Release Information – PSS®SINCAL Platform 15.0

This document describes the most important enhancements and changes to the new program version. See the product manuals for a more detailed description.

1   General Remarks

1.1   Licensing

To operate the PSS SINCAL Platform 15.0, new license files are required. Once the program is installed, these can be requested at the **PSS SINCAL Platform Support** (phone +43 699 12364435, email sincal@simtec.cc).

1.2   System Requirements

The following hardware and software requirements include the minimum requirements to operate an application of the PSS SINCAL Platform 15.0.

Recommended Hardware

PC or notebook

CPU: >= 2 GHz (MultiCore)

RAM: 8 GB

Hard disk: >= 20 GB

Graphics card: >= 1920 x 1200, True Color

Mouse: 3 buttons (wheel mouse)

Operating Systems Supported

Windows 7 (x86 & x64)

Windows 8 (x86 & x64)

Windows 8.1 (x86 & x64)

Windows 10 (x86 & x64)

Windows Server 2008 R2 (x64)

Windows Server 2012 R2 (x64)

Windows Server 2016 (x64)

Database Systems Supported

Microsoft Access

SQLite 3.x

Oracle 9i

Oracle 10g

Oracle 11g

SQL Server 2008, SQL Server Express 2008

SQL Server 2008 R2, SQL Server Express 2008 R2

SQL Server 2012, SQL Server Express 2012

SQL Server 2014, SQL Server Express 2014

SQL Server 2016, SQL Server Express 2016

1.3   SQLite Database System

PSS SINCAL now also supports the SQLite database system. This database system is now used in a large number of different applications: Its uses start with current web browsers, in virtually all mobile applications, right through to complex development environments such as Visual Studio.

SQLite is based on a public domain program library that features a complete relational database system. A large share of the language commands defined in the SQL-92 standard are supported here.

SQLite can be used effectively, especially when structuring and efficiently managing large data sets. The database is file-based and explicitly not multiuser capable. It largely combines the efficiency of a binary data storage system with the ability to store and update structured data.

The SQLite connection in PSS SINCAL was implemented like the existing Access connection. The data is stored in a local database file (.db), which is saved in the _files directory of the PSS SINCAL network. This makes it possible to use the SQLite database in exactly the same way as Access. The network can thus be copied in the usual way and the standard document behavior of PSS SINCAL can be used without problems.

The large benefit of SQLite compared to Access is the ability to manage even large data volumes very efficiently. Furthermore, no additional drivers or database components have to be installed or configured. All the necessary functions are directly integrated in PSS SINCAL. The use of the 64-bit PSS SINCAL version is therefore possible without any problem.

A further benefit of SQLite is the direct support in Python and also Java. This enables automation solutions accessing and evaluating the PSS SINCAL database to be created even more easily.

As with all other database systems in PSS SINCAL, SQLite also allows mixed operation, i.e. databases in different system can be combined as required for use in the user interface and calculation methods. The network data can also be converted very easily to a different database system (e.g. from Access to SQLite). This can be done simply by using the function **File** – **Save as** in the PSS SINCAL GUI.

2   PSS®SINCAL

2.1   User Interface

2.1.1 New Tabular View

PSS SINCAL now offers a new Tabular View that optimizes the processing of large quantities of data and their efficient evaluation. This same implementation of the Tabular View was previously used in PSS NETOMAC and is now standardized with use in PSS SINCAL for operation in both applications.

Toolbar

Browser
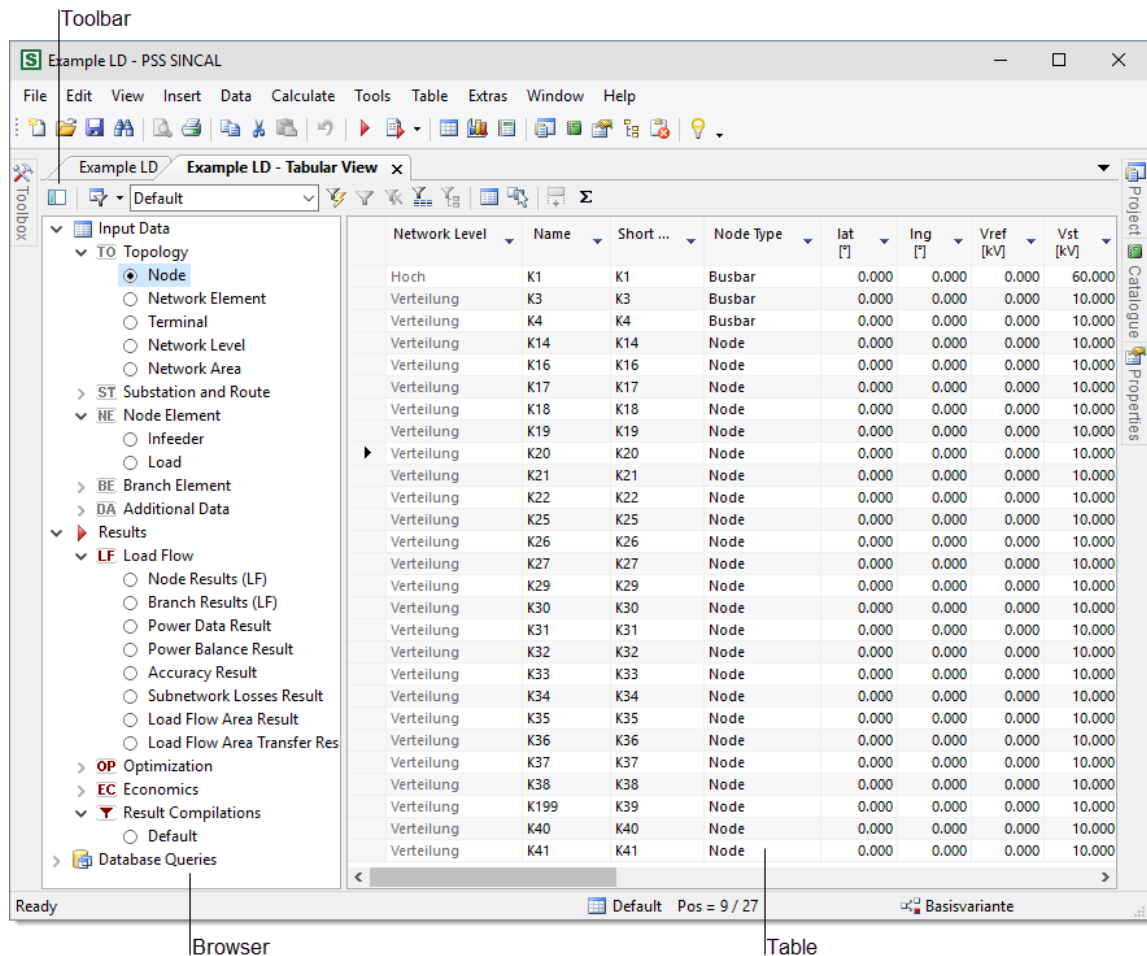
Table

A clear display of all input and result data is an important feature of the table. Complex evaluations can be carried out quickly and easily through the use of the integrated search, filter and sorting functions.

The **new Filter line** makes it particularly easy to evaluate the data displayed in the table selectively. The filter line is activated for this by clicking the appropriate toolbar button. The line then enables any filters to be defined for each column of the table. This can be performed in two ways. The display range can firstly be reduced simply by means of a simple typing filter. It is also possible to define a query for number fields. In other words, an operator (=, <>, >, >=, <, <=) with a filter value is defined. The use of OR or AND enables several terms to be linked in a query.
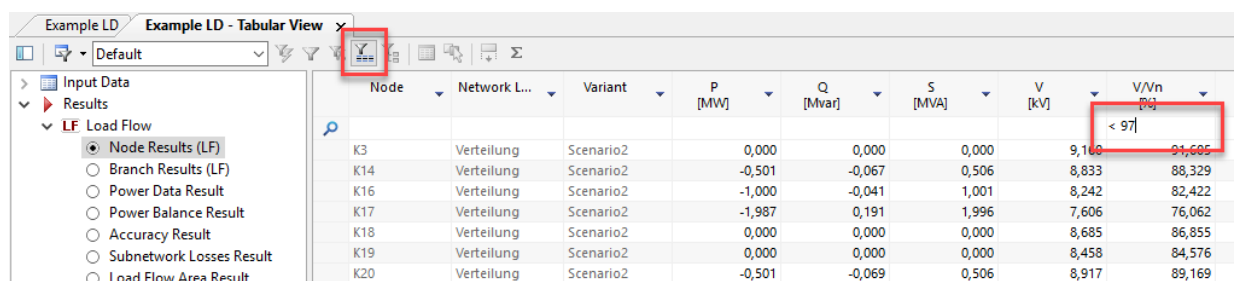
The **Filter with Network Browser** is another new function. If this function is activated, only the data shown in the section **Connected Topology** is displayed in the Tabular View. The use of the function is very helpful if networks have to be analyzed without a network graphic. This enables the structure

of the network to be analyzed in the network browser and evaluated with the Tabular View.
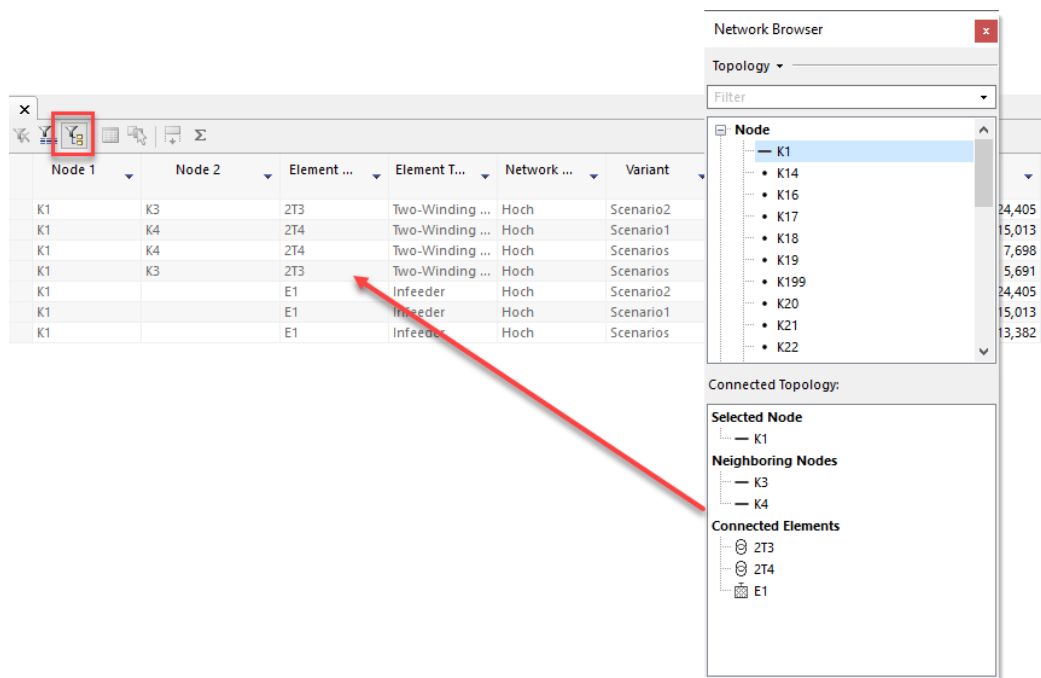
The enhanced context menu functions are also new. The input data, the current results and all other selected results evaluated for the lines selected in the table can be displayed at any time in screen forms, in the same way as the network graphic.

Result Compilation in Tabular View

Result compilations make it possible to make any user-defined combination of results of different calculations (e.g. load flow and short circuit). The actual idea here is to combine as clearly as possible only the results relevant for evaluation. This function was made available with PSS SINCAL 14.5, however the display was previously only possible in the result view. This display is very flexible and clear, but does not offer the extensive evaluation functions of the table. The result compilations are therefore now also provided in the Tabular View.

All user-defined compilations are listed in the browser of the table under **Result Compilations**. Click the selected compilation to visualize it.
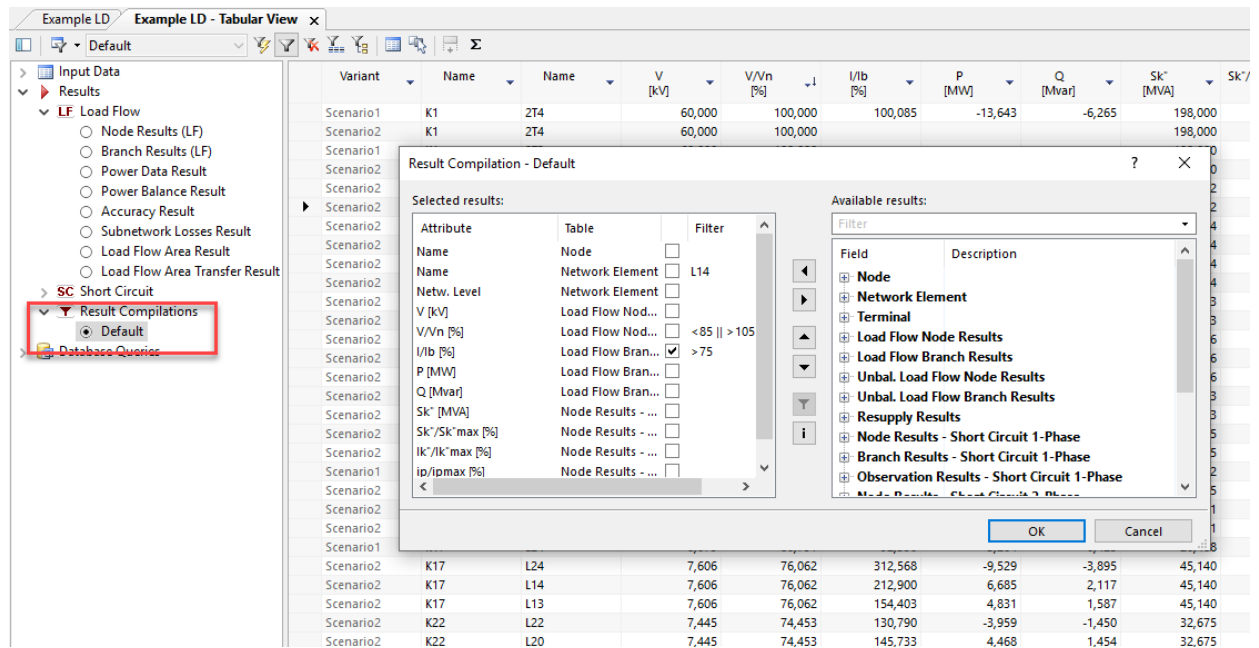
The display range in the table is exactly the same as that of the result view. The display can also be adjusted at any time in the **Result Compilation** dialog box. These settings also apply both to the table as well as to the result view.

2.1.2 Enhancements in the Network Browser

The network browser is a universal tool for showing the structure of the network in different ways. This is particularly useful if networks have to be analyzed without a complete graphic. It is therefore particularly important that the network browser can be used simply and quickly in all networks. The processing speed was therefore optimized at many points, particularly in the topology display. The master resource display was also completely updated in order to enable efficient use even in large CGMES data sets.

New Pop-Up Menu Functions

The pop-up menus for the different display types in the network browser were revised and standardized. The possibility was also provided for selecting in the table for those functions enabling the selection of elements in the network graphic.

Substation Display

The new **Substation Display** was implemented specially for CGMES data sets but also for those networks in which economy calculations are carried out. The substations of the network are visualized with all assigned operational devices and network elements. They are displayed in hierarchies of substations and bays, including all assigned operational devices and network elements. This then provides largely CGMES-compliant access to the hierarchical structure of the network model.

2.1.3 Enhancements for Views

PSS SINCAL enables any number of graphical views to be created in a network. These are only

different graphical displays of the network, which can be schematic or geographical.

PSS SINCAL always requires a primary view. This is automatically displayed when a network is opened, and the network is also closed when the primary view is closed. The primary view was previously always the first view. This has been redesigned for more flexibility. The primary view can now be defined in the **Views** dialog box via the **Standard** checkbox and also changed at any time.
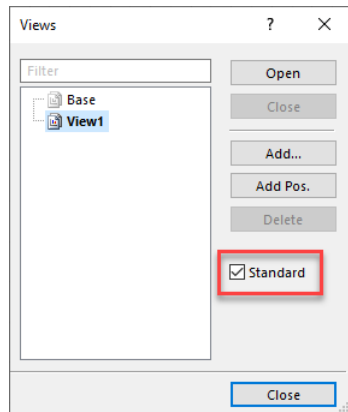
2.1.4 Modified Options for Parallel Calculation and Logging

The setting options for the maximum number of processes to be used and also those for logging are now no longer provided in the Calculation Settings dialog box. These control parameters can now be configured individually by the user in the **Options dialog box** in the **Calculation** tab.
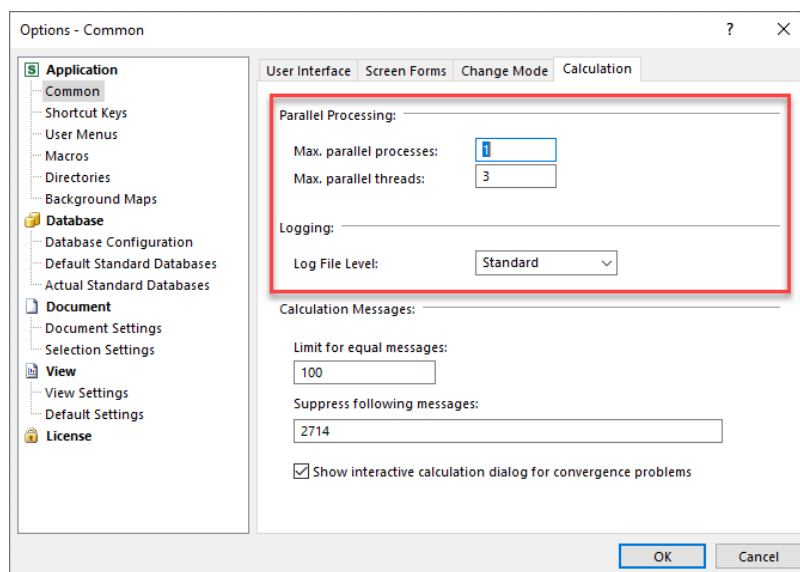
The parallel calculation in PSS SINCAL can be defined in the **Max. parallel processes** input field. This defines the maximum number of calculation processes that can be started at the same time. PSS SINCAL sets the actual number of processes itself using selected calculation processes and the current network configuration.

The **Max. parallel threads** input field is used to control the internal parallel processing in the calculation methods. If a value of "-1" is entered here, PSS SINCAL automatically determines the maximum possible number of parallel threads according to the hardware configuration.

The **Log File Level** selection field enables the output range of the calculation log file in the message window or in the new log evaluation in the result view to be defined.

2.1.5 New Logging of the Calculation Methods in SQLite Database

The network models to be calculated in PSS SINCAL are becoming increasingly more complex and the calculation modules are taking on more and more functions to ensure "optimum" network operation. The calculation modules very often only supply compressed results that are determined by a number of different calculations. A good example of this is the integration capacity module (ICA). This carries out different calculations, such as load flow, short circuit or protection with profiles. The following simple calculation example illustrates this process:

(number of nodes * calculation steps + additional calculations) * times from the profile

(300 * 20 + 4) * 96 = 576.384

As can be seen, even a very small ICA observation area with 300 examined nodes and 96 different times requires more than 500,000 calculations.

If now specific details on limit values or overloads of the individual calculations performed are to be recorded, this will result in impractically large log files in which the information can no longer be usefully evaluated.

To rectify this problem, the same approach was chosen in PSS SINCAL that is also used for the profiling of software. The information recorded in the analysis is saved here in a compact database, which can then be evaluated. The log information is saved in a compact SQLite database that is located in the directory of the network. This log database contains information about the databases used, calculation modules implemented and also calculation times. For example, a log output for a special load flow iteration (in the above example one of the 576,384 calculations carried out) can be assigned to a particular time.

The **Log File Level** is an important control option for logging. This must be already defined in the **Options dialog box** in the **Calculation** tab before the calculation. The following log file levels are available here:

- Low:
  Only minimal information is written into the log file.
- Standard:
  The amount of information in the log file is selected so that the course of the simulation can be reconstructed and potential problems can be analyzed.
- Advanced:
  Very comprehensive information is provided in the log file. This information is mainly useful in the reliability calculations or the hosting capacity, since each individual load flow is documented in detail.

The result view was enhanced for evaluating and analyzing the log information. The calculation log can now be selected here.

The display in the result view is divided into two sections.

The started calculation method and the precise times of calculation start and end are shown in the **General Information** section.

The actual log information is displayed in the form of a table in the **Calculation Log** section. The display range of the log messages can be adjusted and filter criteria defined in order to reduce it. The filter can be configured according to method, log code, description, time stamp and elements assigned to the log.

2.1.6 Interactive Calculation Control

An interactive calculation dialog box is also provided in PSS SINCAL, which operates in the same way as in PSS NETOMAC. In other words, the calculation methods can if required interact with the user in order to control complex processes with user settings.

The dialog box is currently only used for convergence control in electrical networks in the load flow calculation and in the steady-state calculation in pipe networks. If the load flow is not convergent, the calculation dialog box is opened and options are provided in order to carry out further iterations, to output those elements that do not meet the convergence criteria and continue the load flow as convergent if required. This considerably simplifies the analysis of problems in the network because it makes it possible to set a low number of iterations and directly analyze in the dialog box which network elements do not meet the convergence criteria.

The following illustration shows the interactive calculation dialog box for a non-convergent load flow.
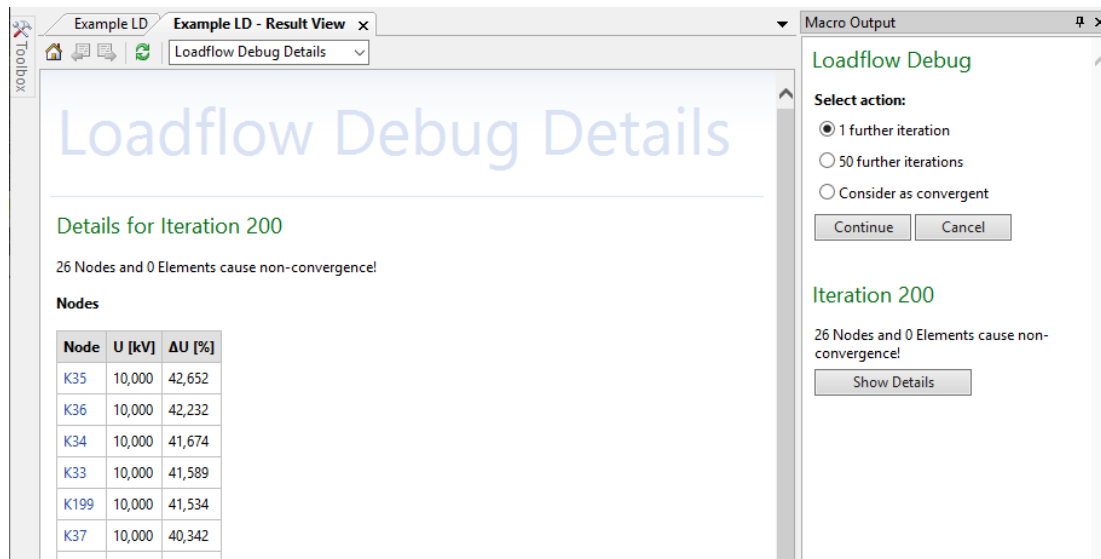
The dialog box makes it possible to carry out further iterations or to consider the load flow as convergent. Clicking **Show Details** makes it possible to open the result view containing more information on those network elements which cause convergence problems.

As the use of the interactive calculation control is not always required, the automatic opening of the dialog box can be activated or deactivated in the **Options dialog box** in the **Calculation** tab.

2.1.7 Management Functions in the Result View

The result view provides additional toolbar buttons for managing the results.
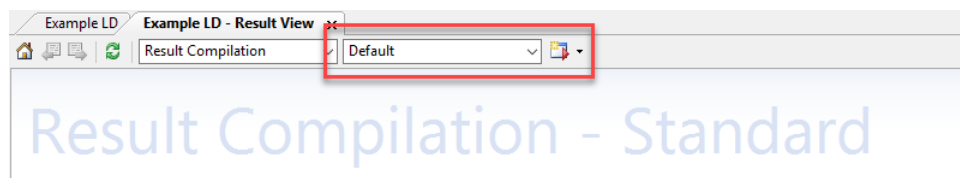
The idea behind these is to retain different results, between which the user can move. This is carried out via the combination box, and the drop-down button behind it enables management functions to be called up, such as for copying, renaming, or deleting results.

This function is currently available for the results of the protection analysis and for result compilations.

2.1.8 Improvements for Models

A new manual is now provided for describing standard models in order to simplify the use of models in PSS SINCAL. The manual is not yet complete but will be continuously updated in order to provide full documentation for the standard models in the Online Help.
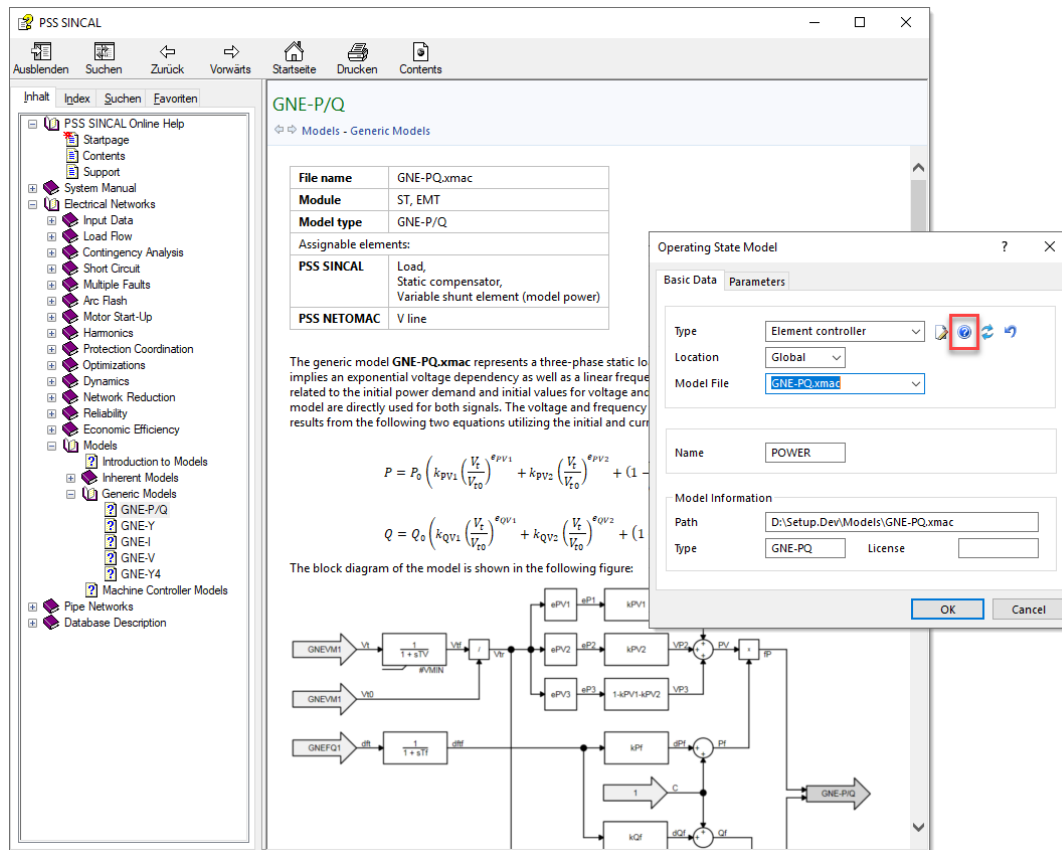
The dialog box for editing model parameters was also enhanced for this purpose. When suitable documentation is available for a model, this can be opened directly from the dialog box.

2.1.9 Modified Sample Files

PSS SINCAL now provides new sample files which show the functions in the area of dynamics:

- Example EMT Energization
- Example RMS CGMES Test Case

Some automation scripts for the user interface and calculation methods are also new:

- FeederEval.py:
  Automated GUI that shows how visualization functions of the feeders can be used.

- SimAutoSincal.py:
  Automated calculation of LF and SC calculation with result output, database version check, matrix export and license check.

- SimMultiCalc.vbs:
  Example of using multiple calculations.

- SimPortDet.vbs:
  Automation example for determining new fault locations.

A special function for copying sample files to the user directory is provided in the **Options dialog**

box in the **Directories** tab.

2.2 Electrical Networks

2.2.1 Enhancements for Harmonics Calculation

New Frequency Scan

This is a new harmonics calculation method that not only allows the frequency but also the network elements to be varied. The actual idea here is to take into account the different switch operations of the network in the frequency response calculation.

To achieve this, a network element group is used, in which those elements are defined that can be changed as follows according to the control parameters:

- Individual: Individual malfunctions of the elements in the network element group,

- Combinations: 2^n combinations in which the network elements are switched on and off (combination of filters) and the control positions can be varied if required.

The following example network shows the operating principle:
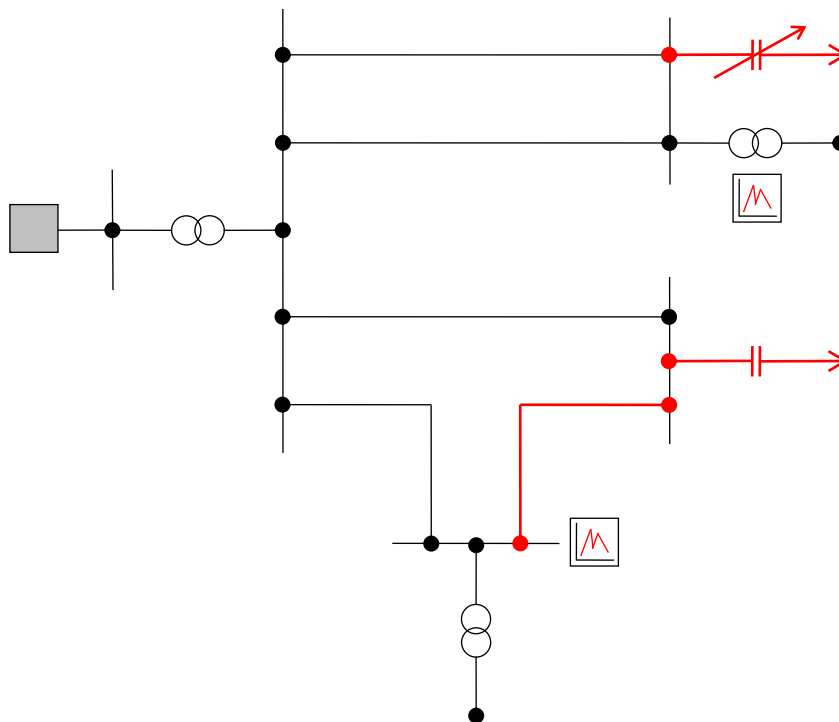
This shows a network element group with the following elements (shown in red in the illustration): Line, capacitor with fixed power value and capacitor with variable power value in 3 tap positions and actual controller position 2.

Network configurations for an single failure:

Configuration	Malfunctioning elements
1	None
2	Line
3	Capacitor with fixed power value
4	Capacitor with variable power value

Network configurations with failure combinations without considering the controllers:

Configuration	Malfunctioning elements
1	None
2	Line
3	Capacitor with fixed power value
4	Capacitor with variable power value (Pos = 2)
5	Line and capacitor with fixed power value
6	Line and capacitor with variable power value (Pos = 2)
7	Capacitor with fixed power value and capacitor with variable power value (Pos = 2)
8	Line, capacitor with fixed power value and capacitor with variable power value (Pos = 2)

Network configurations with failure combinations without considering the controllers:

Configuration	Malfunctioning elements
1	None
2	Line
3	Capacitor with fixed power value
4	Capacitor with variable power value (Pos = 1)
5	Capacitor with variable power value (Pos = 2)
6	Capacitor with variable power value (Pos = 3)
7	Line and capacitor with fixed power value
8	Line and capacitor with variable power value (Pos = 1)
9	Line and capacitor with variable power value (Pos = 2)
10	Line and capacitor with variable power value (Pos = 3)
11	Capacitor with fixed power value and capacitor with variable power value (Pos = 1)
12	Capacitor with fixed power value and capacitor with variable power value (Pos = 2)
13	Capacitor with fixed power value and capacitor with variable power value (Pos = 3)
14	Line, capacitor with fixed power value and capacitor with variable power value (Pos = 1)
15	Line, capacitor with fixed power value and capacitor with variable power value (Pos = 2)

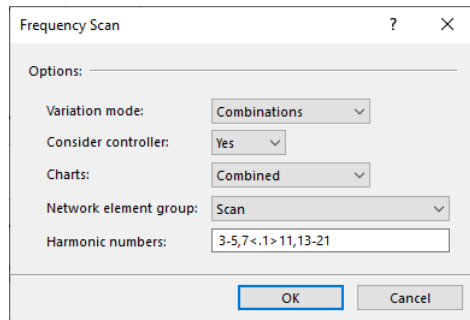| 16	Line, capacitor with fixed power value and capacitor with variable power value (Pos = 3)

The frequency scan can be measured for each node at which a harmonic frequency response is carried out. This determines the impedance for the different network configurations for the set harmonic numbers. The different network configurations are determined from the elements of the specified element groups and the options from the start dialog box.

The new calculation method is opened via **Calculate** – **Harmonics** – **Frequency Scan**. This opens the dialog box with the control parameters.

The **Network element group** and the **Variation mode** can be selected in the dialog box. This determines how the elements in the frequency response calculation are taken into consideration. The **Harmonic numbers** field defines the harmonic numbers for which the frequency scan is carried out. Individual harmonic numbers, ranges and also step widths can be set here.

After a calculation is successfully completed, the results for all nodes with a harmonic frequency response are provided in diagram form.
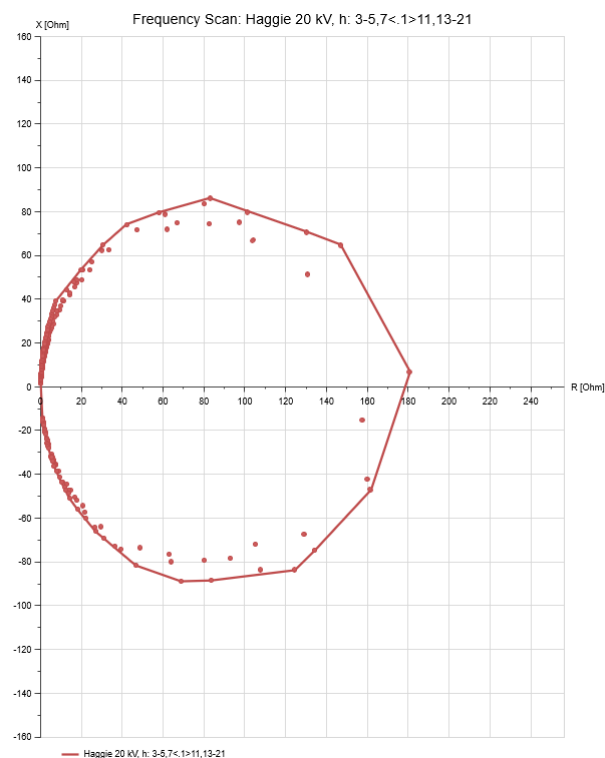
Harmonics without Load Flow Calculation

Previously a load flow was always calculated in the harmonics calculation in order to determine the currents at network frequency. These currents are required for:

- the determination of I_h/I_l for evaluation not according to IEEE,

- the determination of the basic current of harmonic current sources if this is defined with 0.0.

To prevent any convergence problems in the load flow with the harmonics calculation and also increase the processing speed, the basic current is determined from the start voltage according to IEEE. A load flow calculation is then no longer needed.

2.2.2 Enhanced Determination of Fault Locations

The aim of this calculation procedure is to determine the location of a fault in the network.

It has already been possible in PSS SINCAL to determine the fault locations in the network through the stored impedances registered at the protection device. This fault location procedure has been enhanced in order to enable the determination of the fault location using the **registered measured values** (current and voltage).

No other data for the protection devices is entered for the new fault location procedure. Measured values at the terminal where the protection device is installed must be recorded instead.

In order to enter the currents of all conductors in different ways, up to 4 measured values (L1, L2, L3 and N) are required on the same terminal.

The type of fault and the faulty phase(s) are determined on the basis of the values of the measured currents. This information is required for the short circuit calculations.

The measured voltage is determined for checking the pickup in order to determine the direction. The voltage is therefore unimportant for a non-directional trip. The current angle is also not important for non-directional OC protection devices.

The pickup of the protection devices is then checked with these currents and voltages. A network trace in the direction of the line is started for protection devices with a pickup. The network trace ends with the next protection device in the same direction or the one after.

As different locations are determined when measuring several protection devices, the individual possible fault positions are evaluated. Besides the positions in the network, the deviation of the measured currents from the calculated currents is also provided as the result.
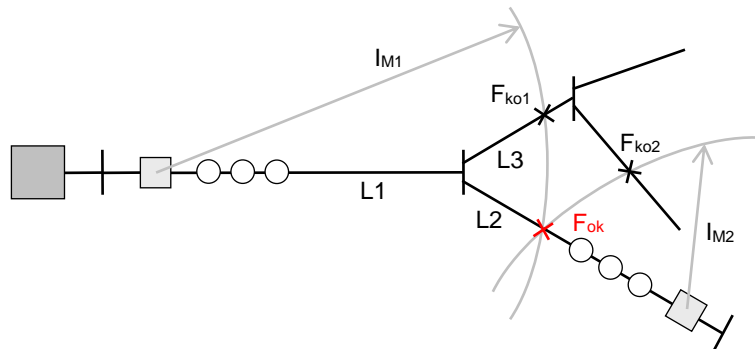
In the example above, the actual fault is located on line L2. The percentage current deviation at this fault position has a value of about zero. The percentage deviation at all other fault positions is considerably higher.

As measured values are recalculated, the network is simulated as realistically as possible. A calculation that strictly complies with the standard does not achieve this aim. The stated short circuit calculation is not used here.

The current short-circuit capacity is used for infeeders. The current short-circuit capacity must also reflect the current state.

The new calculation method is started via **Calculate** – **Protection Device Coordination** – **Determining Fault Locations**. This opens the dialog box in which the fault localization method can be selected.
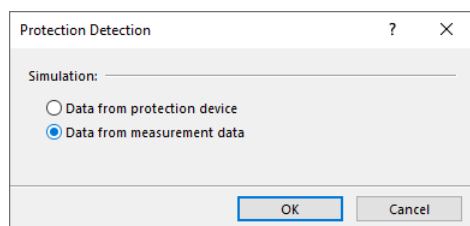
After calculation is successfully completed, the determined fault location results are provided in two ways:

- in the message window
- in the result view

The results in the **Message Window** are displayed as information messages. This makes it possible to easily identify the affected network elements.
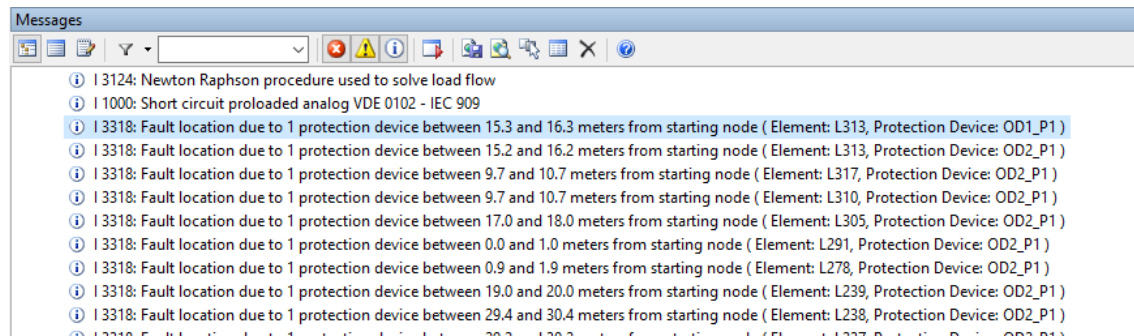
This information message shows the number of protection devices where the fault was registered. It also shows the line on which the fault is probably located and the distance of the fault from the start node. Those protection devices that have registered the fault are also listed.

The results of the fault localization determination are also presented in the **Result View**.
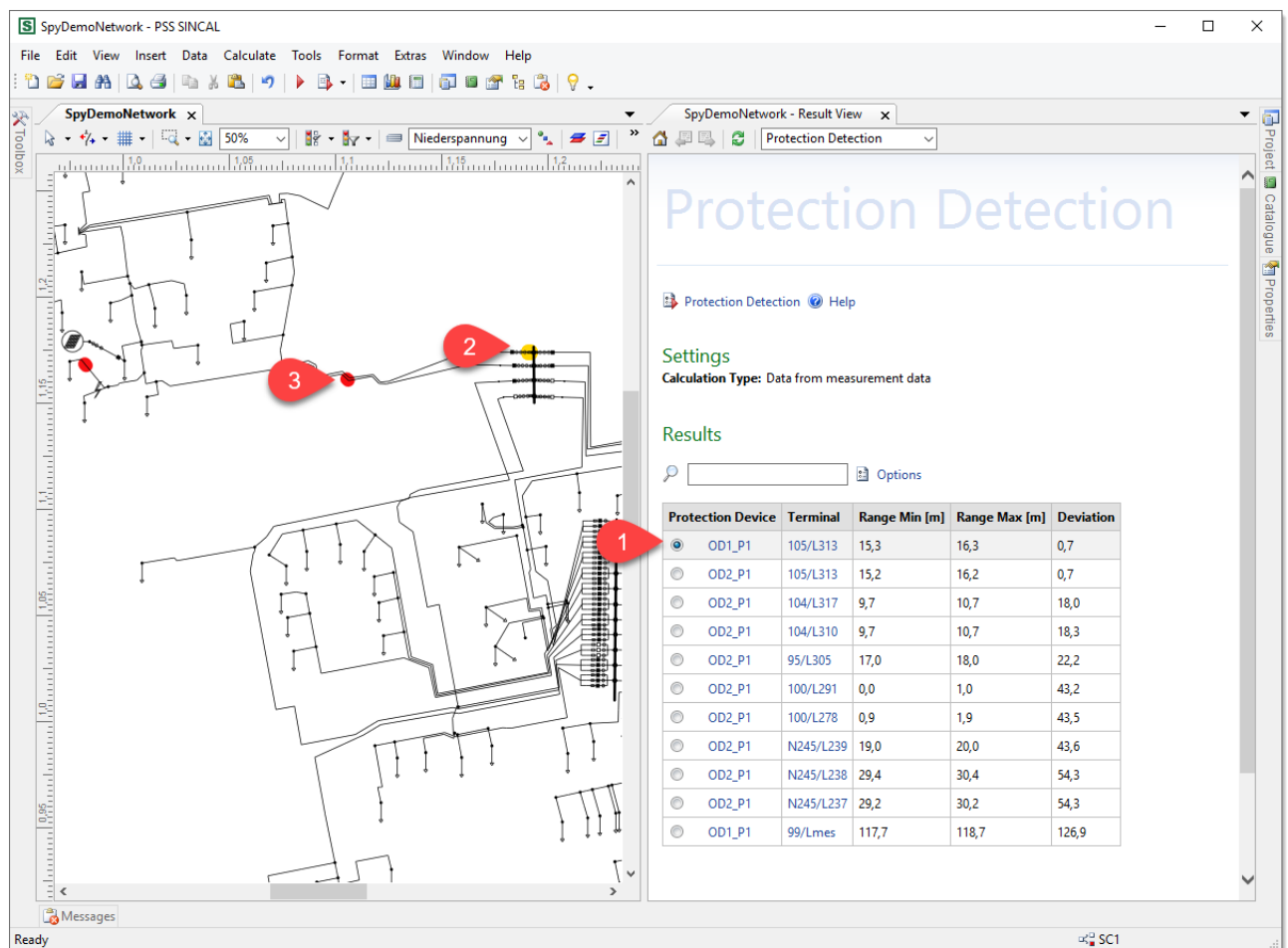
The protection device and the terminal (node/element), as well as the distance on the element from the fault location are shown in a table (1). The display range can be reduced with the filter field in order to restrict the evaluation to individual devices. It is also possible to directly highlight the protection device (2) and the possible fault locations determined (3) in the network graphic.

2.2.3 Switching Sequences in Protection Coordination

The data model of the protection devices and also the processing of the switch operations in the protection coordination have been enhanced in order to enable the modeling of reclosers in PSS SINCAL.

A recloser or automatic circuit recloser is defined by IEEE as:

> a "self-controlled device for making, carrying, and automatically interrupting and reclosing an alternating-current circuit, with a predetermined sequence of opening and reclosing followed by resetting, hold-closed, or lockout operation. It includes an assembly of control elements required to detect overcurrents and control the recloser operation."

In other words, a recloser can be opened and closed several times and the delay for this opening and closing can change. A recloser essentially has the following switching types:

- **Initial switching:** The disconnection is carried out with a normal OC tripping characteristic curve with setting values for the delay time and opening time.

- **Delayed switching:** The disconnection is carried out with the same OC tripping characteristic curve as with initial switching. The setting values for the delay time and opening time are different here.

The switching can be repeated cyclically. Example: Initial switching, 2 x delayed switching, delayed 4 x switching with other times. The higher the switching frequency, the greater the delay and opening time normally are.

The switch operations of the recloser are defined in PSS SINCAL in the OC settings screen form.

Up to four switch sections can be set, which can in turn be repeated many times. For this the **Cycles**

of the reclosings and the **Time** between the switch off and reclosing can be set. The tripping behavior of the section is specified at **Tripping**. The tripping characteristic curve can be compiled through the use of different tripping zones as follows:

- Ip: Characteristic-curve tripping

- I>: 1st instantaneous tripping

- I>>: 2nd instantaneous tripping

- Ip, I>: Characteristic-curve tripping & 1st instantaneous tripping

- Ip, I>>: Characteristic-curve tripping & 2nd instantaneous tripping

- Ip, I>, I>>: Characteristic-curve tripping & 1st instantaneous tripping & 2nd instantaneous tripping

- I>, I>>: 1st instantaneous tripping & 2nd instantaneous tripping

The tripping that finally switches off after all sections have been processed is defined at **Final**:

- Ip: Characteristic-curve tripping

- I>: 1st instantaneous tripping

- I>>: 2nd instantaneous tripping

The tripping for the final switch off of the recloser must be set at **Lockout**. No further reclosing is carried out.

- None: No stop tripping present

- I>>>: 3rd instantaneous tripping

The complete switching sequence is divided into individual switching operations. A switching operation starts with the excitation and ends with the reclosing. The time sequence is based on the following.
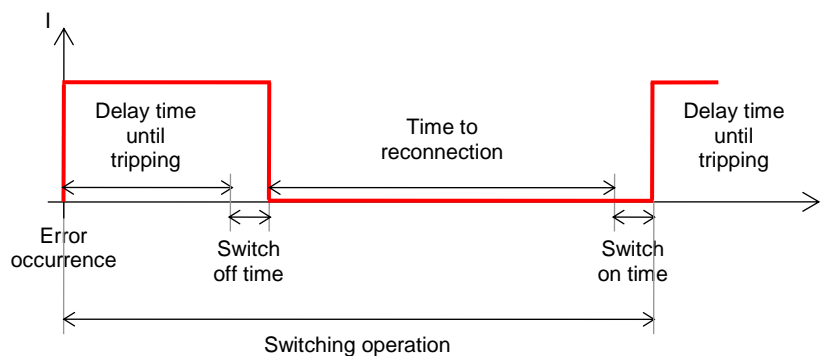
This switching operation is repeated depending on the configuration. Three switching operations produce the following curve characteristic for the section.
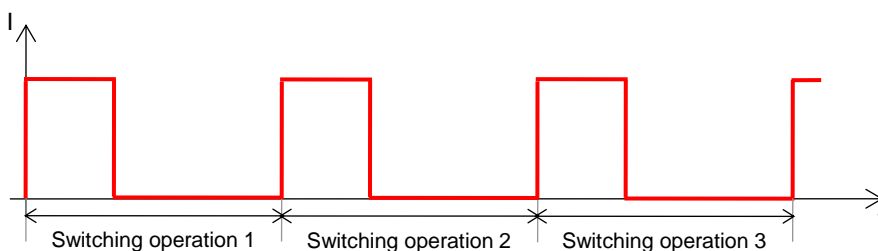
All switching operations have the same time duration. After all switching sequences the final disconnection is completed with the final tripping.
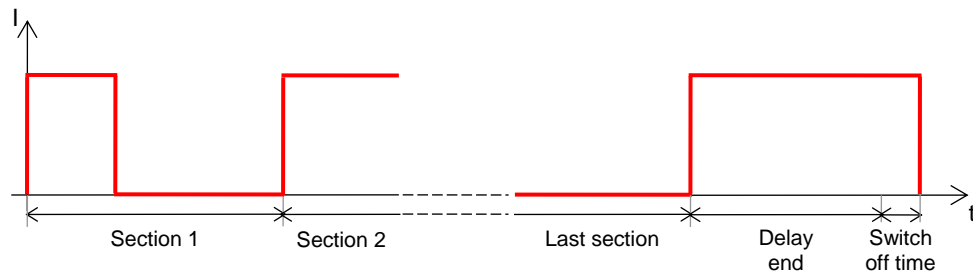
The stop tripping interrupts the switching sequence. Reconnection is not performed after the stop tripping.

2.2.4 Functional Enhancements in Protection Coordination

Enhancements have been implemented at many points in the protection coordination in order to accommodate the requests of users and also to increase the functional range of the calculation module.

Redesign of the Screen Form for the Installation Location

The tabs in the screen form for the installation location have been updated in order to improve the assignment of input fields:

- Basic Data:
  Topological information on the installation location, instrument transformer for phase and ground.

- Directional Element:
  All directional data.

- Additional Data:
  Additional data for the protection device, such as switching costs, switching times and also data for fault location determination.

Multiple Current Transformers for OC and DI Protection Devices

It is now possible for up to 4 current transformers for phase and ground to be defined at the installation location.

With OC and DI protection devices, the **Additional Data** tab makes it possible to define how these additional current transformers should be considered. The **Transformer Polarity** section is used to set how the current transformer should be considered:

- Ignore:
  The current transformer is not used.

- Normal:
  The currents of the transformer are included in the calculation.

- Invers:
  The inverse currents of the transformer are included in the calculation.

The currents are added on the secondary side for each phase in the protection coordination. This is added irrespective of the conversion ratio of the transformers but a warning is output if the conversion ratio is not the same.

Additional Delay Time for OC Protection Devices

It is now possible to set an additional delay time for each tripping zone individually if this is supported by the selected type of protection device.

If an additional delay time is set, the tripping of the OC protection device is not performed in the time determined on the basis of the current/time characteristic curve, but from the sum of both times.

Multiple Differential Protection Areas per Protection Device

The differential protection area is now no longer defined globally at the installation location of the protection device but directly in the screen form with the differential protection input data. This enables different differential protection areas to be assigned to an installation location (= protection device).

Summary of Measure Points for Differential Protection Devices

A transformer differential protection in PSS SINCAL previously required a current transformer to be inserted at each transformer connection.

However, in reality a current transformer is not normally positioned at each terminal in order to reduce costs. Instead of placing a current transformer on the secondary side of a transformer, it is also possible to use the negative current total of all secondary feeders for the tripping. If a line differential protection has to be installed at all feeders anyway, this eliminates the need for a current transformer.

For this assignment to also be possible in PSS SINCAL, the setting values input dialog box for differential protection was extended. A selection field has been provided for the assignment to a different measure point for measure points 3 to 12. This enables the correct current rotation to be carried out for each measure point.

In the example below, the infeeder, generator and the two secondary transformer feeders are protected with an OC protection. The transformer has no protection. However, it is surrounded by protection devices which have a negative total current that always produces the value 0.0 in the event of faults on the transformer. These devices can therefore always be used for differential protection.
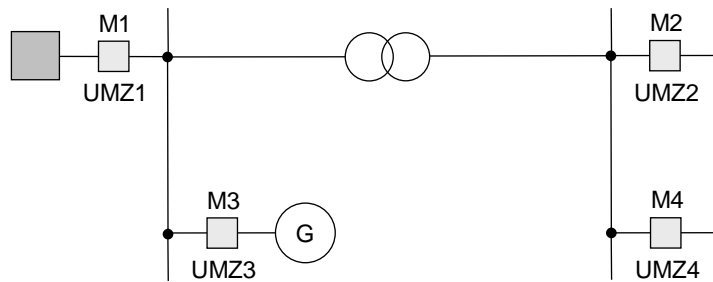
For this, differential protection setting values are entered for each protection device in the protection device dialog box in addition to the OC setting values, and **two-winding transformer** is selected as the protection object.

Protection devices must be taken as measuring point 1 and measuring point 2, between which the phase rotation of the transformer occurs.

Measuring points 3 and 4 can then be selected as required. However, an assignment must be specified for these two measuring points. The assignment must be made so that the phase rotation of the transformer for these two measuring points is correctly considered.

The entry in the protection device dialog box is therefore as follows:

Device	Measuring point	Polarity	Assignment
OC1	M1	activated	
OC 2	M2	activated	
OC 3	M3	activated	M1
OC 4	M4	activated	M2

The OC3 protection device (measuring point 3) is located on the same side of the transformer as protection device OC1 (measuring point 1). There is also no phase rotation between these two devices. The same applies to protection devices OC2 and OC4 (measuring points 2 and 4).

Sensitive Ground Fault Detection for Protection

The angle difference between zero voltage and zero current ($\cos_\varphi$ method) is used to determine the direction of protection devices for ground faults in resonant grounded networks.

To simulate this in the PSS SINCAL protection coordination, a new method was implemented for determining the direction. The new method is activated in the protection device screen form in the **Directional Element** tab with the **Direction Determining** selection field. The selection option **Isolated** is provided here for activating sensitive ground fault detection.
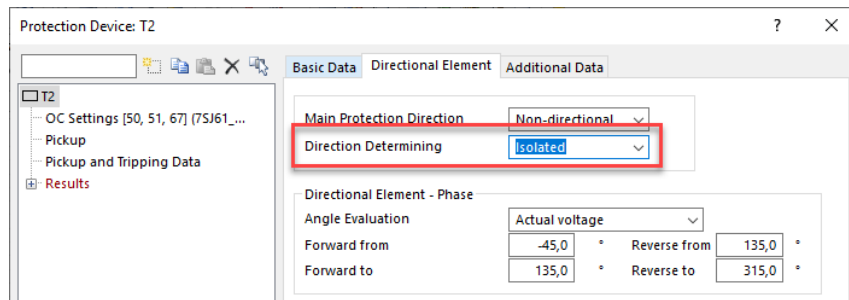
2.2.5 Enhanced Tap Zone Determination

The tap zone determination function defines the tap zone position of feeders at minimum and maximum load. The entire feeder is only represented here by a consumer. With this simulation the transformer losses and the voltage drops at the transformer are only considered in simplified form.

The enhanced tap zone determination enables the transformer tap position to be determined also when modelling the feeder. This considers the transformers and the losses occurring in the feeder precisely.

If only one load with measured values is connected behind the transformer, no further information is required. If more than one load is connected behind the transformer, measuring devices for trimming the loads must be specified.
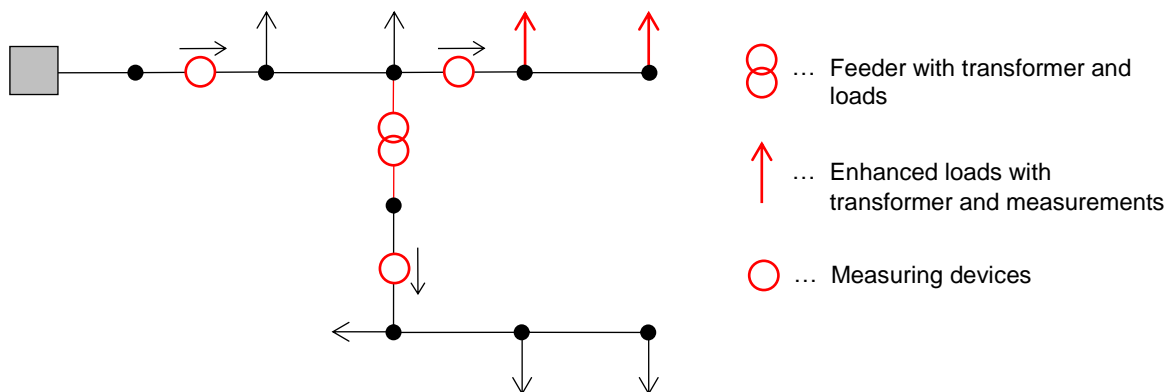
2.2.6 Load Flow Q(P) Control

The reactive power controller already available in PSS SINCAL was provided with an additional option enabling the reactive power to be set in relation to the active power. Like the controllers already provided so far, this enables either a simplified simulation to be created with two points or a detailed simulation based on a characteristic curve.

The new type of reactive power controller was implemented for the infeeder, the synchronous machine, the power unit and the DC infeeder. The parameters of the controller are set in the **Controller** tab of the screen forms. The **Type of Controlling** field also enables the **Active power – Q** option to be selected in addition to the previous options.

This special reactive power controller is particularly important when decentralized infeeders are involved. The network operator mostly requires here a reactive power infeeder adjusted to the active power.

The reactive power normally increases or decreases with the load of the supply source. Above or below a set load limit, the decentralized supply source must keep the set inductive or capacitive reactive power factor constant. The reactive power factor is continuously adjusted between the load limits.
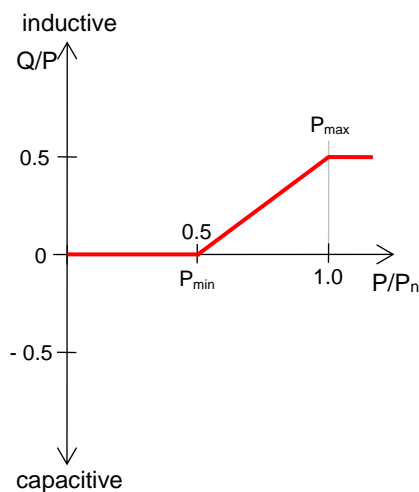
2.2.7 Verifying the Connection Conditions according to IEEE 1547-2018

The EEG module for verifying the connection conditions was extended to meet the requirements of the IEEE 1547-2018 standard.

The check function is started via the pop-up menu of the DC infeeder or machine to be checked via **Calculation at Element** – **Verify Connection Condition**.

The control dialog box is then opened with the parameters for the check.

The **Technical Data** tab now also enables **IEEE 1547** to be selected in the **Connection rule** selection field. The specific input options are activated for this in the dialog box tabs by selecting the connection rule.

In many areas, the verification in accordance with IEEE 1547 is the same as the verification according to BDEW with other limit values. However, the verification process has the following differences:

- The check area is defined differently. The check at the PCC (Point of Common Coupling) is based on IEEE 1574. In other words, this PCC must be created in the network.

- The PCC and the check area are determined starting from the network element to be checked.

- The harmonics check is considerably different to BEDW. This requires a complete harmonics calculation in the check area in which the TRD (total rated current distortion) is also determined. This TRD is determined for the DER without including the remaining elements in the observation area.

- The voltage change check is restricted to the fast voltage change. Other limit values are used here for the checks.

- The flicker check is based on short-time flicker measurements (2 h in the 10 minutes interval). These values must be entered in the **Flicker Data** tab.

The results of the check are shown clearly in the result view as before. This enables the result to be assessed at a glance. A special verification log is also provided in a Word document.

2.2.8 Performance Optimization in Calculation Methods

The complexity and size of the networks to be analyzed is increasing continuously, and also the number of calculations that have to be carried out. For this reason, software performance has been optimized in many places. The aim was to achieve considerable improvements, particularly for those

processes that run the many calculations in succession.

For this the data structures of the most frequently used modules, such as load flow and short circuit, were analyzed in terms of performance and optimized wherever possible. The algorithms were likewise designed for greater efficiency at many points.

The MKL library is now primarily used in the load flow calculation, the short circuit calculation and also in the harmonics calculation for the simultaneous solving of the sparse admittance matrix. The following table shows the change in the calculation time for different networks and methods:

Method	Calculation Information	V14.5 Duration [s]	V15.0 Duration [s]	Factor
LP	Network with 26,052 nodes, load profile for 365 days.	262	185	1.42
ICA	Asym. network with 500 nodes and coupling data, 5621 load flows.	7551	5919	1.28
PF	Network with 25,000 nodes, asym. load flow.	8.02	4.16	1.93

2.2.9 Enhanced Functions for Scenarios

A scenario is a combination of change data which is assigned to an existing network. This enables the operating state of the network elements (active/inactive), the switching of connections and naturally also the individual data of the network elements (e.g. power values, factors, controller settings, control method etc.) to be changed.

The new enhanced functions now make it possible to define new network elements and nodes via a scenario. Completely new analyses can therefore be carried out with scenarios, particularly for future planning and network optimizations. It cannot normally be expected that all future elements are already present in the network and just have to be activated/deactivated.

A small example network is used to explain the operating principle.

Basic network without scenario:
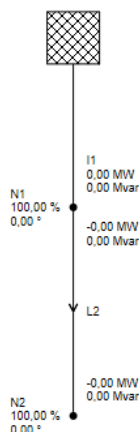
Network with scenario:
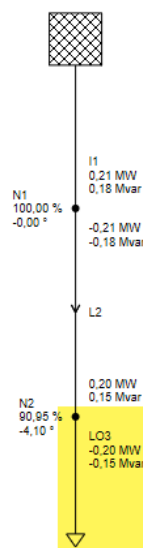
In the example shown, a new load has to be connected to node N2. The appropriate changes in the network are described with a special scenario file. The area for creating a new load is highlighted in the following extract from this scenario file.

```xml
<?xml version="1.0" encoding="UTF-8"?>
<sincase xmlns="http://www.simtec.cc/sincase/1.0">
<Document>
<name>Scenario new load</name>
<Settings>
    <ExportRange>Full</ExportRange>
    <Content>SwitchState</Content>
    <Content>OperatingState</Content>
    <Content>ElementData</Content>
</Settings>
<NetworkData>
    <Node id="N2" objid="2" type="Node">
        <Name>N2</Name>
        <ShortName>N2</ShortName>
    </Node>
    <Element id="E-3" objid="-3" type="Load" node1="N2" mode="new">
        <Name>LO3</Name>
        <ShortName>LO3</ShortName>
        <VoltLevel_ID>1</VoltLevel_ID>
        <Group_ID>1</Group_ID>
        <InputState>3</InputState>
        <P>0.200000</P>
        <Q>0.150000</Q>
    </Element>
</NetworkData>
</Document>
</sincase>
```

The **Element** tag defines the load and the **mode="new"** attribute specifies that it is a new network element and not a change in an existing element. The attributes in the element tag also establish the connection to the terminal node. The negative ID in the **objid** attribute indicates that it is a new element. This ID must be unique in order to enable more complex connections with new elements and nodes.

The data of the load is defined in exactly the same way as normal changes in the scenario. The data that is not specified explicitly is provided with the default values from the data model. Only the changes to the default values therefore have to be stored in the scenario file. This helps to makes the file clear and compact.

The function for creating scenario files from variant changes in the network model was also adapted. This includes the measuring of new elements and thus also enables complex scenario files to be created with the PSS SINCAL user interface.

2.2.10 Automation Function for Saving Virtual Databases

This new automation function for the calculation methods enables the network data from the virtual database to be saved in a physical database. This very special functionality is particularly useful for highly integrated coupling solutions to third-party systems, since only the PSS SINCAL calculation modules are often used without a physical database. This generates the network model directly in the main memory of the calculation modules. However, if a physical database has to be created in order to utilize the many extensive reprocessing and evaluation capabilities of the PSS SINCAL user

interface, it was previously necessary to implement another variant of the coupling solution that filled the PSS SINCAL database directly.

The new automation function now enables the virtual database to be saved in a physical database. For this the already existing SaveDB() automation function of the calculation was enhanced so that all input data can be saved in addition to the results.

```
' Save load flow results from virtual database into physical database.
SimulateObj.SaveDB "LF_NR"

' Save all data from virtual database into physical database.
SimulateObj.SaveDB "ALL"
```

The new function can be used with all database systems supported by PSS SINCAL 15.0. In order to enable saving, the database must already be opened when the calculation is started. In other words, the physical database must already be available in the correct version before the automation function or must be generated beforehand within the automation function.

2.2.11 Enhancements in the PSS E Import and Export

IEC File Import

The short circuit data for PSS E IEC Version 2 can now also be imported. However, network element conversions for the import are not supported, i.e. the network element is specified via the RAW file.

GNE Device Data Import

The GNE device data (Generic Network Element) from the RAW file is now included in the import. However, the different modeling of the data in PSS E and PSS SINCAL requires a different simulation:

- The GNE Device Data section in PSS E only contains node information. The GNE devices are user-defined elements that are connected to these nodes.

- In PSS SINCAL the GNE device data is assigned to existing node or branch elements. The data then functions as an operating point model which controls the behavior of the network element.

In order to balance out these modeling differences, variable shunt or serial elements are generated with the import for each GNE device data record.

Export of Network Elements with Operating Point Models

The underlying network element for models that supply the absolute values is not included in the export and only a corresponding GNE device data set is generated in the RAW file.

Only the underlying network element is exported in the RAW file for models that supply relative values. A warning message is output in order to indicate the problem.

Export of Filter Elements

Filters were previously always exported to the RAW file as impedance loads. To balance the loads in the network this is not normally desired and so a shunt is exported to the RAW file for each filter element.

2.2.12 Enhancements in the CGMES Import

The following enhancements were implemented for the CGMES import in PSS SINCAL:

- The node import was revised so that problematic combinations of ConnectivityNode and TopologicalNode can be processed better.

- The import of network elements with node/breaker models with graphic data was improved.

- Missing network element levels (voltage level, base voltage) are detected and recorded better.

- Branch elements that are connected with both terminals at the same node (self-references), are detected as invalid and not imported.

- Faulty or unsupported data is detected better and recorded.

3   PSS®NETOMAC

3.1   User Interface

3.1.1 Importing and Exporting Workspaces

Like PSS SINCAL, the user interface now provides a function for importing and exporting workspaces. The functions are available via **File** – **Import** – **Workspace** and **File** – **Export** – **Workspace**.

This opens the dialog box in which the workspace file and the import/export range can be selected.
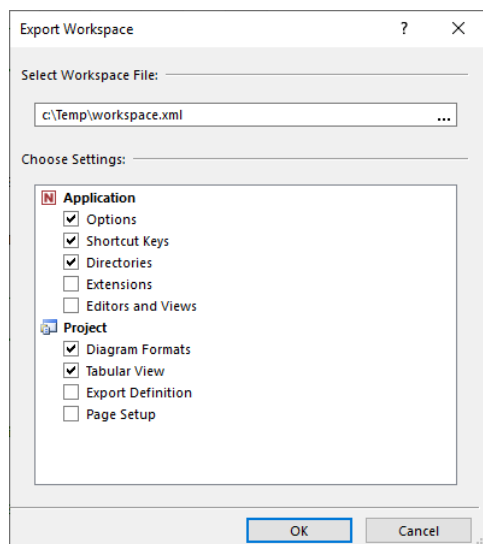
The dialog box offers the most important project settings and globally also application settings which are only available in the registry (such as shortcuts). This then enables these settings to be exchanged also between different product versions on different PCs. An XML file is use to save the workspace data.

3.1.2 Enhancements for Projects

Saving of Project Data

Changes in the project were previously only saved on closing. In order to ensure that the changes made in the project are not lost in the event of an unforeseen closing down of the application, the menu item **File** – **Save Project** was provided for saving the project manually at any time. The project is now also saved automatically when calculation methods are started.

Renaming Project Files

The new **Rename Files** function has been provided in the pop-up menu of the Project Explorer. This enables all the standard files of a project to be renamed. This is useful if existing projects are to be copied and also the file names in the project are to be changed.

All project files with the correct names apart from the files with the following suffixes are renamed: .mac, .xmac, .dll, .std, .lib.

3.1.3 Changes for Manufacturer DLLs
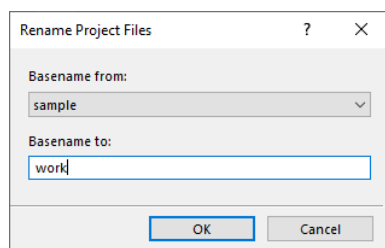
Manufacturer DLLs in PSS NETOMAC can be used in the load flow and in the simulation in the time range. These DLLs are created on the basis of the IEC 61400-27-1 interface specification, which defines a standard API. This enables the DLLs to be created with any programming environment and used by any software that supports this standard.

The functionality of the DLLs is basically enclosed in a black box. Defined APIs, which supply the black box with inputs and parameters and also supply the outputs, are provided in order to link them to the applications:
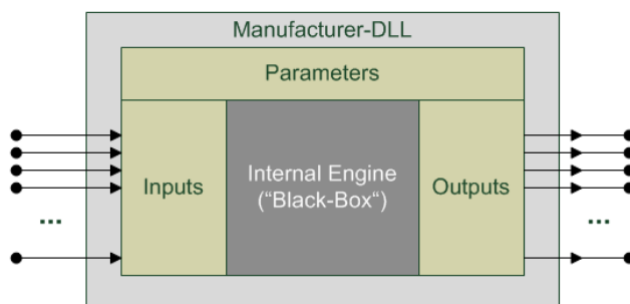
The manufacturer DLLs were previously incorrectly called SIMULINK DLLs in PSS SINCAL. They are now correctly called **Manufacturer DLL**.

These DLLs must be enclosed in a MAC file defining the required control parameters in order to use

them in PSS NETOMAC. This is carried out via **Tools** – **Conversions** – **Manufacturer DLL**. This reads the interfaces of the DLLs, and saves the parameters required and input and output values in a MAC file. This MAC file can then be used in the PSS NETOMAC models in order to connect the manufacturer DLLs. This conversion function can now also be used if no project is opened.

3.1.4 Improvements for Snippets

Snippets are predefined text blocks which can be inserted in the source editor with a key combination (CTRL+ spacebar).

The new version now provides a number of new predefined snippets covering many areas of the PSS NETOMAC input format. In order to simplify the selection of snippets, it is now possible to use wildcards in the filter line of the selection window.
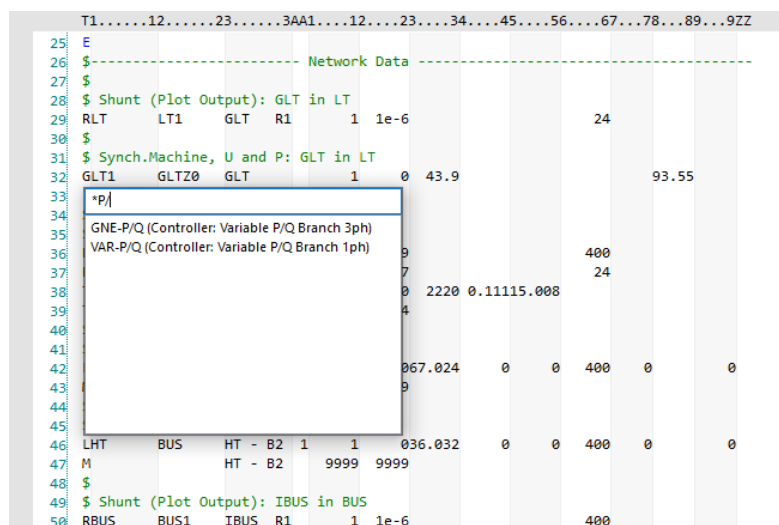
The dialog box for editing snippets was also updated in order to make the definition of snippets more user-friendly. The dialog box is more clearly designed and its size can be adjusted as required.
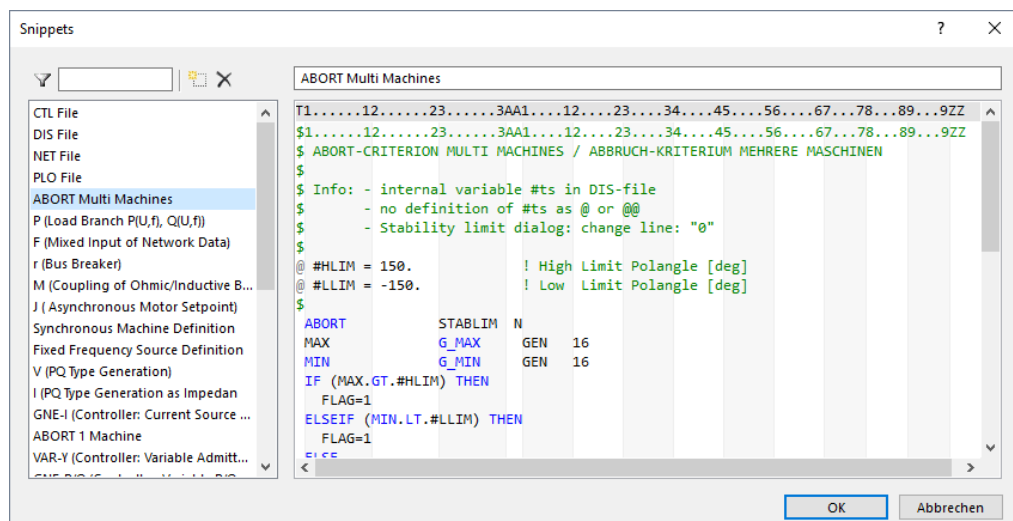
3.1.5 Improvements for Diagrams

Enhanced Variant Comparison in the Diagram

In order to simplify the comparison of variants with the diagrams, the pop-up menu of the diagram now provides the new **Add Signals from Variant** function. This enables all those signals of the selected variants to be added to the existing signals for all graphs of the diagram page.
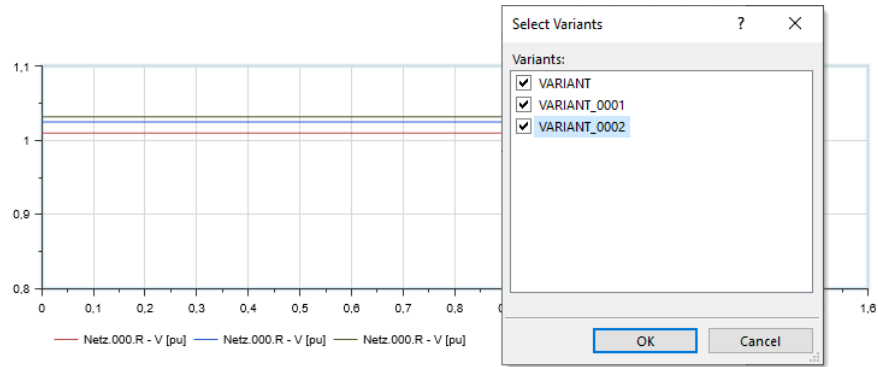
Improved Display of Tables in Diagrams

PSS NETOMAC also displays tables with additional information in the different diagrams, such as with ASM identification or in the S plane diagram of the eigenvalue analysis and the eigenvalue screening.

The display of these tables was improved so that it is more compatible with the diagram style and is also more legible.

Parameter	Iteration 1	Iteration 19
R 1	0,041998	0,034525
X 1	0,010005	0,017007
X 2	7,540126	3,396914
X 3	0,085474	0,044278
R 4	0,009087	0,003860
X 4	0,200000	0,184902
R 5	0,627493	0,222051
X 5	0,478106	0,518451

Starting / nominal conditions:

Slip [%]	100,000	0,349
Current [pu]	5,397	1,003
cos phi	0,264	0,847

Identification parameters:

Ia [pu]	cos phi.a	cos phi.n	eta [%]	Ia	In	cos phi.a	x.sat theor.	Isat/Ia
5,4	0,25	0,85	95,8	5,0	5,0	5,0	0,2	0,32

No-load characteristic:

V/Vn	0,0	0,5	0,75	0,9	1,0	1,1	1,2	1,35
Ierr/Ierr.o	0,0	0,5	0,8	1,09	1,32	1,6	2,1	5,0

3.1.6 Improvements for Models

Graphical Model Editor

In order to simplify the selection of blocks, it is now possible to use wildcards in the filter line of the selection window.

Documentation for Standard Models

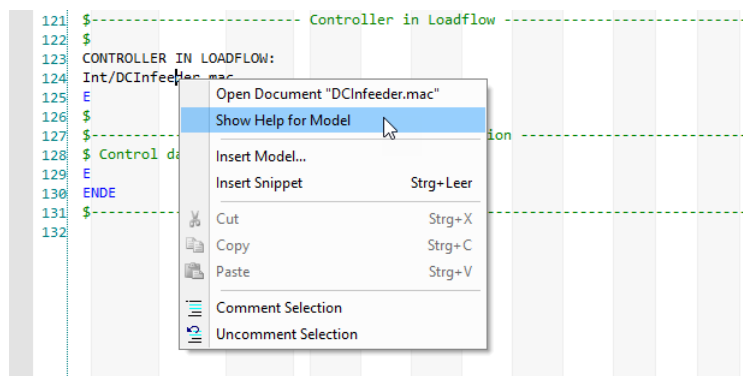As already mentioned in chapter 2.1.8, a new manual is now provided for describing standard models. This manual is also integrated in the PSS NETOMAC Online Help.

If a standard model is edited/displayed in the model editor, the direct help for the model can be opened via **Model** – **Show Help for Model**. This help connection is also provided in the NET file via the pop-up menu.

Changes to Standard Models

All supplied standard models are now located in the folder \INSTALL_PATH\Models\ and can be assigned directly by default without specifying an absolute folder.

New Models:

- GNE-I.xmac: Generic model of a 3-phase current source
- GNE-V.xmac: Generic model of a 3-phase voltage source
- GNE-Y.xmac: Generic model of a 3-phase variable admittance
- ExcELIN1.xmac: CIM CGMES model for excitation system
- ExcOEX3T.xmac: CIM CGMES model for excitation system
- ExcPIC.xmac: CIM CGMES model for excitation system
- ExcREXS.xmac: CIM CGMES model for excitation system
- ExcSCRX.xmac: CIM CGMES model for excitation system
- UnderexLimX1.xmac: CIM CGMES model for underexcitation limitation

Updated Models:

- GGOV1.mac: Adaption of the initialization and the standardization
- AC7B.mac: New implementation
- AC7B.xmac: Improved parameter handling

- IEELBL.mac: Resorting of the parameters according to PSS E documentation

- GNE-PQ.xmac: New implementation according to documentation

- GNE-Y4.xmac: Graphical revision and renaming

3.1.7 Modified Sample Files

The sample files supplied with PSS NETOMAC for illustrating program functions with simple network models are now located in a different directory. The examples are now no longer contained in the "Projects" directory, which is intended for storing user projects. They are located in the separate "Samples" directory.

The following new or enhanced sample files are available:

- CaseStudy_06_MachineSynchronization:
  Synchronization of a synchronous machine on the fixed frequency network with different conditions with regard to voltage, phase and frequency.

- CaseStudy_13_TransientRecoveryVoltage:
  Examination of the recovery voltage on a circuit breaker.

- CaseStudy_14_Energization:
  Examination of a magnetization process on a model with line and transformer with the appropriate switch-on operations.

- CaseStudy_15_FaultRideThrough:
  Examination of the fault behavior of a synchronous machine.

- CaseStudy_18_FrequencyResponsePassive:
  Creation of a passive frequency response of a network model.

- CaseStudy_19_FrequencyResponseActiveCL:
  Creation of an active frequency response of a network model with active elements.

- CaseStudy_20_StabilityLimit:
  Sample for the "Stabilization limit" function. Iterative finding of the critical fault rectification time with the example of a 1 machine model.

The following automation scripts are new:

- EVA.py:
  Automation function that shows how eigenvalue analysis can be performed without a user interface. The results are provided in the XRES file.

- CIMtoNETOMAC.py:
  Example of the conversion of the CGMES data to the PSS NETOMAC format.

In order to copy the current sample files to the user directory the **Options dialog box** in the **Directories** tab provides a special **Copy** function.
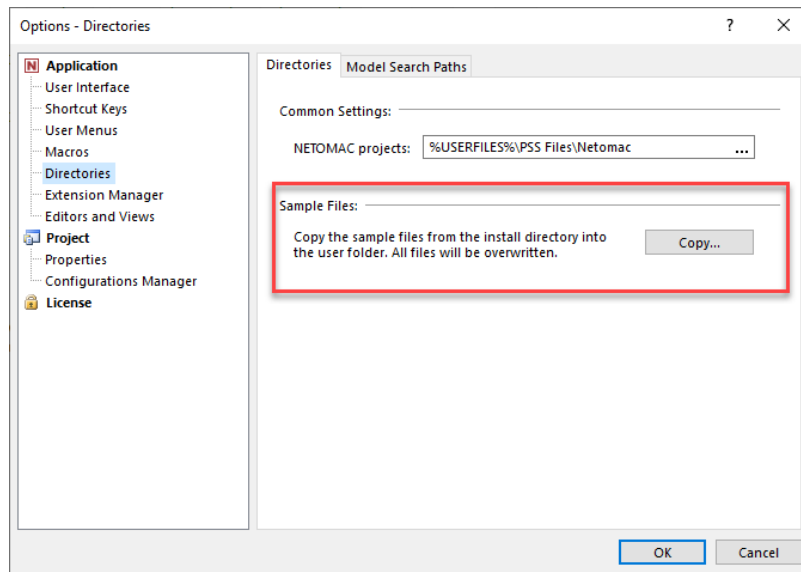
3.2   Calculation Methods

3.2.1 Improvements in Eigenvalue Analysis

The calculation parameters of the eigenvalue analysis were reduced and many functions that formerly could only be specified before the actual calculation can now also be changed later in the interactive analysis.
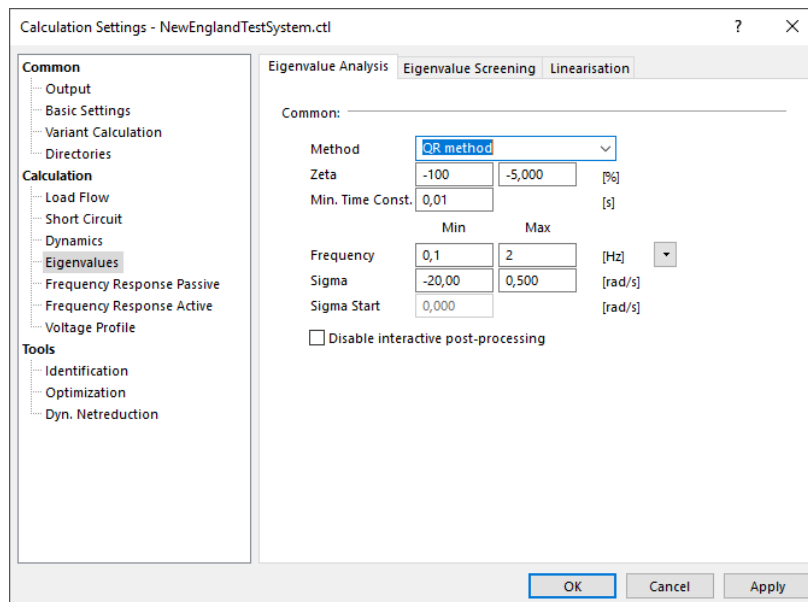
However it must be remembered here that the parameter settings define the basic result range, which can then be reduced with the interactive analysis. However, any extension of the range is not possible in the interactive analysis. For example, those eigenvalues that are filtered by setting the minimum zeta value are no longer available.

The result range for the evaluation is controlled via the s-plane diagram in connection with the filter

dialog box.
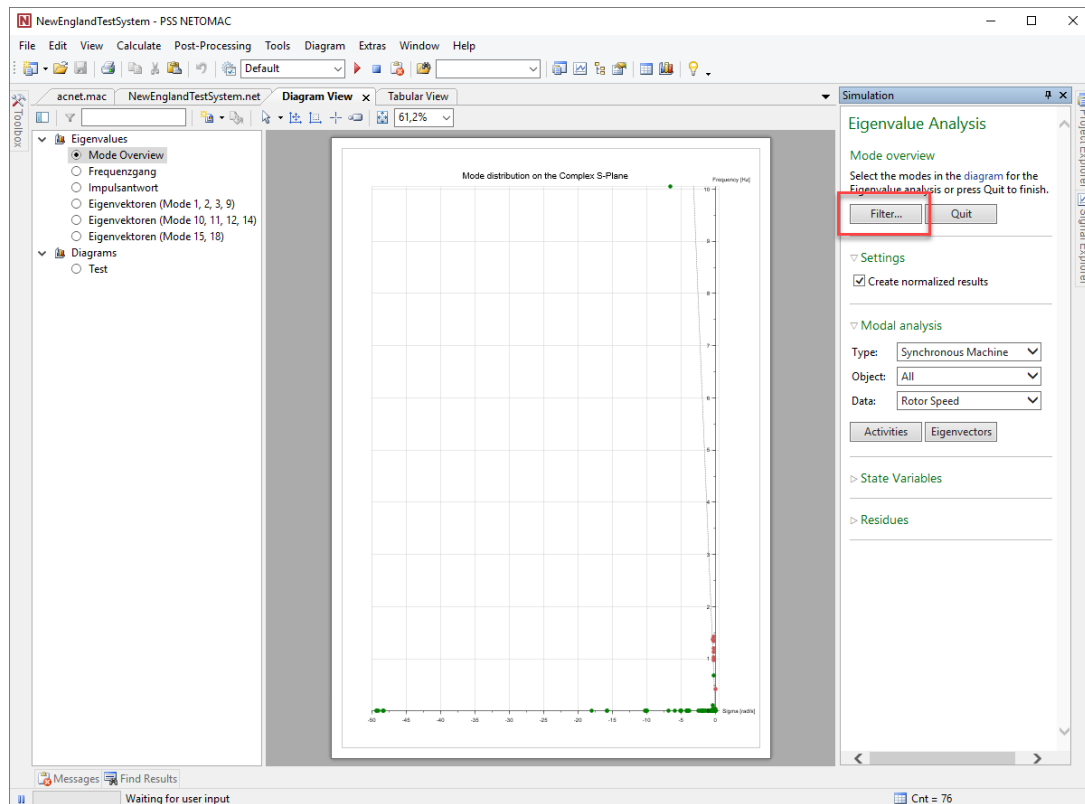
The filter dialog box was extensively revised and now offers many new functions. All modes available in the s-plane diagram are listed in the dialog box.
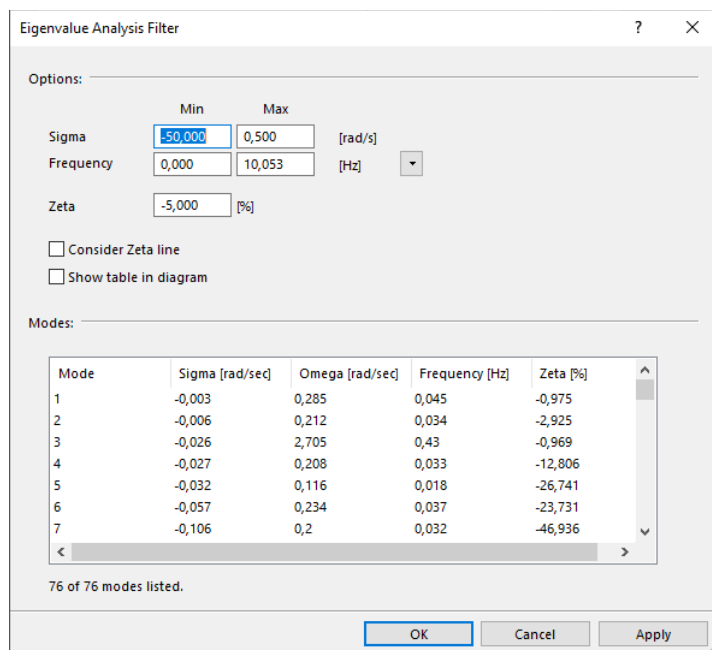
The display range can be controlled in the s-plane diagram by entering a range for **Sigma** and **Frequency**. The modes in this range are also listed in the dialog box and form the basis for the other analyses. In other words, only these modes are considered.

The zeta line can now be changed in the diagram at any time by entering a value for **Zeta**. The additional new **Consider Zeta line** option causes only the "problematic" modes to be displayed on the right of the zeta line.

The interactive analysis enables the **Mode Analysis**, **State Variables** and **Residues** to be evaluated. The results of the evaluations are presented in the form of diagrams and tables. The display range in the tables has been reduced to the relevant values. The results can now either be displayed with absolute values or in the normalized form. The selection is made via the appropriate option in the calculation window.
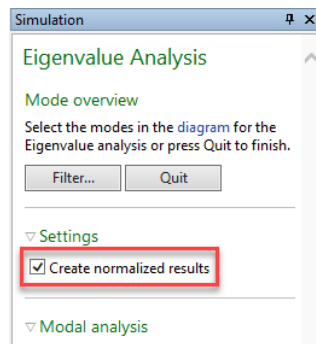
If normalized results are selected, an additional table with the reference values is also provided for each result table.

Another new feature is provided in the diagram which visualizes the eigenvectors of the modes. For each mode the position is shown in the s-plane diagram and the zeta value.
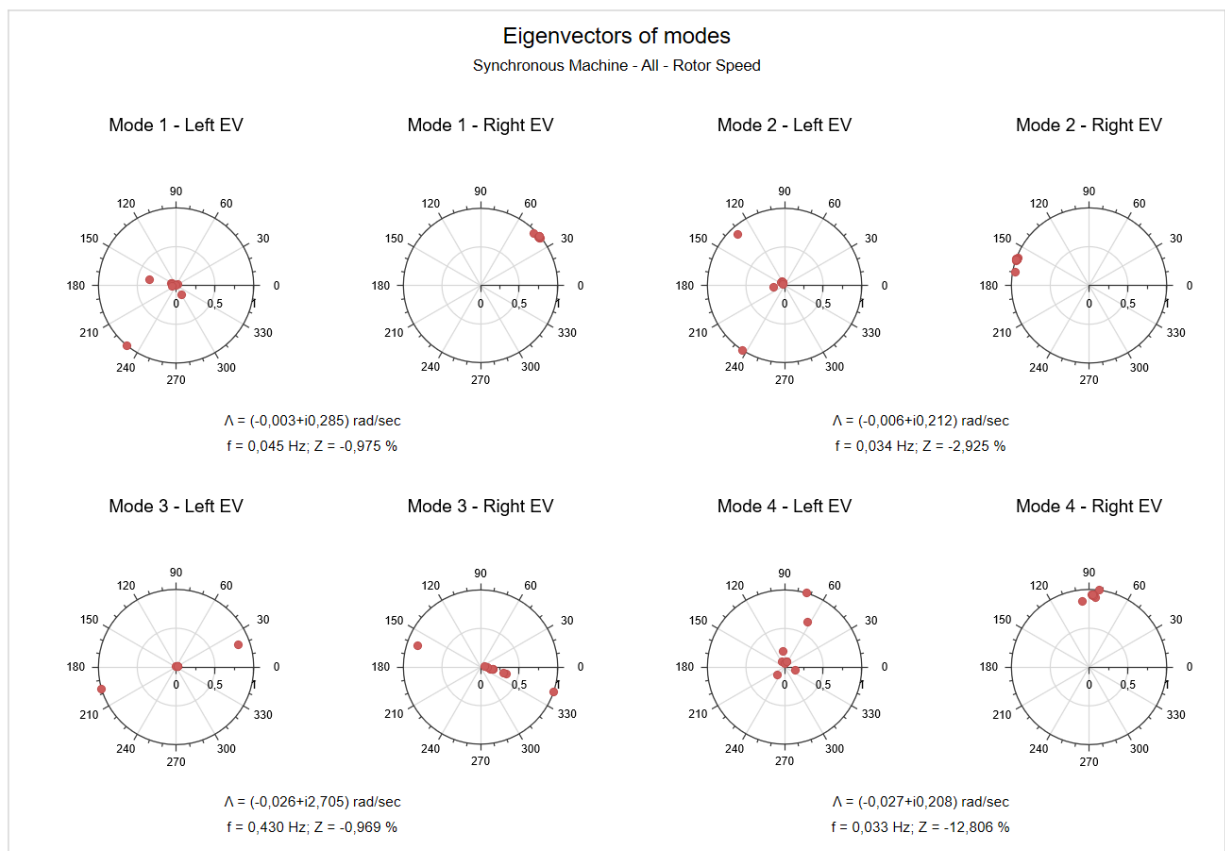
3.2.2 Enhancement for Short Circuit Calculation

It is now possible in the short circuit calculation to perform calculations without Z lines for machine data, provided that dynamics data is available. In this case, the values required for the short circuit are determined from the dynamics data.

This enhancement is explicitly designed to eliminate the need to carry out a short circuit calculation according to the standard. It enables instead the expected short circuit currents to be determined very easily and quickly at all nodes in the network.

3.2.3 Changes with BOSL Blocks

LIM

The **LIM block** (limitation) was specially extended for PI controllers according to IEEE 421.5-2016 (page 125). The following evaluation controller shows the enhanced operating principle:

```
$1......12......23......3AA1....12....23....34....45....56....67...78...89...9ZZ
 AUSWERT      INT     N

 IF(TIME > 4)THEN
  A=-1
 ELSEIF(TIME > 1)THEN
  A=1
 ELSE
  A=.0D0
 ENDIF

 P      A     PROP    1     .1
 INT    A     INT     1
 PI           SUM                    P     INT
$1......12......23......3AA1....12....23....34....45....56....67...78...89...9ZZ
 LIM          LIM     -1    1                           INT
              ENDE
E
ENDE
$1......12......23......3AA1....12....23....34....45....56....67...78...89...9ZZ
```

Operating principle of the block:

- The LIM block reaches a limit (pos or neg). The integrator (HZ7) is stopped and the input value is set to 0. The output value is the last calculated value.

- A possible second integrator (HZ8) is stopped and the input value is set to 0. The output value is the last calculated value.

MEMREAD, MEMWRITE and ALLOCATE()

The implementation of the **Blocks MEMREAD and MEMWRITE** has been completely revised to ensure that no more problems can occur with dynamic memory management. These changes were already provided in Update3 for PSS NETOMAC 14.5.

A new implementation for FORTRAN code is provided in models to improve the use of the memories. This includes the **ALLOCATE()** statement for reserving memories. The allocated arrays are accessed as in FORTRAN in the normal way with the operator (). The following snippet shows a

simple example:

```
$11111111122222222233333333AA11111122222223333333444444555555666666777778888899999ZZ|
 EVALUATE          N11_mov  N
$Allocate memory block N1234567()
ALLOCATE(N1234567(22))
$Loop to set MEMORY values
 DO K=1,3
 DO N=1,22,3
   N1234567(N)=N
   b=N1234567(N)
 bla1              FORMAT   LK    N     b
 ('K =', f9.3,' N =', f9.3,' b= ', F9.3 )
FEND
 ENDDO N
 ENDDO K
$11111111122222222233333333AA11111122222223333333444444555555666666777778888899999ZZ|
```

PRINT

The **PRINT block** was provided to offer a simplified diagnostic output. This enables the numerical values of block outputs to be output to the LST file in the G10.4 format.

Use in MAC file:

```
$1......12......23......3AA1....12....23....34....45....56....67...78...89...9ZZ
 out01          PRINT    N_ua1 N_ub1 N_ia1 N_ib1 N_pa1
```

Output in LST file:

```
N_ua1   = 0.8829
N_ub1   = 0.4695
N_ia1   = -9.880
N_ib1   =  1.542
N_pa1   =  8.000
```

3.2.4 CIM Import

The automation functions of the PSS SINCAL Platform enable CIM models based on the IEC 61970-301 standard to be converted to the PSS NETOMAC format.

This requires the data to be available in one of the following profiles:

- **CIM V10 (CIM Standard):**
  This profile is a universal implementation based on the minimum requirements for CIM data exchange. It is based on the specification for "CPSM Minimum Data Requirements in Terms of the IEC CIM Version 2.0" from Joe Evans and Kurt Hunter.

- **CIM V12 (CIM for Planning):**
  This profile is based on the specification for "CIM Planning Network Model Exchange Profile for Steady State and Short Circuit", Revision 1.1. It addresses, in particular, network data exchange for planning data and, as such, is more appropriate than earlier versions for exchanging network data.

- **CIM V14 (CIM for ENTSO-E):**
  This profile is based on the specification for "ENTSO-E Common Information Model (CIM) – Model Exchange Profile, Revision 1.0 Version 14 from May 10th, 2009". This was conceived for universal data exchange between the members in ENTSO-E (European Network of

Transmission System Operators for Electricity).

- **CIM V16 (CIM for ENTSO-E):**
  This profile is based on the specification for "ENTSO-E Common Information Model (CIM) – Model Exchange Profile, Version 2.4.15 from August 7th, 2014". This was conceived for universal data exchange of load flow, short circuit and dynamic data between the members in ENTSO-E (European Network of Transmission System Operators for Electricity).

The data can be converted either manually via the PSS SINCAL user interface or completely without any user interaction via the automation script.

The following Python snippet shows how CIM data can be imported automatically to the virtual database of the calculation methods:

```python
# Create SINCAL simulation as external COM server (out-process)
SimulationSrv = win32com.client.Dispatch("Sincal.SimulationSrv")
if SimulationSrv == None:
    print("Error: Creating Sincal.SimulationSrv failed!")
    CleanupAndQuit()

Simulation = SimulationSrv.GetSimulation()
if Simulation == None:
    print("Error: Sincal.Simulation not available!")
    CleanupAndQuit()

# Import data
Simulation.BatchMode(2)
Simulation.SetParameter("IMPORT_VIRTUAL_DATABASE", 1)
Simulation.SetParameter("BASE_FREQUENCY", 50.0)
Simulation.SetParameter("CIM_FORMAT", "CIM_V16")
Simulation.SetParameter("CIM_NAME",1)
Simulation.SetParameter("CIM_SHORTNAME", 2)
Simulation.SetParameter("TOOL_VARIANT_SUPPORT", 0)
Simulation.SetParameter("CALC_PARAM_DB_LOAD_MASTERRESOURCE", 1)

Simulation.Start("CIM_IMP")

# Check status, exit on errors
if Simulation.StatusID != siSimulationOK:
    CleanupAndQuit()
```

After being successfully imported, the network model can be exported to the PSS NETOMAC format:

```python
# Export data
strCalc = "NETO_EXP"
Simulation.DataFile(strExpFile)

Simulation.SetParameter("EXPORT_NAME", 1)
Simulation.SetParameter("EXPORT_NETOMAC_SV", 1)

# Load data from virtual DB
Simulation.LoadDB(strCalc)
if Simulation.StatusID == siSimulationLoadDB_Failed:
    print("Error: Load database failed\n")
    CleanupAndQuit()

strExpDir = os.path.dirname(strExpFile)
if os.path.exists(strExpDir) == False:
    os.makedirs(strExpDir)

# Perform simulation
Simulation.Start(strCalc)
```

The Python script "CimToNETOMAC" is an extended version of the simple snippet shown, which is available with the sample files:

```
>CIMtoNETOMAC.py -h
usage: CIMtoNETOMAC.py [-h] [-calc] Out Inp [Inp ...]

Convert CIM to NETOMAC.

positional arguments:
  Out        Path and name of .net file for output.
  Inp        CIM files to be converted.

optional arguments:
  -h, --help  show this help message and exit
  -calc       Perform load flow calc instead of standard export in PSS SINCAL.
```