer-specific Mho, polygonal distance zones and distance starting units
  - Out of step detection and power swing blocking unit (requires Stability Analysis functions (RMS) or Electromagnetic Transients functions (EMT))

# DlgSILENT

## PowerFactory 15.2

### Advanced Functions

#### ARC-FLASH ANALYSIS

- Arc-Flash calculation in accordance with IEEE-1584 2002, NFPA 70E-2012 and BGI/GUV-I 5188
- Incident Energy, Flash-Protection Boundary and PPE Category on the single line diagram
- Automated preparation of Arc-Flash labels via MS Excel/Word
- Automatic protection-based fault clearing time determination (requires Protection functions)
- Calculation of arcing-current energy **NEW**

#### CABLE SIZING

- Automatic cable sizing based on IEC 60364-5-52, NF C15-100, NF C13-200, and BS 7671, etc.
- Cable reinforcement optimisation
- Verification of global and/or individual thermal and short-circuit constraints
- Verification of user-defined voltage drops per terminal and/or feeders
- Balanced (positive sequence) or unbalanced calculation with support of all phase technologies (1-, 2- and 3-phase systems, w/o neutral conductor)
- System phase technology and cable type consistency checks in the feeder
- Various verification reports and automatic modification of cable types in the existing network via network Variations

#### POWER QUALITY AND HARMONIC ANALYSIS

##### Harmonic Load Flow

- Harmonic voltage and current indices (IEC 61000-3-6, BDEW 2008)
- Balanced (positive sequence) and unbalanced (multiphase) model
- Unbalanced harmonic sources
- Non-characteristic and inter-harmonics
- Multiple harmonic injections: current and voltage sources, thyristor rectifiers, PWM-converters, SVS, non-linear loads, Norton equivalents
- Background distortion frequency-dependent R and L values
- Various harmonic distortion indices such as THD, HD, HF, THF **NEW**, TAD, TIFmx, total RMS currents and voltages (defined according to IEEE and DIN/IEC standards)
- Harmonic distortion plot with pre-defined distortion limits according to international standards
- Waveform plots
- Calculation of K-Factors and Loss Factors for 2-winding transformers (UL1562, BS7821, IEEE C.57.110-1998) **NEW**

##### Flicker Analysis

- Flicker Assessment (IEC 61400-21):
  - Short- and long-term flicker disturbance factors for continuous and switching operations
  - Relative voltage changes
- Flickermeter (IEC 61000-4-15):
  - EMT or RMS signals
  - Support of multiple file formats such as COMTRADE, CSV, user-defined, etc.

##### Frequency Sweep

- Automatic step size adaption or constant step size
- Balanced (positive sequence) and unbalanced network model
- Self and mutual impedances/admittances (phase and sequence components)
- Frequency-dependent R and L values and line/cable models
- Spectral density of voltage amplitude/angle

##### Filter Analysis

- Various filter models
- Design and layout parameters
- Filter sizing and verification reports
- Ripple control analysis

#### CONNECTION REQUEST ASSESSMENT

- According to D-A-CH-CZ guidelines
- Assessment at PCC:
  - Voltage changes and flicker
  - Voltage unbalance
  - Harmonics
  - Commutation notches
  - Interharmonic voltages
  - HV resonances **NEW**

#### TRANSMISSION NETWORK TOOLS **NEW**

##### PV curves calculation

- Voltage stability assessment by determination of critical point of voltage instability
- Support contingency analysis, i.e. detection of "limiting contingency"

##### Power Transfer Distribution Factors

- Analysis of the impact of a power exchange between two regions
- Various load and generation scaling options

##### Transfer Capacity Analysis

- Determination of maximum power transfer capacity between two regions
- Various load and generation scaling options for exporting and importing region
- Thermal, voltage and contingency constraints options

#### DISTRIBUTION NETWORK FUNCTIONS

##### Tie Open Point Optimisation

- Optimisation of tie open point positions subject to loss minimisation and/or improvement of system reliability
- Support of balanced/unbalanced systems
- Thermal, absolute voltage, and voltage drop/rise constraints
- Enhanced reporting features and graphical visualisation

##### Voltage Profile Optimisation

- Verification **NEW** and optimisation mode
- Voltage profile optimisation for bi-directional power flows in systems with a high level of distributed generation

- Determination of optimal distribution transformer tap positions for production and consumption cases (**simultaneous or independent**) **NEW**
- Combined consideration of MV and LV feeder voltage profiles with enhanced plotting features

##### Optimal Capacitor Placement

- Determination of optimal locations, types, phase technology and sizes of capacitors
- Economic assessment considering costs of losses against installation costs under predefined voltage constraints
- Support of load variation via characteristics

#### RELIABILITY ANALYSIS FUNCTIONS

##### Failure Models

- Line, transformer, distribution transformer **NEW**, and busbar failures
- Generator failures with stochastic multi-state model **NEW**
- n-1, n-2 and common mode failures (n-k)
- Double earth faults
- Independent second failures
- Protection/circuit breaker failures

##### Optimal Power Restoration

- Failure effect analysis (FEA)
  - Automatic protection-based fault clearing
  - Intelligent high-end system restoration with potential network reconfiguration and load-shedding
  - Support of thermal, absolute voltage, and voltage drop/rise constraints
  - Sectionalising (remote controlled switches, short-circuit indicators, manual restoration)
  - Substation automation with switching rules
- Animated tracing of individual cases
- Detailed reports for restoration action plans

##### Reliability Assessment

- Fast state enumeration incl. optimal power restoration techniques for balanced/unbalanced systems
- Calculation of all common reliability indices (IEEE 1366)
- Contribution of components to reliability indices
- Support of load variation, incl. load distribution curves
- Consideration of maintenance schedules
- Support of various tariff and cost models

##### Optimal Remote Control Switch (RCS) Placement

- Determination of optimal number and locations for RCS installation for improvement of system reliability
- Economic assessment for various objective functions

##### Optimal Manual Restoration

- Calculation of optimal switching scheme for manual power restoration phase

##### Generation Adequacy Analysis

- Stochastic assessment of system supply capabilities (loss of load probabilities, capacity credit, etc.)
- Consideration of generator outages and maintenance schedules (Monte Carlo), as well as load variation
- Enhanced probabilistic models for wind generation
- Rich suite of reporting and plotting tools



## OPTIMAL POWER FLOW (OPF)

### Reactive Power Optimisation (OPF I)

- Minimisation of losses
- Reactive power optimisation (interior point method)
- Various controls such as:
  - Generator reactive power
  - Transformer and shunt taps
- Flexible constraints such as:
  - Branch flow and voltage limits
  - Generator reactive power limits
  - Reactive power reserve
  - Boundary flows

### Economic Dispatch (OPF II)

- Various objective functions, e.g.:
  - Minimisation of losses
  - Minimisation of costs (eco dispatch)
  - Optimisation of remedial post-fault actions, e.g. booster tap changes (pre- to post-fault)
- AC optimisation (interior point method)
- DC optimisation (linear programming)
- Various controls such as:
  - Generator active and reactive power
  - Transformer, quad booster and shunt taps
- Flexible constraints such as:
  - Branch flow and voltage limits
  - Generator active and reactive power limits
  - Active and reactive power reserve
  - Boundary flows
- Contingency constraints (DC only)

## STATE ESTIMATION

- P, Q, I and V measurement models
- Measurement plausibility checks
- Automatic bad data detection/elimination
- Verification of system observability
- Various options to handle unobservable regions (e.g. pseudo measurements)
- Consideration of load flow constraints

## STABILITY ANALYSIS FUNCTIONS (RMS)

- Multi-phase AC networks, DC networks
- Support of balanced and unbalanced grid conditions
- Fast, fixed step size and adaptive step size algorithm
- A-stable numerical integration algorithms supporting long-term stability simulations with integration step sizes ranging from milliseconds to minutes, individually selectable for each model
- High precision event and interrupt handling
- Simulation of any kind of fault or event
- Transient motor starting (synchr./asynchr. machines)
- Support of all protection library relays
- Real-time simulation mode
- Simulation scan feature, e.g. frequency scan, loss of synchronism scan, **synchronous machine speed scan [NEW](#)**, voltage-/voltage recovery scan, or common variable scan
- Combined RMS and EMT simulation mode (requires Electromagnetic Transients functions (EMT))

## DigSILENT Simulation Language (DSL) for Dynamic RMS Modelling

- Graphical editor for drawing any kind of block diagram (AVR, prime mover, relay, etc.)
- Fully flexible signal wiring schemes having access to any grid object and their parameters via definition of Frames
- Nesting of frames and model building blocks
- DSL for fully flexible definition of simulation functions via the DSL syntax
- High precision built-in macros & functions
- Automatic initialisation of complex, non-linear models
- Large built-in standard IEEE model library **with fast precompiled models [NEW](#)**
- **Generic C interface for user-defined controller models [NEW](#)**
- **Automatic DSL-to-C interface converter [NEW](#)**
- Support of MATLAB/Simulink interface
- Optional: OPC interface for real-time applications
- Optional: DSL crypting function

## ELECTROMAGNETIC TRANSIENTS (EMT)

- Integrated simulation of electromagnetic transients in multiphase AC and DC systems
- Fast, fixed step size or adaptive step size algorithm
- Simulation of FACTS, HVDC interconnections (VSC, thyristor-based) and static var systems (SVCs, STATCOMs), etc.
- Power electronic devices (PWMs, rectifiers) and discrete components (diodes, thyristors, etc.)
- Constant and frequency-dependent distributed parameter cable/OHL models
  - OHL/cable constants calculation
  - OHL transpositions
  - Single core and pipe-type cables
  - Cable cross-bonding
  - Semi-conducting layers
- Non-linear elements and saturation characteristics
- Series capacitors incl. spark gap model
- Surge arrester models
- Impulse voltage & current source for lightning surge analysis
- **Support of AC-DC intercircuit fault events [NEW](#)**
- Accurate EMT models of renewable generation (wind/PV, etc.) and storage systems
- Discrete R-L-C elements
- Flexible template definition to create and re-utilise user-specific models library
- Insulation coordination analysis including temporary (TOV), switching (SOV) and lightning (LOV) transient over-voltages
- Stochastic switching analysis and point-on-wave (POW) switching
- Fast Fourier Transform (FFT) analysis
- Inrush, ferro-resonance, SSR and TRV studies
- COMTRADE file support
- Combined RMS and EMT simulation mode (requires Stability Analysis functions (RMS))

## DigSILENT Simulation Language (DSL) for Dynamic EMT Modelling

- Graphical editor for drawing any kind of block diagram
- Fully flexible definition of simulation functions and signal wiring schemes having access to any grid object and its parameters via definition of Frames
- Nesting of Frames and model building blocks
- High precision built-in macros & functions
- Automatic initialisation of complex, non-linear models
- **Generic C interface for user-defined controller models [NEW](#)**
- **Automatic DSL-to-C interface converter [NEW](#)**
- Support of MATLAB/Simulink interface
- Optional: OPC interface for real-time applications
- Optional: DSL crypting function

## MOTOR STARTING FUNCTIONS

- Single or multiple motor starting
- Transient motor starting (synchr./asynchr. motors), with full support of controller models
- Steady-state motor starting
- Various motor starting methods (reactor, auto transformer, variable rotor resistance, star delta, etc.)
- Thermal limit check of cables and transformers
- Automatic starting check function, visualised in single line diagram
- Detailed report

## SMALL SIGNAL STABILITY (EIGENVALUE ANALYSIS)

- Full and selective eigenvalue analysis
- Balanced (positive sequence) and unbalanced (3-phase) network representation incl. non-conventional generation such as wind turbines, PV systems, HVDC, VSC and other FACTS devices
- Interactive eigenvalue, mode bar and mode phasor plots
- Tabular reports of eigenvalues incl. damped frequencies, damping time constants, etc.
- Detailed reports of oscillatory modes including participation factors of state variables, controllability and observability

## SYSTEM PARAMETER IDENTIFICATION

- Parameter estimation of non-linear dynamic MIMO-systems fully integrated with DSL modelling

## POWERFACTORY INSTALLATION OPTIONS

- Licence options:
  - Workstation Licence (Single-User) via local USB hardlock
  - Network Licence (Multi-User) via Licence Server with optional Floating Licence
- Database options:
  - Single-User Database
  - Multi-User Database with Microsoft SQL Server and/or Oracle drivers (requires Network Licence)

# DIGSILENT PowerFactory System Integration

## GIS INTEGRATION

Geographic Information Systems (GIS) together with Asset Management Systems are the main sources of network topology and equipment data. Many utilities use GIS exports as a basis for the PowerFactory network model. These exports may comprise detailed substation data including topology, line/cable data, load/generation data and GPS coordinates/schematic diagram information, etc.

The built-in Compare & Merge Tool and the versioning mechanism perfectly support the frequent data exchange with GIS.

PowerFactory Engines are directly integrated into GIS systems providing calculation functionality such as evaluation of renewable generation connected to the low voltage grid.



## SCADA INTEGRATION

The PowerFactory OPC interface is utilised worldwide for real-time integration of PowerFactory with SCADA systems. The applications range from Online State Estimation, simulation mode functions (Dispatcher Load Flow, Contingency Analysis, Switching Validation) to Dispatcher Training Simulator with real-time transient grid simulation.

Controller manufacturers use the PowerFactory OPC interface for controller development, e.g. smart grid controllers, PV or wind farm control schemes.

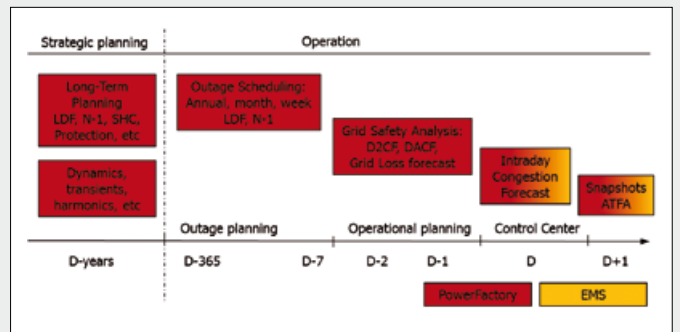


## BUSINESS PROCESS AUTOMATION

PowerFactory supports standard ENTSO-E operation planning processes such as D2CF, DACF and IDCF (Intraday). The Intraday process runs as a fully-automated, parallelised process.

The ESB interface adapter features message-based data exchange such as load forecast, planned generator dispatch, day-ahead cross-border exchange programs, UCTE-DEF files, EMS snapshots, dynamic line rating and market coupling data.

The combined MV/LV calculation for the distribution grid of a whole country (>2000 MV substations) has been automated using PowerFactory and bulk data GIS exports.

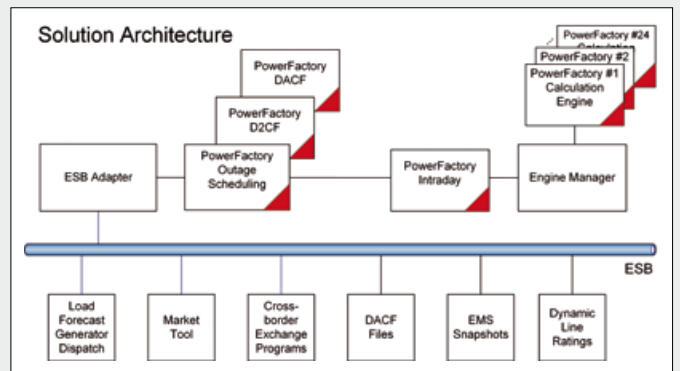


## INTEGRATION COMPONENTS

The PowerFactory Engine Mode provides complete PowerFactory functionality for external systems. The Engines can be controlled via the PowerFactory API and DPL or Python scripts. Various interfaces such as CIM, UCTE-DEF, OPC and DGS support bi-directional data exchange with different systems.

The ESB interface adapter connects to an Enterprise Service Bus enabling modern message-based data exchange.

The Engine Manager component provides access to multiple PowerFactory Engines via web services. The built-in queuing and scheduling simplifies the Engine integration into other applications.





# DIGSILENT Company Profile



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

**DIGSILENT** was founded in 1985 and is a fully independent, privately owned company located in Gomaringen/Tübingen, Germany. DIGSILENT continued expansion by establishing offices in Australia, South Africa, Italy, Chile, Spain and France, thereby facilitating improved service following the world-wide increase in usage of its software products and services. DIGSILENT has established a strong partner network in many countries such as Mexico, Malaysia, UK, Switzerland, Colombia, Brazil, Peru, China and India. DIGSILENT services and software installations have been conducted in more than 120 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, distributed generation, real-time simulation and performance monitoring for system testing and supervision. For wind power applications, PowerFactory has become the power industry's de-facto standard tool, due to PowerFactory models and algorithms providing unrivalled accuracy and performance.

**DIGSILENT StationWare** is a reliable central protection settings database and management system, based on the 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 and integrates with PowerFactory software, allowing powerful and easy-to-use settings coordination 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 into a Wide-Area-Measurement-System (WAMS). PowerFactory Monitor can be fully integrated with PowerFactory software.

## **DIGSILENT Consulting**

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



DIGSILENT GmbH  
Heinrich-Hertz-Straße 9

72810 Gomaringen  
Germany

T +49 7072 9168-0  
F +49 7072 9168-88

mail@digsilent.de  
www.digsilent.de