NEPLAN®

Successfully used all over the world

Planning and optimization system for electrical, gas, water and district heating networks

17/10/05
Data management

- All equipment can be entered graphically and/or table oriented (like in an excel sheet).
- A single line diagram can easily be generated through a very user friendly CAD systems.
- There is no restriction on drawing sizes and number of nodes and elements.
- Extensive editing functions like undo, redo, delete, copy, move and zoom for processing the network diagram are available. An element can be moved from one node to an other node without deleting the element.
- OLE functionality: Data and graphic can be moved to and from third party software (like MS-Excel, MS-Word). Project documentation was never easier.
- The equipment data are entered in dialogs, with plausibility checks provided. A coloring tool helps to show which data is needed for which analysis (e.g. short circuit, transient stability etc.)
- Integrated Variant Manager (insert, delete, append, compare variants, compare results, etc.).
- ASCII file or SQL database oriented import/export functions for exchanging network data, topology data and load data are available.
- Interfaces to external programs (e.g. measured data acquisition systems) can be implemented.
- Import of a geographic map as a background graphic, for easier schematic capturing.
- Import of almost any raster and vector graphic files (e.g. PCX and DXF files).
- Graphics can be exported as raster files (e.g. JPG, which can be used in any internet web browser).
- Option for combining and separating networks. Any number of independent network areas and zones are possible. Each element and node can belong to any independent area and zone.
- Extensive functions for network statistics and network documentations are available.
- A state of the art library manager with extensive libraries for each element type facilitates data entry.
- All computation modules access a shared database.
- Integrated chart manager allows to analyze and compare all results from all variants.
- Languages: program and manual in English, French, Spanish, German and Italian.
Data Management, Interactive Graphics  

**Variant Management**

- Non-redundant storage and management of variants.
- For each network, you can select
  * any desired switch states (topology file)
  * any desired loading states (loading file)
- For each network you can define and store any desired number of variants and subvariants (variant tree). In the variant data, only the differences from the parent variant are saved.
- Variants can be compared, merged and deleted.
- The diagrams of different projects and variants can be displayed at the same time
- Results from two different variants can be displayed on the diagram in one result label.
- Results of two variants can be compared in the chart manager.

**Multi-Diagram and Multi-Layer-Technique**

- i-Diagram and Multi-Layer-Technique
- Multi-Diagram and Multi-Layer-Technique
- A network can be entered in several different diagrams, so that the HV network, for instance, is in one diagram, and the MV network in one or more other diagrams.
- Each diagram can have any number of graphic layers. These layers can be colored, locked, hidden or shown.
- Zooming into stations: in the overview diagram, a station is shown as a black box, while in another diagram it is depicted in detail, with all its breakers, protective devices and instruments.
- Topological linkage of elements over more than one diagram.
- All diagrams will be considered for the various analysis (e.g. load flow).
- One element can have more than one graphical representation in the same diagram or in different diagrams.
- OLE. copy/paste graphic data from and to MS-Word
**Auxiliary Graphics**
- Auxiliary graphics can be used for documenting the diagram.
- Input of lines, rectangles, ellipses, arcs, ellipse sections, polygons, polylines, any kind of bitmap graphics.
- Input of user text with selectable character set.
- Color for background, foreground, line, outlines and fill patterns is user-selectable.
- Functions available for rendering overlapped symbol elements, rendering, alignment and rotation

**Network Diagram Coloring**
- Colors and line types can be freely selected.
- Elements overloaded after a load flow or short-circuit-current analysis are color-highlighted.
- Isolated elements can be highlighted.
- Coloring options to distinguish user-selectable network areas, zones, voltage levels, earthed or not feeded networks and galvanic separated networks.
- Differences to the parent variant or the root net can be colored.
- Each element can be colored individually.
- User defined graphic layers can be colored.
- Coloring according to ranges. Many calculated variables can be colored according to their values (e.g. according to element losses or according to voltage drops)
Symbol-Editor
- The user can create and define for each element type and node his own symbols.
- Any number of different symbols per element type or node can be defined.
- All symbols will be displayed while entering the diagram. Just drag and drop the desired symbol to the diagram.
- On the diagram the symbols can be flipped, rotated and resized.

SQL Database Connection
- All element data can be imported and exported to any SQL database (like Oracle, MS-Access, etc.)
- SQL database includes all network equipment. (HVDC, SVC, STATCOM, TCSC, UPFC, protection devices, etc.).
- The network topology can be stored.
- Graphic of the elements and nodes can be exported and imported.
- All data of all libraries can be imported and exported.
- Can be used as interface to existing GIS and NIS or DMS/SCADA systems.
- Very flexible storing and import features, like full import or only updating, storing only variant differences, etc.
- Partial reading of data fields (e.g. read only the line length but do not read the R and X values)
- The database can be simply upgraded to form a NIS using the database functions.
Library Manager

- The comprehensive library manager is fully integrated.
- For each equipment type a library exists or can be created by the user.
- While entering network data the data in the library can be accessed. Further more the data entered in the network, can be exported to the library.
- All network data can be updated with changed library data.
- The data can be entered through excel like table sheets.
- Import/export to MS-Excel with drag and drop.
- Import/export to any SQL database. Update functionality from/to database is provided.
- Part of diagrams with all technical data can be stored in the library (e.g. used for IEEE control circuits).

Chart Manager

- The chart manager allows to display the results in different charts (e.g. line, bar, etc.).
- Any number of sub charts can be displayed in one chart.
- A user defined logo (as bitmap) can be added to the header for documentation purposes
- Results from different variants can be compared and displayed in the same chart.
- Export the chart to *.JPG file for any internet browser.
- Copy/paste to the clipboard for documentation (e.g. MS-Word).
Station Kaisterfeld

UCTE Network

ZOOM into STATION Kaisterfeld

Detail Diagram
Background Raster Graphic

Example with a calculated geographic map in the background.

Designed by Gelsenwasser AG
Load Flow Analysis

- Computation procedures: Current Iteration, Newton Raphson, Extended Newton Raphson, Voltage Drop
- Limit check and appropriate automatic conversion of the node type.
- Voltage and flow control with phase-shifting transformers, controllable three windings transformers.
- FACTS devices: SVC, STATCOM, TCSC, UPFC
- Node types: slack, PQ, PV, PC, SC, PI, IC. More than one slack node possible.
- Power interchange between area / zones (area interchange control).
- Asymmetrical network elements and loads
- Predefined and user defined scaling factors for fast load and generation variations
- Distributed slack node
- Load balancing
- Calculation of loss sensitivities
- Step length convergence control
- Initialization file input / output
Results

- Automatic output of results.
- 'Move' and 'Delete' function for result boxes.
- Placeholders are saved.
- Self-defined result output: the user can select items, units, font, precision, placement.
- Overloaded elements or nodes with voltages outside predefined limits are highlighted.
- Line thickness corresponds to element loading.
- Results can be saved in a text file (ASCII).
- Table output: for the whole network, individually for each area / zone. Listing of power flows between area/zones, overloaded elements, sorting function, selective output.
- Table interface with MS-Excel.
Short Circuit Analysis

- Computations: IEC 909/VDE 0102, ANSI/IEEE, IEC 60909, superposition method
- Consideration of prefault voltages from a load flow computation.
- Computation of single-, two- (with and without earth connection) and three-phase faults.
- Option for computing user-defined fault types (e.g. double earth fault, fault between two voltage levels).
- Library with special faults is available (can be extended by user).
- Option for computing line faults (fault location on line user-selectable).
- Computable fault current types: initial symmetrical short-circuit current and power, peak, breaking, sustained short-circuit current, thermal and asymmetrical breaking current, plus DC component.
- Computation of minimum/maximum short-circuit current.
- Precise model for transformer earthing connection.
- Asymmetrical network structure are allowed for (asymmetrical short circuit)
- Current limiting due to circuit breakers

Line Coupling

- Mutual impedances and capacitances in the positive and negative-sequence systems are allowed for in short-circuit current computation.
- Circuit and coupling parameters of the overhead lines are computed from the conductor configuration.
- Overhead lines with up to 6-phase systems and 3 earth wires can be computed.
- Bundled conductors are allowed for.
- Unrestricted number of overhead lines can be entered.
- Parameters and conductor configuration are saved in an SQL database.
Short Circuit Analysis

Results

- Automatic entry of results.
- Move and delete function for result boxes.
- Placeholders are saved.
- Self-defined result output in regard to units, formats and fault current types.
- Results can be inserted either at the beginning and/or end node, or also in the element's center.
- In the event of a short-circuit, all overloaded pieces of equipment (current transformers, voltage transformers, circuit-breakers, etc.) are highlighted.
- Results can be saved in a result file (ASCII file) and in an SQL database.
- Result lists can be saved in text files.
- List output: sorted by voltage levels. Short-circuit impedance and all computable fault currents are output as phase values or as symmetrical components.
Transient Stability

General features

- Dynamic models for synchronous machines, asynchronous machines, loads, power electronic devices (SVC, UPFC, TCSC, STATCOM), HVDC systems, protection devices, control circuits
- Graphical input of control circuits with predefined function blocks.
- Various synchronous machine models: classic, transient, subtransient; saturation of d- and q-axis considered.
- Extensive event report, monitoring any variable on the screen.
- Case handling is very easy.
- Definition of all kind of disturbances.

Control Circuits

- Any control circuit (AVR, GOV, SVC, etc.) may be built freely by basic function blocks.
- More than 50 basic function blocks are available.
- User friendly editing facilities. Select function blocks from a list, drag into position by mouse, connect with one another by lines.
- Import/export facilities for control circuits between the editor and libraries.
- Storage of control circuits, such as, exciter, regulator, PS-stabilizer, V-transducer etc., separately in the Library.
- Concatenation of control circuits.
Protection Devices

- Min-max-relays (overcurrent, undervoltage, frequency,...): modeled with up to 4 tripping stages. E.g. various load shedding schemes may be simulated.
- Fuses
- Pole slip relays, model includes binary input signals from external sources
- Distance protection: pick-up and tripping stages, impedance diagrams, binary input signals from external sources.

Disturbances

- Generation and storage of various disturbance cases.
- Each disturbance case may have more than one event.
- Definition of faults (symmetrical and unsymmetrical) on buses, bus elements, branches.
- Loss of generator excitation
- Different switching operations (feed-forward control in control circuits, cross coupling of protective devices, in/out of branches, etc.).
- Transformer tap modification.
- Load shedding scenarios (also in relation to frequency relay).
- Disturbances with function generators (step, ramp, sinusoidal function or combination).
- Start-up of motors with different start-up devices.
Small Signal Stability

The NEPLAN Small Signal Stability module provides eigenvalue analysis (modal analysis) for electrical power systems. It combines exceptional ease of use with the latest techniques and standards in both electrical power engineering and software design. Like the other modules, Small Signal Stability is a seamless module within NEPLAN.

Applications

- Analysis of interarea oscillations
- Analysis of interplant oscillation
- Identification of groups and subgroups of machines swinging against each other
- Determination and improvement of power oscillation damping
- Design and placement of control equipment, such as power system stabilizers
Main Features

- Automatic construction of the linearized state space notation for the complete system, including generators, static loads, control circuits, etc.
- Advanced synchronous machine modeling: choose for every synchronous machine one of the five models infinite, classical, transient, subtransient and general. Saturation curves for both, d-axis and q-axis.
- Automatic calculation of eigenvalues, eigenvectors, mode shapes, participation factors for eigenvalues and state variables.
- Text results: results are presented in clear form and can be customized by several output options.
- Graphical results: results can be visualized by the fully integrated graphical results manager. Charts can be easily printed and exported to external programs (e.g. Microsoft Word) by clipboard functions. A variety of chart options is available.
- The only requirement is the NEPLAN load flow module. However, the Small Signal Stability and the Transient Stability (time simulation) module of NEPLAN complement each other ideally.
- The Small Signal Stability module is completely integrated in NEPLAN and uses standard dynamic element data (like the Transient Stability module).
As an integral part of NEPLAN software, the Voltage Stability module provides 4 approaches for static voltage stability analysis of power systems: V-Q curves, P-V curves, V-Q sensitivity analysis and Q-V eigenvalue analysis (modal analysis). This module allows examination of a wide range of system conditions. It is an ideal tool to provide much insight into the nature of voltage stability problems.

Applications

- Identification of weak / not controllable / unstable areas
- Identification of weak and heavily loaded links
- Proper distribution of reactive reserves in order to maintain an adequate voltage stability margin
- Voltage sensitivity information
- Degree of voltage stability
- Most effective measures in improving voltage stability
Main Features

- Automatic calculation of P-V curves, V-Q curves, dV/dQ self-sensitivities, dV/dQ mutual sensitivities, eigenvalues, eigenvectors, bus participation factors, branch participation factors and generator participation factors.
- Result tables: results are presented in clear form and can be exported by Copy-Paste-methods to external programs (e.g. MS-Excel).
- Graphical results: results can be visualized by the fully integrated graphical results manager.
- Export files: results are stored in text files for advanced data export.
- Charts can be easily printed and exported to external programs (e.g. MS-Word) by clipboard functions. A variety of chart options is available.
- Input: standard load flow input data
Harmonic Analysis

- Module is fully integrated, and works independently of the type and size of the network concerned.
- Planning of ripple control systems, dimensioning of compensators (SVC) and harmonic filters, plus determination of network impedance for subsynchronous resonances.
- Option for simulating frequency response of intermeshed networks.
- Harmonic generators (current and voltage sources) are entered directly in the single line diagram. Libraries available.
- Unrestricted number of harmonic generators can be computed with each harmonic.
- Computation of network impedance, and the harmonic level for each frequency and for each node.
- Frequency-dependence of elements is allowed for.
- Libraries for frequency-dependence are available (can be extended by the user).
- Length of computation steps for impedance computation is automatically adjusted to resonance proximity.
- Harmonic load flow

Harmonic Levels

- Current and voltage computation at all frequencies and at all predefined nodes and elements.
- Computation of r.m.s. values for harmonic voltages and Currents.
- Computation of total harmonic voltage factor in conformity with DIN/IEC and distortion factor in accordance with IEEE.
- Computation of telephone parameters (TIF, IT, KVT).
- Comparison of computed harmonic levels with the limit values laid down in VDE 0160/5.88 or with any other standards desired.
- List output of ripple control currents and voltages at any desired frequencies and at each node and each element.
- Automatic entry of results in the single line diagram.
- Harmonic sum calculation: vectorial, geometric, arithmetic, acc. to IEC 1000-2-6
Harmonic Analysis

Filter Dimensioning

- Filter elements are transferred directly into the single line diagram.
- Filter elements: filters (normal, HP, C-filter), series RLC-circuits with or without earth connection, ripple control traps.
- Filters are dimensioned directly by the program.
- Filter data are listed or saved in a text file.
- Result lists can be saved in text files.
- Results can be saved in result files for evaluation by means of spreadsheet programs (like MS-Excel).
Overcurrent Protection

- All types of protective devices with an overcurrent-time characteristic can be entered: fusegear, circuit-breakers, definite-time overcurrent relays and inverse-time relays, electronic relays.
- Up to 6 protective functions (blocking of directional and non-directional overcurrent protection) can be assigned to each protective device.
- Extensive libraries with protective devices from a variety of manufacturers are available, and can be extended at will.
- Option for entering user-defined characteristics for simulating motor start-ups or thermal loadability of conductors, transformers, etc.
- Characteristic can be shifted using a k-factor (inverse-time relay).
- Entry options for characteristics: point-by-point or formula in conformity with BS142 or the American ASA standard.
Selectivity Diagram

- Relays and current transformers are positioned in the network plan graphically.
- Transformation ratios of current transformers incorporated in the network plan are allowed for in the selectivity diagrams.
- A maximum of 6 characteristics can be incorporated in one diagram.
- Unrestricted number of diagrams can be processed simultaneously.
- Selectivity analysis over more than one voltage level, and independently of the network type and size involved.
- Two reference voltages for diagrams can be user-defined.
- Individualized coloring of the characteristics.
- No limit on number of diagrams and protective numbers for management.

Transferring Current Values

- Direct connection from short-circuit current and load flow module for transferring the currents.
- Up to 6 currents can be transferred into one diagram.
- Import/export functions.
Network Reduction

This module is designed to reduce the size of a network model by replacing sets of buses and the network elements (lines, transformers,...) that connect them with a smaller but exact, numerically equivalent network. For a properly chosen set of buses, this equivalent network will have fewer buses and branches than the original, yet still provide the correct response to faults or load flow calculations in the unreduced portion.

The network can be reduced for

- symmetrical or asymmetrical short circuit calculations according to IEC909, IEC60909, ANSI/IEEE or superposition method and
- load flow calculation.

The reduced network gives the same short circuit or load flow results as the original network. Giving the nodes to be reduced, the program determines the boundary nodes automatically.
Network Reduction

**Input**
- any network as for short circuit or load flow calculation
- nodes to be reduced during network reduction
- functions to select a complete network area to be reduced are available
- boundary nodes are determined automatically by the program

**Output**
- shunt and series equivalents, which can be saved in the data base
- the shunt and series equivalents consists of data for the positive, negative and zero system dependent on the type of network reduction (load flow or short circuit)
- for load flow network reduction boundary injections and boundary generators are calculated
Optimal Power Flow NEPLAN®

- Control variables: active / reactive power generation, schedule voltages of generators and ULTC-transformers, reference values of HVDC systems and FACTS (UPFC, STATCOM, SVC, TCSC,...)
- Variable limits for bus voltages, branch loadings, active and reactive power of generators
- Individual or general limits, 'consider/not consider' limits function
- Objective function: apply to whole network / to a certain area or zone, minimize / maximize MW losses, Mvar losses, generation costs, MW import or Mvar import
- Multi objective function is possible (use of weight factors)
Results

- Automatic output of results.
- 'Move' and 'Delete' function for result boxes.
- Placeholders are saved.
- Self-defined result output: the user can select items, units, font, precision, placement.
- Overloaded elements or nodes with voltages outside predefined limits are highlighted.
- Line thickness corresponds to element loading.
- Results can be saved in a text file (ASCII).
- Table output: for the whole network, individually for each area / zone. Listing of power flows between area/zones, overloaded elements, sorting function, selective output.
- Table interface with MS-Excel.
Motor Starting Computation

- Simulation of motor start-up in unlimited networks.
- Simultaneous or time-delayed start-up for any desired number of motors.
- Identification of motor parameters using the least square of error method.
- Different motor models, depending on the motor data entered.
- Saturation and eddy-current losses in the motor allowed for (linear or point-by-point).
- Libraries for standard motor data, plus additional libraries for Me(s), I(s) and cosφ(s) are available (can be extended by the user).
- Operating point computation for all non-starting motors in accordance with their load characteristics (Newton-Raphson).
- Automatic tap changing transformers are allowed for after a user-defined time-delay.
- Load torque entered as a characteristic or as a linear or quadratic load torque curve.
- Libraries for load torques are available (can be extended by the user).
- Start-up devices are allowed for, such as star-delta starter, series resistor, transformer.

Voltage Drop

- Computation of voltage drop to the moment t = 0.
- Reduced data entry for motors and computation parameters.
- Non-starting motors can be simulated by a user-defined load PQ (constant power) or shunt.
- Overloaded elements, measuring instruments and protective devices or nodes with voltages outside a defined range are highlighted.
- Results of the voltage drop computation are displayed in the single line diagram.
- The motor data entered and the motor parameters computed can be accessed by clicking on the motor concerned in the single line diagram.
Results

- Computation of voltage $U(t)$ at predefined nodes.
- Computation $I(t)$, $P(t)$, $Q(t)$ for each predefined element.
- Computation of motor current $I$, load torque $M$, electromagnetic torque $M_e$, active power $P$ and reactive power $Q$ as functions of time, or of the slip for starting-up and non-starting-up motors.
- Graphical output of the characteristic curves and time characteristics, with automatic scaling of the axes.
- Dimensioning and colors can be altered.
- Result lists can be saved in text files.
- Results can be saved in result files for evaluation by means of spreadsheet programs (such as MS-Excel).
Load Flow with Load Profiles

Input Data

- User-defined load and generation profiles (day, week, month and year factors)
- Unlimited number of profile types for consumers and generators (e.g. household, industry, ...)
- Import of measurement data and behaviors of power factors

Calculations

- Single load flow calculation (load forecast) and time simulation
- User-defined time increment
- Combination of time intervals
- Load balancing mode: loads are automatically changed in the way that load flow results fit best to measured values (behaviors)
Results

- Time behavior and value range charts
- Characteristics of network, elements and nodes (voltages, currents, loadings, power, MW losses, energy losses, …)
- Any system quantities may be plotted, or compared
Wind Power Applications

Steady State and Dynamic Simulation

Generator models
- Asynchronous machine
- Double fed asynchronous machine
- Synchronous machine

Calculation modules
- Load flow
- Short circuit
- Transient stability
- Voltage stability
- Over current protection
- Harmonic analysis

Typical applications
- Verification of connection conditions
- Steady state and dynamic simulation of whole wind parks
- Determination of optimal connections in regard of technical and economical aspects
- Increase of short circuit currents
- SC capacity of cables and equipment
- Protection settings
- Reactive power compensation
- Harmonics level calculations
- Functions to represent different wind conditions
- Pitch control representation
- Tower and blades mechanism
- Stability aspects in power system and wind park
Probabilistic Reliability Analysis
Determining the frequency, average duration and cost of network component failures, leading to voltage sags and supply interruptions.

Consideration of
- Outage behavior (failure rate and repair times) of network equipment
- Network operation in normal state and for multiple order network contingencies
- Admissible short-time component over-loadings
- Protection concept including protection failures
- Realistic generation patterns and load curves

Reliability Analysis is imperative for
- Optimum asset allocation and cost-benefit analysis for investments in transmission and distribution networks
- Design and evaluation of innovative substation layouts
- Weak-point analysis in existing networks
- Design of automation concepts in public and industrial distribution networks
- Detailed and objective discussion of network connection concepts for high-demand customers and power plants
- Cost-effective mitigation of power quality problems (voltage sags)
- Add-on for NEPLAN-Main – a tool to apply Reliability Centered Maintenance (RCM) Strategy, which leads to substantial reduction of maintenance expenses
Procedure of Reliability Analysis

**Relevant component failures**

*Single order contingencies:*
- Stochastic failures
- Common-Mode failures
- Spontaneous protection tripping

*Second order contingencies:*
- Overlapping independent stochastic outages
- Failure occurring during the maintenance of the backup components
- Protection failure or overfunction
- Multiple earth-faults

**Calculated results**

- Frequency of supply interruptions \( f_d \) in #/yr
- Probability of supply interruptions \( q_d \) in min/yr
- Mean interruption durations \( T_d \) in hrs
- Energy not served in time \( W_d \) in MWh/yr
- Interruption cost \( C_d \) in $/yr

**Presentation of results**

- Result values printed at load nodes in network plan
- Color shading of the network graph in dependence of the reliability results
- Various filter functions implemented for detailed analysis
- Integrated flexible diagram functions to visualize the calculation results
- Results fully exportable for use in tables and diagrams

**Evaluation functions**

- Consideration of power/energy-specific interruption cost
- Filter to investigate component contributions to load node interruptions
- Copying of diagrams into clipboard
- Shading of network diagram in dependence of load node results
- Analysis of system reaction after faults