SIMPOW®
SIMulation of POWer systems

Calculation Modules

- Power-flow analysis
- Fault analysis
- Dynamic analysis
  - Short, Mid and Long term stability
  - Linear analysis
  - Electromagnetic transients (EMT)

Features

- Developed since 1977, and used by ABB for the design of HVDC, HVDC Light®, FACTS and traction systems
- Analysis in both time and frequency domain
- Switch between phasor and instantaneous value mode during simulation
- Instantaneous value representation in some parts of a system and fundamental frequency in other parts
- Interactive or in background mode (semi batch)
- Extensive linear analysis module
- Variable or fixed time step
- Robust numerical technique
- Import of PSS/E™ files
- Integration possibilities in the NEPLAN® software (see separate pamphlet)

Mode

- Basic models such as nodes, lines, transformers, series reactors and capacitors, varistors, shunt impedances, voltage and frequency dependent loads, synchronous and asynchronous machines, double-fed asynchronous machine, mechanical loads, turbines, turbine governors, exciters and voltage regulators, power system stabilisers etc.
- Advanced models such as rotary-, HVDC-, PWM- and cyclo converters, synchronous machine start-up model, ferroresonance transformer model, transformers with magnetising and saturation, high-frequency line model, inertia models etc.
- Build your own models with the high level programming language DSL (Dynamic Simulation Language) or the DSL Code Generator

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SIMPOW® used in projects for the design of HVDC, HVDC Light®, FACTS and traction systems e.g.:

- Itaipu HVDC project, Brazil
- Gotland II HVDC project, Sweden
- Rihand-Delhi HVDC project, India
- Gotland HVDC Light, Sweden
- Québec-New England Phase II HVDC project, Canada/USA
- Three Gorges-Changzhou and Guangdong HVDC Transmission project, China
- Pulches-Henderson series compensation project, Argentina
- Kanpur 2x140 Mvar SVC project, India
- McCullough, SC, 500 kV-project, Nevada Power, USA
- Raipur, SSR-study, TCSC, 400 kV-project, India
- London Underground, SVC project, Great Britain

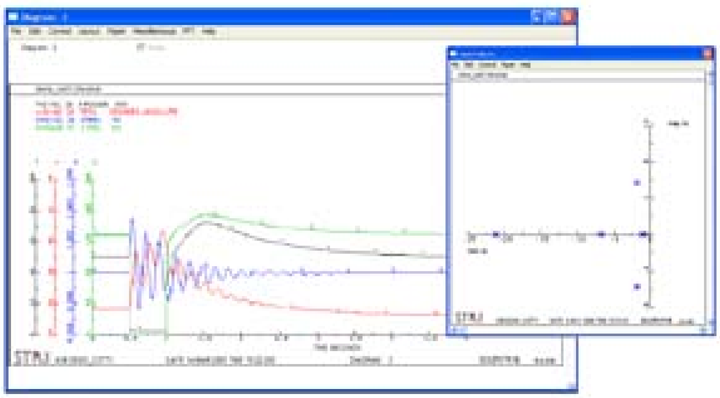

Photo by ABB

SIMPOW® used in studies, typically:

- Fault calculations and relay protection studies
- Power oscillation studies
- Tuning of Power System Stabiliser (PSS)
- Motor start simulations
- Inrush current calculations
- Harmonics analysis
- Reactive compensation studies
- Ferroresonance phenomena
- SVC design studies
- Voltage stability studies
- Filter design calculations
- Subsynchronous torsional interaction studies (SSR, SSTI)
- Auxiliary power supply studies, e.g. in power plants
- Fault and harmonics calculation in a large underground train power supply system
- Design and dynamic performance of wind generator parks in a power system taking advantage of HVDC Light® as system stabiliser

Validation of models

Validation of the existing models has been done in various ways. The simplest models such as transformers, lines, nodes, faults, etc. have been validated in accordance with text books, plausibility of results and comparison with theory. Advanced SVC and HVDC components and regulators as well as associated synchronous machines, have been verified against analogue simulator and also against test results from existing SVC plants and HVDC links, e.g. the Gotland Link.

The validation has also been done by comparison of results from other computer programs similar to SIMPOW.

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SIMPOW® Power Flow

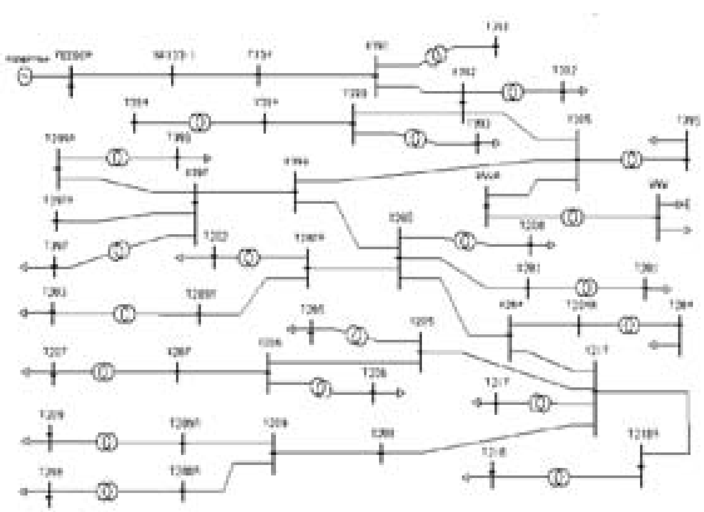
Used for usual power-flow simulations such as calculation of load-flow balance, transformer tap settings, initial state for dynamic runs etc.

Simulates the steady-state symmetrical conditions, considering power-frequency voltages and currents. The power system is represented by a single-phase model using positive sequence quantities only. The state of the system is given by node voltages in the form of phasors, injected active and reactive power and some other variables.

- Dynamic or Newton Raphson method
- Dynamic method uses backward differentiation method to find the stationary solution – robust and fast
- Multi load-flow runs by run instructions in a Command File
- Possible to specify a variety of constraints on variables and limits

Models

- Nodes
- Lines
- Transformers
- Series reactors
- Series capacitors
- Shunt Impedances
- Voltage dependent loads
- Asynchronous machines
- DFIG
- Mechanical loads
- Rotary converters
- HVDC converters
- PWM converters
- Cyclo converters



- Build your own models with the high level programming language DSL (Dynamic Simulation Language)

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SIMPOW® Fault Analysis

Used for determining the fault level of e.g. industrial networks in order to check the thermal and electromechanical strength of switchgears, cables, and for setting of protective relays.

Simulates steady-state symmetrical or asymmetrical conditions, considering power frequency voltages and currents. Fault analysis processes a linearized "frozen" state from a dynamic simulation, at an arbitrary point of time after the occurrence of an event, normally at zero time.

The fault analysis module performs calculation of power-frequency short-circuit currents and can be specified to include short circuit currents, their distribution, their positive-, negative- and zero-sequence components, as well as the corresponding short-circuit impedances seen from the faulty nodes.

The fault analysis module also includes a function by which short-circuit currents can be calculated according to the procedure and rules of the Standard IEC 60909, which is aimed to produce conservative results. Maximum and minimum values of initial peak, breaking and steady-state short-circuit currents on arbitrary nodes can be calculated.

- Dynamic method or according to IEC60909
- Dynamic method uses backward differentiation method to find the stationary solution – robust and fast
- Single run for all or a limited number of contingencies

Contingencies

- Three-phase fault to ground
- Two-phase fault to ground
- Single-phase to ground
- Two-phase fault
- General fault
- Phase interruption
- General phase interruption
- Travelling shunt faults
- Simultaneous faults

Photo by C Engelbrecht

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SIMPOW®- Dynamic Analysis

Used for large power systems e.g. for traditional stability studies, and in case of small power systems, studies with requirement of detailed time resolution.

Robust numerical techniques assure retained accuracy and numerical stability also for long-term simulations.

Studies

- Transient angle stability
- Small-disturbance angle stability
- Voltage stability
- Frequency stability
- Harmonic analysis
- Subsynchronous resonance
- Ferroresonance
- Machine transients and EMT
- Power system analysis for electric traction etc.

Features

- Analysis both in time and frequency domain
- Analysis in both fundamental frequency and instantaneous value mode under steady state or disturbed symmetrical or unsymmetrical conditions
- Switch between phasor and instantaneous value mode during simulation
- Instantaneous value representation in some parts of a system and phasor representation in the rest of the system
- Variable or fixed time step
- Implicit predictor-corrector method of integration for simultaneous solution of all algebraic and differential equations
- Combination of Gear's integration method and the trapezoidal integration method with automatically controlled variable time step
- Extensive library for hundreds of models or build your own models

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Phasor mode

For feasibility check and tuning of regulators in order to increase the power transmission capability and improve transient stability etc.

Calculates by phasor models the power-frequency components of AC system and the average values of DC system voltages and currents. The primary components are repree sented as positive, negative and zero sequence quantities.

Studies

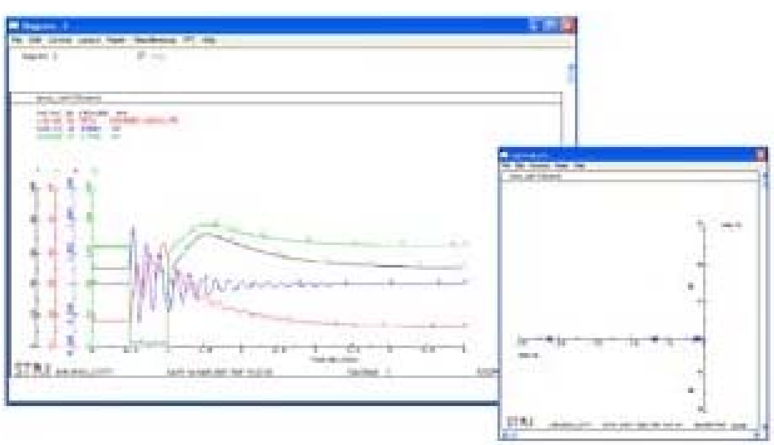
- Transient angle stability
- Small-disturbance angle stability
- Voltage stability
- Frequency stability
- System analysis for power supply of electric traction

Features

- Analysis both in time and frequency domain
- Variable or fixed time step
- Robust numerical technique
- Calculation of Fast Fourier Transform, FFT

Dynamical models

- Basic models such as nodes, lines, transformers, series reactors and capacitors, varistors, shunt impedances, voltage and frequency dependent loads, synchronous and asynchronous machines, double fed asynchronous machine, mechanical loads, turbines, turbine governors, exciters and voltage regulators, power system stabilisers etc.
- Advanced models such as rotary-, HVDC-, PWM- and cyclo converters,
- Build your own models with the high level programming language DSL (Dynamic Simulation Language), e.g. drive systems and special machines



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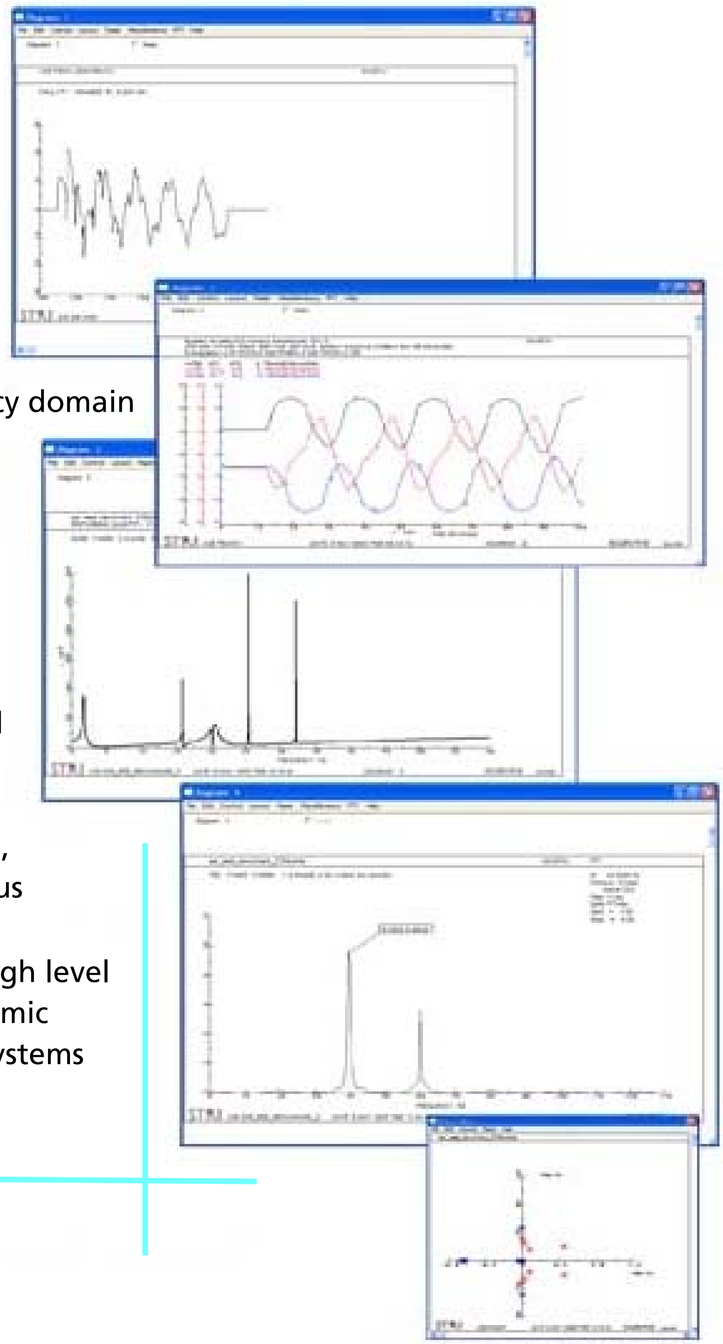
Instantaneous value mode

For simulation of the detailed dynamic performance of induction and synchronous machines during start and load switching conditions, e.g. in industrial power plants with different types, sizes and design of diesel generator and gas turbines sets etc.

Calculates the instantaneous values of voltages and currents. Primary components are represented by their dq0 quantities.

Typical phenomena studied

- Subsynchronous phenomenon
- Ferroresonance
- Start-up of synchronous machine
- Inrush currents
- Harmonics



Features

- Analysis both in time and frequency domain
- Variable or fixed time step
- Robust numerical technique
- Fast Fourier Transform, FFT
- Line parameter calculation

Dynamical models

- Transformer with magnetising and saturation characteristics, ferroresonance models, inertia models, high frequency line model, synchronous machine, asynchronous machine
- Build your own models with the high level programming language DSL (Dynamic Simulation Language), e.g. drive systems and special machines

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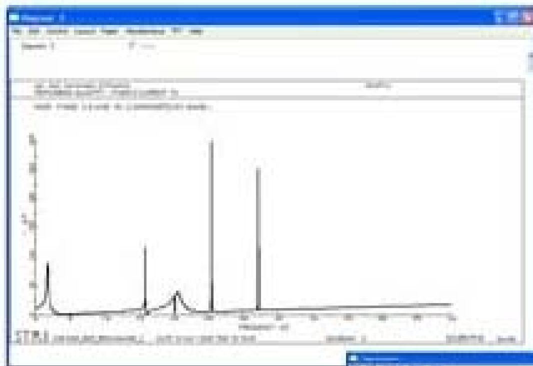
Linear analysis

Eigenvalue calculation and frequency response techniques in the frequency domain. These include linearisation of the power system equations at the actual operating point and consider incremental changes of the state variables around the operating point.

These techniques are excellent tools for the study of small signal stability of generators and automatic control systems.



Studies

- Small-disturbance angle stability e.g. controller interaction
- Tuning of Power System Stabilisers (PSS)
- Subsynchronous resonance
- Harmonic analysis

Features

- Frequency scanning
- Eigenvalues in both phasor and instantaneous value mode
- Eigenvalue sensitivity with respect to parameters
- Eigenvalues locus diagram, when varying an influencing parameter value
- Modal analysis visualised in the single-line diagram as mode shape, mode angle and participation factor
- Applicable at any time during a time-domain simulation

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SIMPOW® DSL and the DSL Code Generator

Dynamic Simulation Language, DSL, a built-in high level programming language, allows user-defined modelling of any power system component such as regulators and primary components, e.g. drive systems, FACTS devices and special machines.

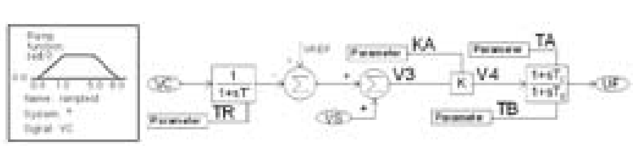
The equations written in DSL are solved simultaneously with other equations of the system.

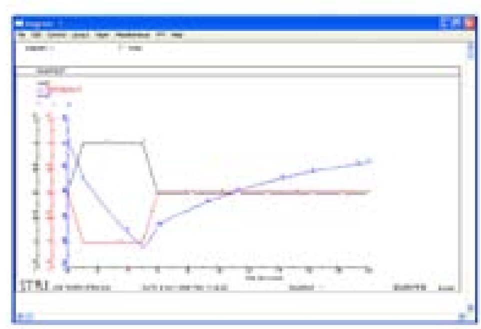
```
!! Multiplies two signals.
   V4=KA*V3
!! Filter (1+sTA)/(1+sTB).
   INTER_1: INTER_1=V4*(1-TA/TB)TB*.D/DT.INTER_1
   UF=TA/TB*V4+INTER_1
   IF (START) THEN
!! Checks start conditions by setting REF.
   REF: UF=UF0
!! Check of the filter (1+sTA)/(1+sTB).
```

The DSL Code Generator, a graphical tool based on HiDraw™*, by which the user can define and generate the required DSL code by connecting pre-defined block diagrams from libraries.

For user-defined modelling of exciters, voltage regulators, power system stabilisers, turbines, turbine governors, protective relays, etc.

Possible to test the model separately and check signals before applying it to a power system





*) HiDraw is a powerful graphical code generating tool used by ABB to produce the applications for their MACH 2™ control and protection system.

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Integration of SIMPOW® in NEPLAN®

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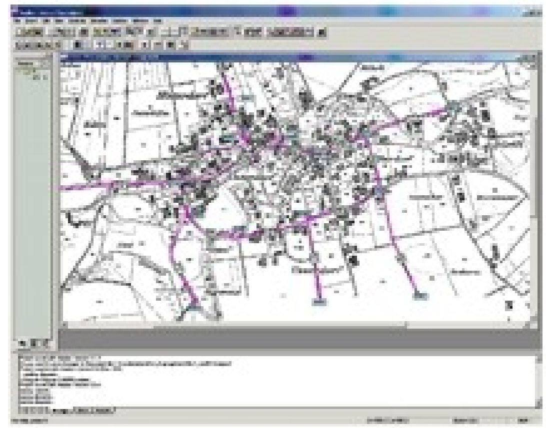
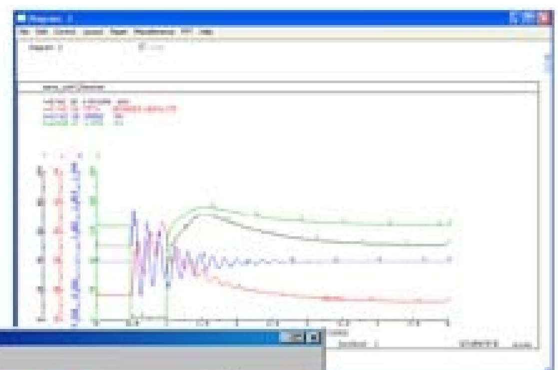
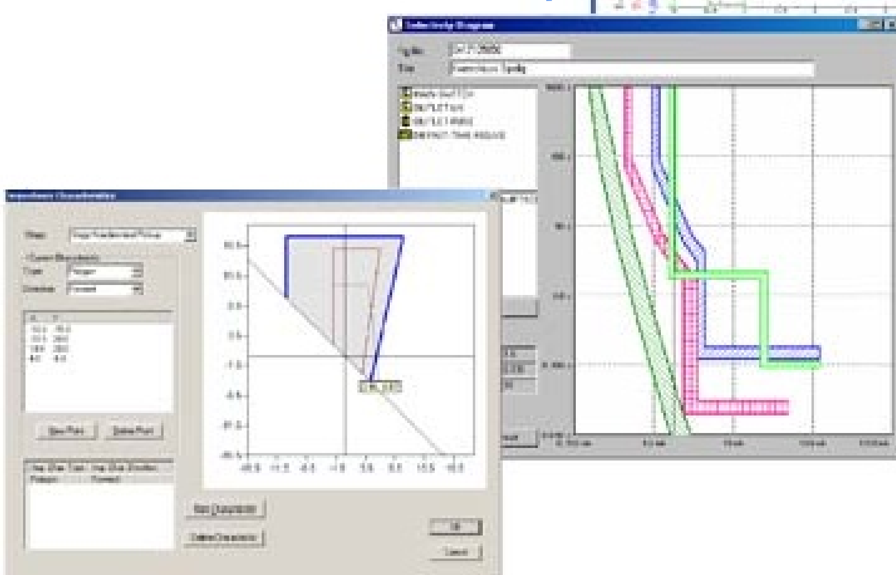
Calculation modules in NEPLAN®

- Load flow analysis
- Contingency analysis with common mode
- N-1 Security constrained optimal power flow
- Available Transfer Capability analysis (ATC)
- Loss minimization in distribution network
- Voltage stability and sensitivity analysis
- SIMPOW® Dynamic analysis:
    - Short-, Mid-, Long-Term stability
    - Linear analysis
    - Electromagnetic transients (EMT)
- Short circuit analysis (IEC, IEEE/ANSI, others)
- Overcurrent/Distance relay coordination
- Harmonic and frequency domain analysis
- Motor starting analysis and cable sizing
- Optimal capacitor placement
- Investment analysis
- Reliability analysis
- Optimal Maintenance Planning (RCM)
- Gas and water pipeline calculation







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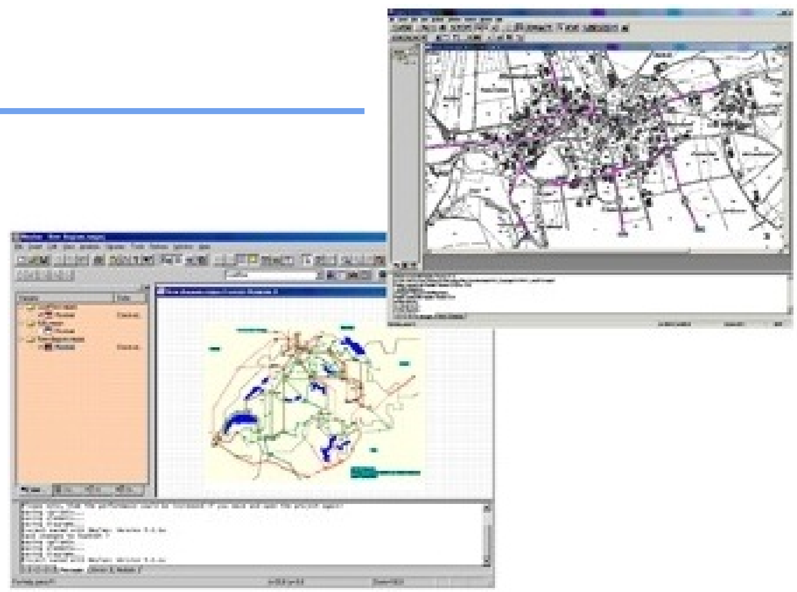
NEPLAN®

NEPLAN® is a Trademark of BCP Busarello+Cott+Partner Inc.

NEPLAN is used worldwide in more than 80 countries by more than 600 companies (> 1800 licenses), such as small and large electrical utilities, industries, engineering companies and universities.

PC program for network studies was developed by BCP Busarello + Cott + Partner Inc. in cooperation with ABB Utilities GmbH and the Swiss Federal institute of Technology, and has been continually improved since its debut in 1989.

Many years of experience with network computations constitute a firm foundation for NEPLAN's dependability.



NEPLAN upgrades your productivity

- Fully-thought-out data management facility, featuring plausibility checks
- Integrated connection to widely used databases
- SQL data scanning for MS-Access, Oracle
- Management of different network variants
- Multi-layer techniques
- Flexible choices for displaying results
- Extensive libraries for network elements and protection devices
- Direct interfacing with geographical information systems (GIS) and SCADA systems
- Option for expansion into your own network information system (NIS)

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