POWERFACTORY

# PowerFactory 2025

## What's New

PF2025

**POWER SYSTEM SOLUTIONS**

MADE IN GERMANY

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February 2025
r12937

***Welcome to PowerFactory 2025*!**

In this year's What's New document, we are excited to share with you details of all the main developments that you will find in *PowerFactory 2025*, including many extensions and features requested by our users.

There are some significant improvements in the data handling and user interface in this version, as described in section 3. We now offer a dark mode, selectable via the user settings, and users who need to use multiple windows will find it easier to adapt the GUI to their needs, with more flexibility in the window layout and a dynamic Output Window.

The management of *PowerFactory* projects and data files outside the *PowerFactory* database has been rationalised, and a new pfdx file format is introduced, so that external files can easily be shared together with an exported project.

The many developments in calculation functions described in section 1 include a new function in the *Reliability and Restoration Analysis* module: *Contingency Restoration Analysis*. And in response to user requests, *Contingency Analysis* combined with *Short-Circuit Calculations* is now available. For dynamic simulations, *PowerFactory 2025* supports model export and import using FMI (Functional Mock-up Interface) version 3.0, and offers improvements in the speed of simulations, as well as the introduction of hybrid modelling using Modelica.

Network diagrams offer a range of new features such as filter layers, and R-X plots have been updated and offer additional options. These and other diagram developments are described in section 2.

As always, there are numerous enhancements to the Power Equipment models, detailed in section 4. These include significant changes to the protection block functionality, the modelling of current-limiting effects in fuses, and a new STATCOM model.

We hope that you enjoy exploring the new features in this version, and we wish you ongoing success with *PowerFactory*.

***Your DIgSILENT team***

# Contents

# 1 Analysis Functions

## 1.1 *Reliability and Restoration Analysis*

### 1.1.1 Contingency Restoration Analysis *NEW FUNCTION*

The aim of grid planning is to enable safe and reliable grid operation. To ensure the reliable connection of customers and a high grid security, the n-1 criterion is used in distribution networks. The n-1 principle states that the network (n) must be able to handle the failure of a piece of equipment (minus 1) at any time whilst minimising loss of customer supply. Depending on the network structure, for example an open ring structure, the failure of one line in a feeder can cause interruption of an entire area's supply, which needs to be restored through switchovers.

With the new Contingency Restoration Analysis, this analysis is possible without the necessity of pre-defining restoration actions for contingency to be investigated. The new tool combines the usability and results evaluation of the classical *Contingency Analysis* with the powerful algorithms of *Optimal Power Restoration*, allowing the user to analyse the post-fault conditions after restoration measures. The *Contingency Restoration Analysis* function is part of the *Reliability and Restoration Analysis* module.

Figure 1.1: *Contingency Restoration Analysis* toolbox

Important to note is that not only radial but also meshed network structures can be analysed with this tool. More information about this can be found in section 1.1.2.

**Fault definition**

Faults to be considered can be defined easily by choosing an equipment class (lines, transformers, busbars) for either the whole network or a user-defined grid/area. In addition, specific fault cases can be created or selected from the Operational Library.

**Selection of switches**

Candidate switches to be used within the restoration process can be configured separately for two stages:

- Fault clearance: Circuit breakers or switches with protection devices can be considered.
- Power restoration: Each breaker has a dedicated option to define whether it can be used during the power restoration. This gives the user the option to only use a dedicated selection of breakers for the restoration, such as remote controlled switches or normal open points.

**Power restoration options**:

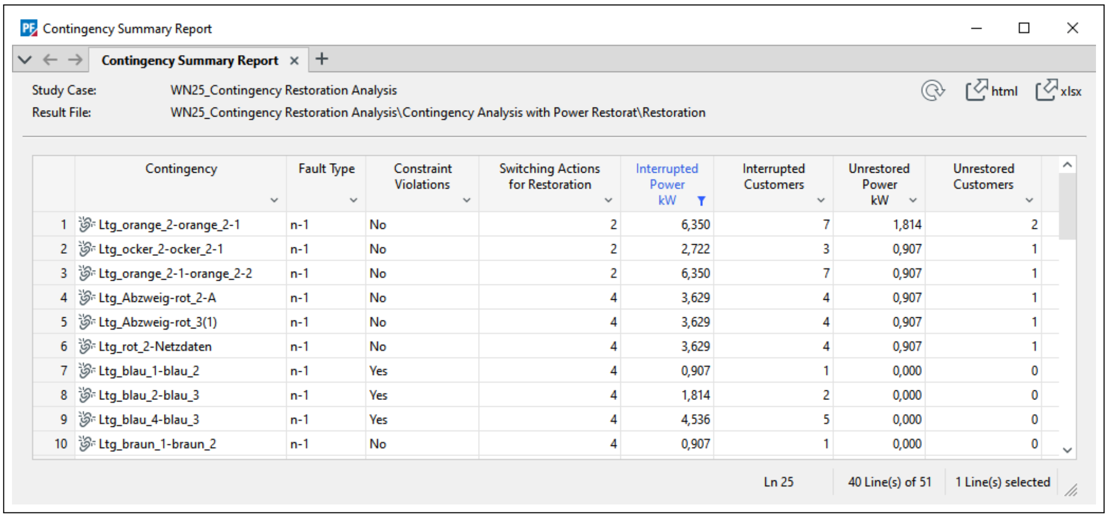
- Maximise restored power: The main objective of the complete restoration is to resupply all customers. The user-defined constraints (loading, voltage) are observed where possible but not if this would prevent restoration.
- Comply with constraints: The objective of this option is to resupply all customers but only if user-defined constraints (loading, voltage) can be kept within the limits. If violations occur, then the network will only be partially resupplied.

Other options such as *Tie Open Point Optimisation*, *Busbar transfer* and *Backward recovery* from the original *Optimal Power Restoration* tool can also be used to alter the power restoration.

**Result Analysis**:

Various tabular reports allow the user to analyse the pre- and post-fault conditions in the network:

- Violation reports: For the available loading and voltage (min./max.) constraints, different violation reports are available to analyse which components violate the user-defined constraints.
  - Worst violations
  - All violations
  - Violations per fault case
- Summary reports: These reports give a good overview about all considered contingencies and relevant quantities to determine which contingencies are critical.
  - Contingency Summary: For each contingency the number of unsupplied customers (after the fault clearance) and resupplied customers (after the power restoration) is listed. The number of switching actions for the restorations can be seen as well as if constraints are violated. With this report it can be easily determined for which contingency a successful power restoration can be achieved. An example report is shown in Figure 1.2.
  - Restoration: For a selected contingency all switching actions are listed.




| | Contingency | Fault Type | Constraint Violations | Switching Actions for Restoration | Interrupted Power kW | Interrupted Customers | Unrestored Power kW | Unrestored Customers |
|---|---|---|---|---|---|---|---|---|
| 1 | Ltg_orange_2-orange_2-1 | n-1 | No | 2 | 6,350 | 7 | 1,814 | 2 |
| 2 | Ltg_ocker_2-ocker_2-1 | n-1 | No | 2 | 2,722 | 3 | 0,907 | 1 |
| 3 | Ltg_orange_2-1-orange_2-2 | n-1 | No | 2 | 6,350 | 7 | 0,907 | 1 |
| 4 | Ltg_Abzweig-rot_2-A | n-1 | No | 4 | 3,629 | 4 | 0,907 | 1 |
| 5 | Ltg_Abzweig-rot_3(1) | n-1 | No | 4 | 3,629 | 4 | 0,907 | 1 |
| 6 | Ltg_rot_2-Netzdaten | n-1 | No | 4 | 3,629 | 4 | 0,907 | 1 |
| 7 | Ltg_blau_1-blau_2 | n-1 | Yes | 4 | 0,907 | 1 | 0,000 | 0 |
| 8 | Ltg_blau_2-blau_3 | n-1 | Yes | 4 | 1,814 | 2 | 0,000 | 0 |
| 9 | Ltg_blau_4-blau_3 | n-1 | Yes | 4 | 4,536 | 5 | 0,000 | 0 |
| 10 | Ltg_braun_1-braun_2 | n-1 | No | 4 | 0,907 | 1 | 0,000 | 0 |

Figure 1.2: *Contingency Restoration Analysis* summary report

Similar to the existing *Optimal Power Restoration* tool, the *Contingency Restoration Analysis* offers a *Trace* functionality to analyse the fault clearance as well as the power restoration actions in detail. An example can be seen in Figure 1.3. The left screenshot shows the load flow results before the investigated fault. The middle screenshot shows the situation after the fault has been cleared which results in unsupplied areas. The right screenshot displays the state after the power restoration where the determined switching actions are highlighted with red circles.

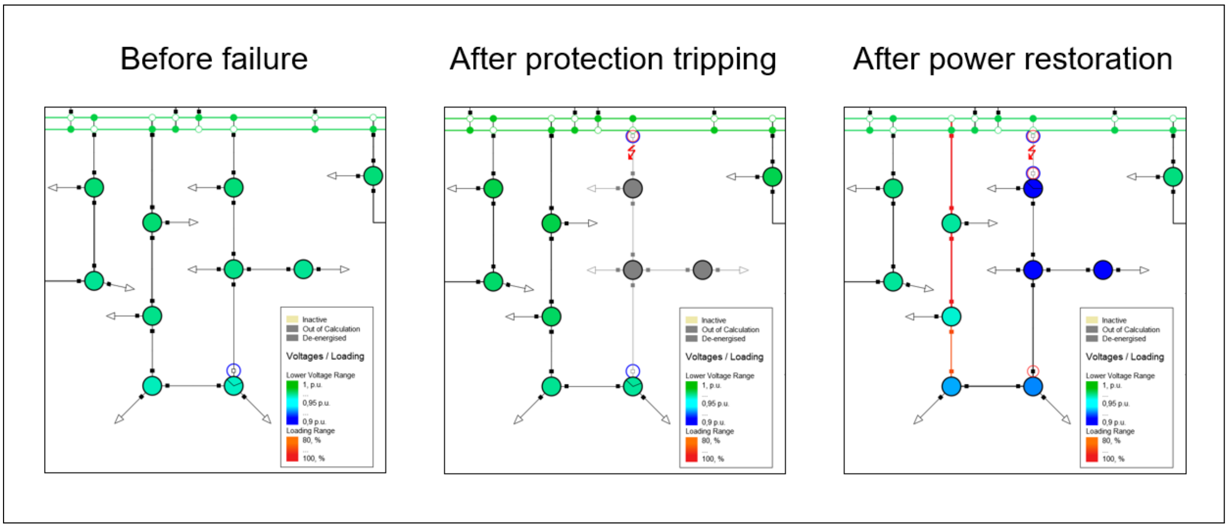



Figure 1.3: *Contingency Restoration Analysis* - Trace of a fault

An additional network colouring mode has been introduced to visualise the overall results of the *Contingency Restoration Analysis* in the network. The colouring of the fault locations as seen in Figure 1.4 allows a fast analysis of the power restoration results.

- Green lines: Complete restoration (all customers supplied) and no constraint violation
- Red lines: Complete restoration (all customers supplied) but constraint violations are detected
- Purple lines: Incomplete restoration (not all customers supplied) and no constraint violation

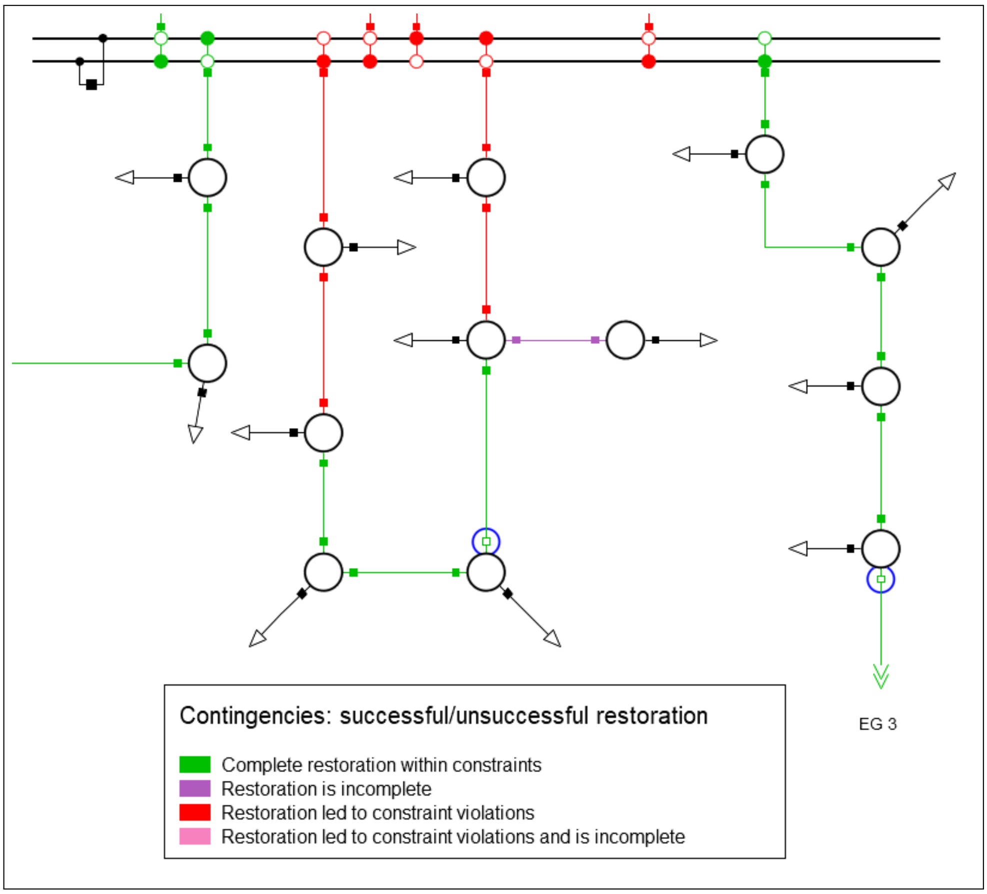



Figure 1.4: *Contingency Restoration Analysis* results in the single line diagram

### 1.1.2 Support of meshed networks

*Reliability Assessment* considers *Optimal Power Restoration* if “Distribution” is selected as the type of the network in the command dialog. However, until now the *Optimal Power Restoration* could only be used with radial feeders and in simple ring structures consisting of two connected feeders. This restriction has been lifted with *PowerFactory 2025* for balanced calculations and it is now possible to use *Reliability Assessment* with *Optimal Power Restoration* in meshed networks. Multiple ring structures with several feeders that are connected or that have cross-connections as shown in Figure 1.5 can now be analysed.

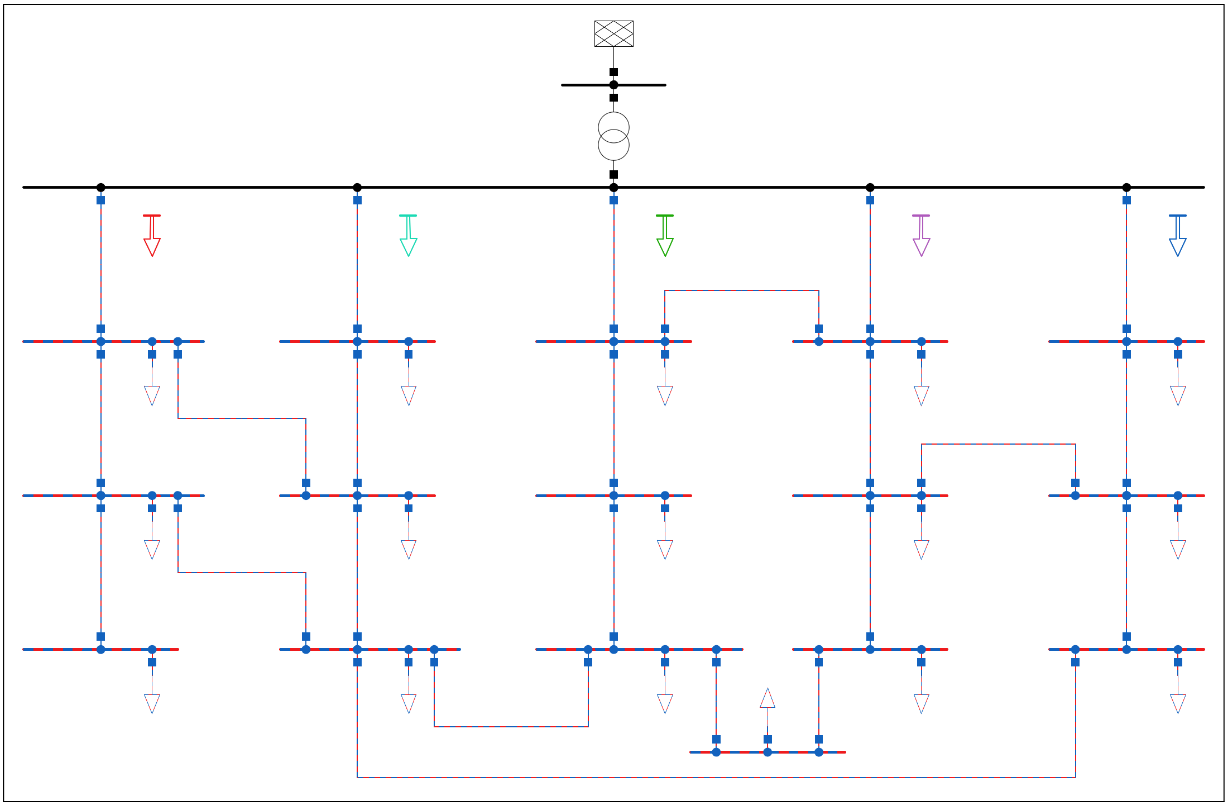


Figure 1.5: Possible meshed distribution network for *Reliability Assessment*

## 1.2 *Short-Circuit Analysis*

The *Short-Circuit Calculation* command dialog has been re-organised in *PowerFactory 2025*, with a dedicated page for each calculation method.

### 1.2.1 *Short-Circuit Calculation* for contingencies

Users now have the possibility to carry out *Short-Circuit Calculations* not only for an intact network but also for contingency cases. Each separate contingency operating state of the network is defined using events and fault cases in the way that users of the existing *Contingency Analysis* functionality will already be familiar with. Whether short circuits are carried out at individual locations or in batches, multiple contingencies can be considered for each circuit location, allowing users to comprehensively analyse the robustness of the system at a single location or across multiple locations simultaneously.

The new feature can be enabled within the *Short-Circuit Calculation* command, on the *Advanced Options* page, as shown in Figure 1.6, and is available for all *Short-Circuit Calculation* methods supported by *PowerFactory* (VDE, IEC, ANSI and complete method). With the *Consider contingencies* option selected, there is a further option to use parallel computing, which is particularly useful if many contingencies are to be considered.

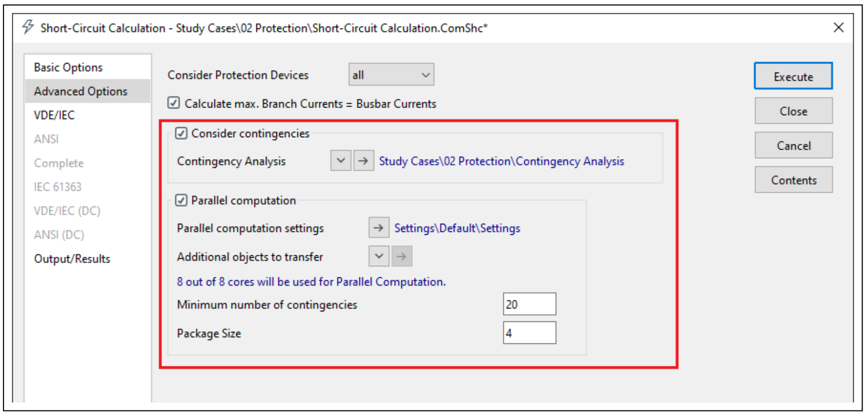



Figure 1.6: New *Contingency Analysis* settings on the Advanced Options page of the *Short-Circuit Calculation* command

### 1.2.2 Result file for *Short-Circuit Calculation* with *Contingency Analysis*

The consideration of contingencies in the *Short-Circuit Calculation* means that multiple sets of results are generated. In order to facilitate the storage of these results, the *Short-Circuit Calculation* command now additionally supports the configuration and use of result files. The options for configuration of the result file are available within the *Short-Circuit Calculation* command dialog, on the Results tab of the Output/Results page; see Figure 1.7. Users have the option to include just the default variables, or select additional variables that may be required.
Use of the result file functionality is automatically enabled when the *Consider contingencies* check-box is checked.

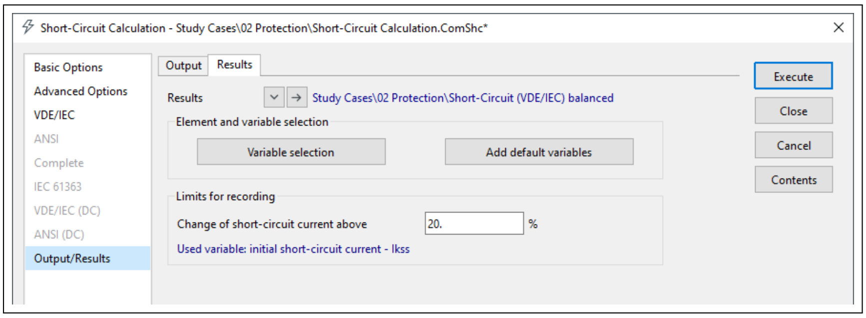



Figure 1.7: Setting up the result file for *Short-Circuit Calculations*

### 1.2.3 *Short-Circuit Calculation* tabular reports

In order to view the results of an active *Short-Circuit Calculation* or the contents of a *Short-Circuit Contingency* calculation result file, a new *Short-Circuit Calculation Tabular Reports* tool *(ComShcreport)* has been developed. The relevant command can be accessed via an icon in the *Additional Tools* toolbox. The structure of the reports can be configured on the *Active Results* and *Result File* pages of the tool. Figure 1.8 shows some sample output from the report command.

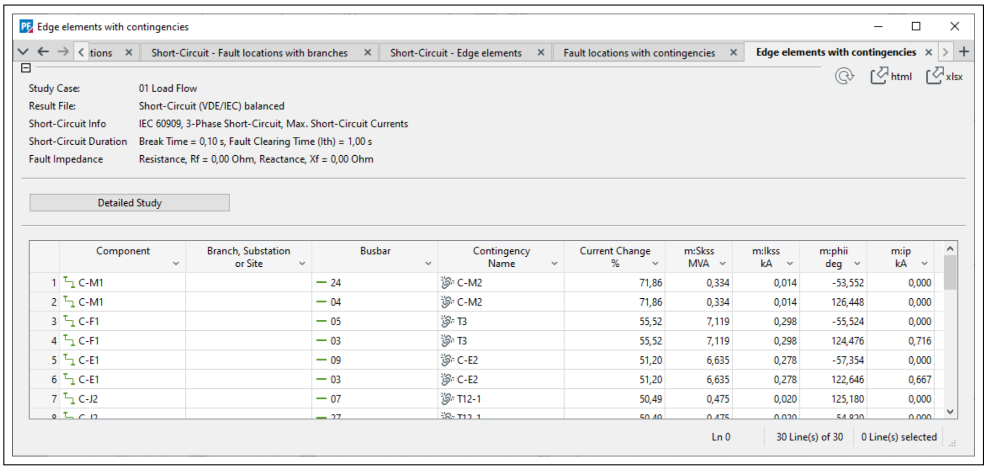



Figure 1.8: *Short-Circuit Calculation* Tabular Reports

### 1.2.4 *Short-Circuit Calculation for Single Contingency*

To analyse the *Short-Circuit* calculation results in detail for a specific contingency case, a dedicated *Short-Circuit Calculation for Single Contingency (ComShccnt)* command has been provided. The results obtained can be displayed and configured in both Single Line Diagram result boxes, in tabular views such as the Network Model Manager, or by using the previously mentioned *Short-Circuit Calculation Tabular Reports*.

The tool can be found in the *Additional Tools* toolbox.

## 1.3 RMS and EMT Simulations

### 1.3.1 Simulation performance improvements

The *Calculation of Initial Conditions* command (*ComInc*) has been extended by an option *Parallelisation of model equations*. During dynamic simulations, the model equations have to be executed and evaluated at various places for the complete set of dynamic models. Simulation algorithms have now been tuned so that they can run the execution and evaluation of model equations in parallel. This can significantly enhance the performance of RMS and EMT simulations in many instances.

In addition, models with many internal states are now handled using specific sparse techniques, speeding up, for example, cases with frequency-dependent cable models.

### 1.3.2 FMI 3.0 support (export and import)

#### Support of Functional Mock-up Interface 3.0: Import

Functional Mock-Up Units (FMUs) created using FMI 3.0 can be imported with certain restrictions (e.g. interface types: Model Exchange and Co-Simulation, variable types: Float64, Int32 and Boolean). Figure 1.9 shows an imported FMU (FMI version 3.0) in a *TypMdl* connected through a Composite Model Frame and time-domain simulation trajectory.

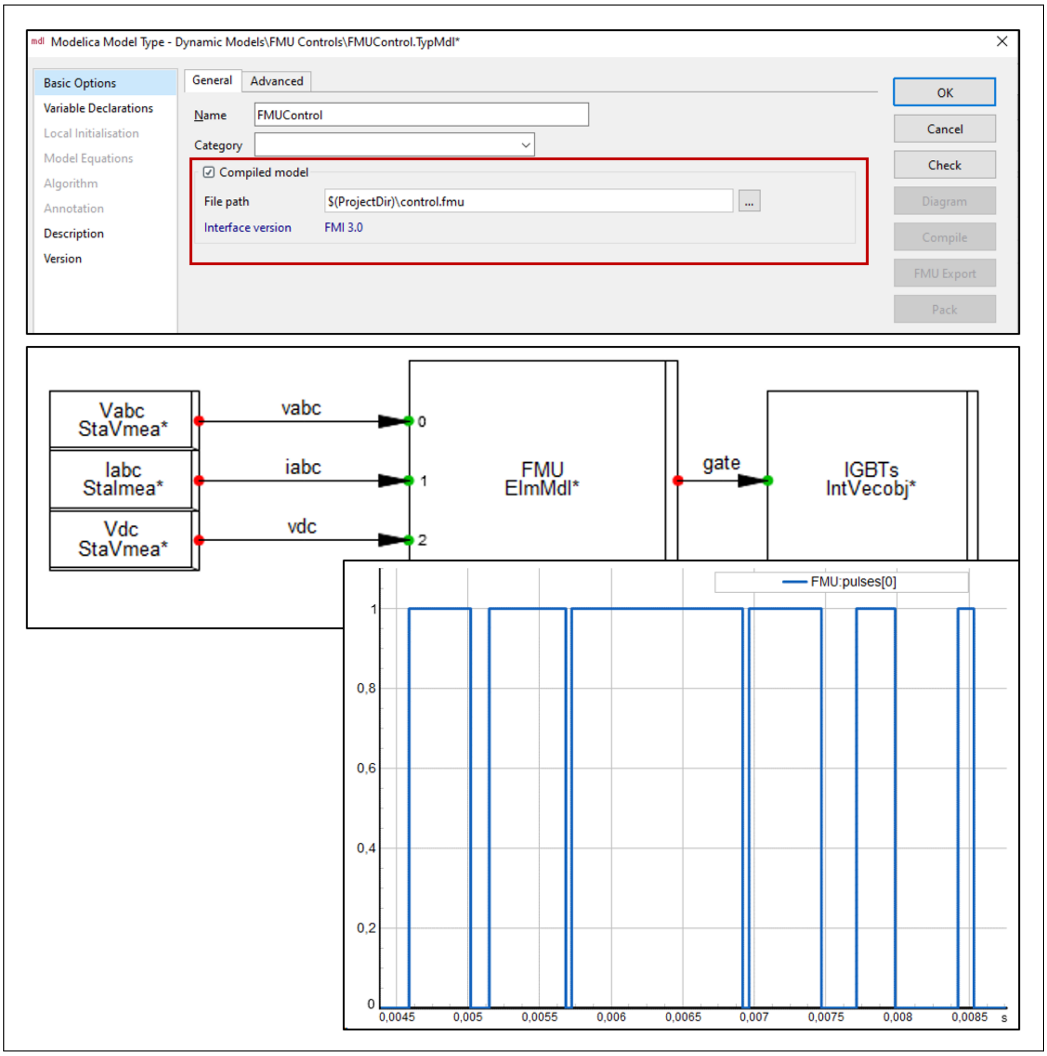



Figure 1.9: Use of FMU using FMI 3.0 in *PowerFactory*

### Support of Functional Mock-up Interface 3.0: Export

The Modelica Model Types (*TypMdl*) now support export to FMU (Model Exchange and Co-Simulation type) using the FMI interface version 3.0, in addition to the FMI interface version 2.0. The command FMU Model Export (*ComFmuexport*) or the button *FMU Export* in the *TypMdl* is used to export FMUs. The interface version can be selected in the *ComFmuexport* as shown in Figure 1.10.

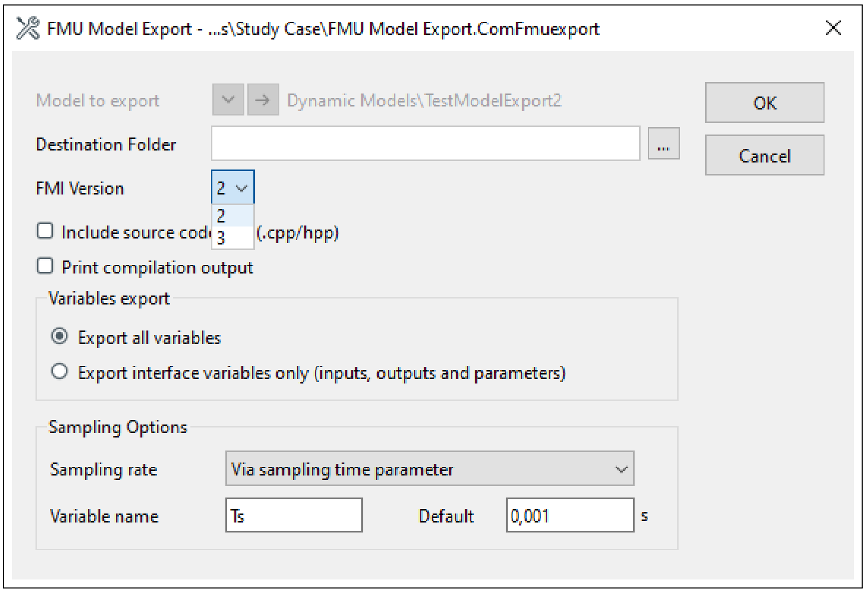



Figure 1.10: The FMU Model Export (*ComFmuexport*) command allows the selection of FMI versions

### 1.3.3 Dynamic model interface enhancements

### Import 32-bit (x86) DLL based dynamic models

A 32-bit (x86) DLL dynamic model created using the following interfaces can now be imported in 64-bit *PowerFactory* :

- Functional Mock-Up Interface (FMI version 2)
- External C Interface according to IEC 61400-27
- DSL-to-C Interface (created using *PowerFactory 2022*)

A 32-bit Functional Mock-Up Unit (FMU) based on the FMI interface (version 2.0) loaded in a Modelica Model Type *TypMdl* is shown in Figure 1.11.

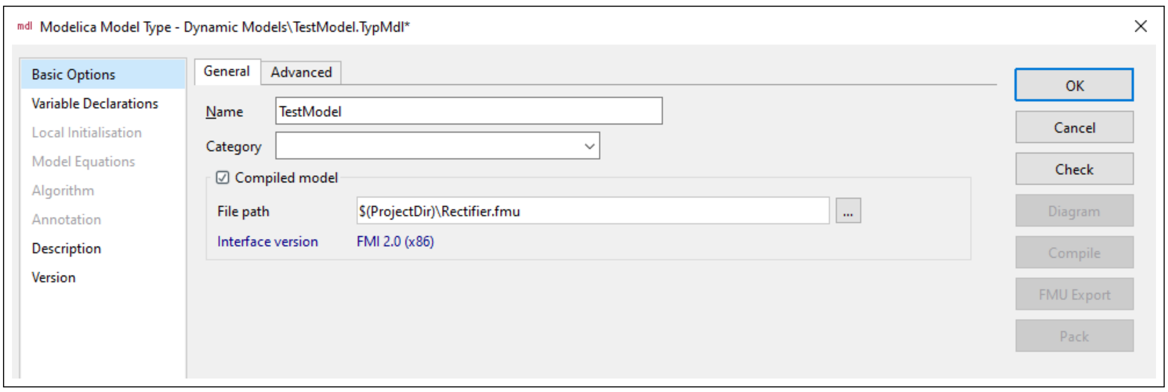



Figure 1.11: A 32-bit FMU loaded in a *TypMdl* in a 64-bit *PowerFactory*

### Backward initialisation FMU and IEC 61400-27 models

External dynamic models using FMI and IEC 61400-27 interface loaded in Modelica Model Types (*TypMdl*) now support backward initialisation of the inputs of dynamic models. All output and input signals can now be initialised locally, i.e. in the model itself, or externally, i.e. by the model it is connected to. For the local initialisation of inputs, the user can define a script to initialise the inputs based on initial output values, for example. The script follows the Modelica syntax.

An example is illustrated in Figure 1.12, which shows the loaded FMU in the *TypMdl*, the data input and output pages. Setting this local or external initialisation of inputs and outputs is done under the column Initialisation in the sub-pages *Inputs* and *Outputs*. The Modelica Model Type edit dialog has a page *Local Initialisation* to write the initialisation of the locally initialised inputs, the page being active if the Initialisation is set to Local for any of the inputs. The trajectory of the output of the FMU during a time-domain simulation is shown in the Figure 1.12.

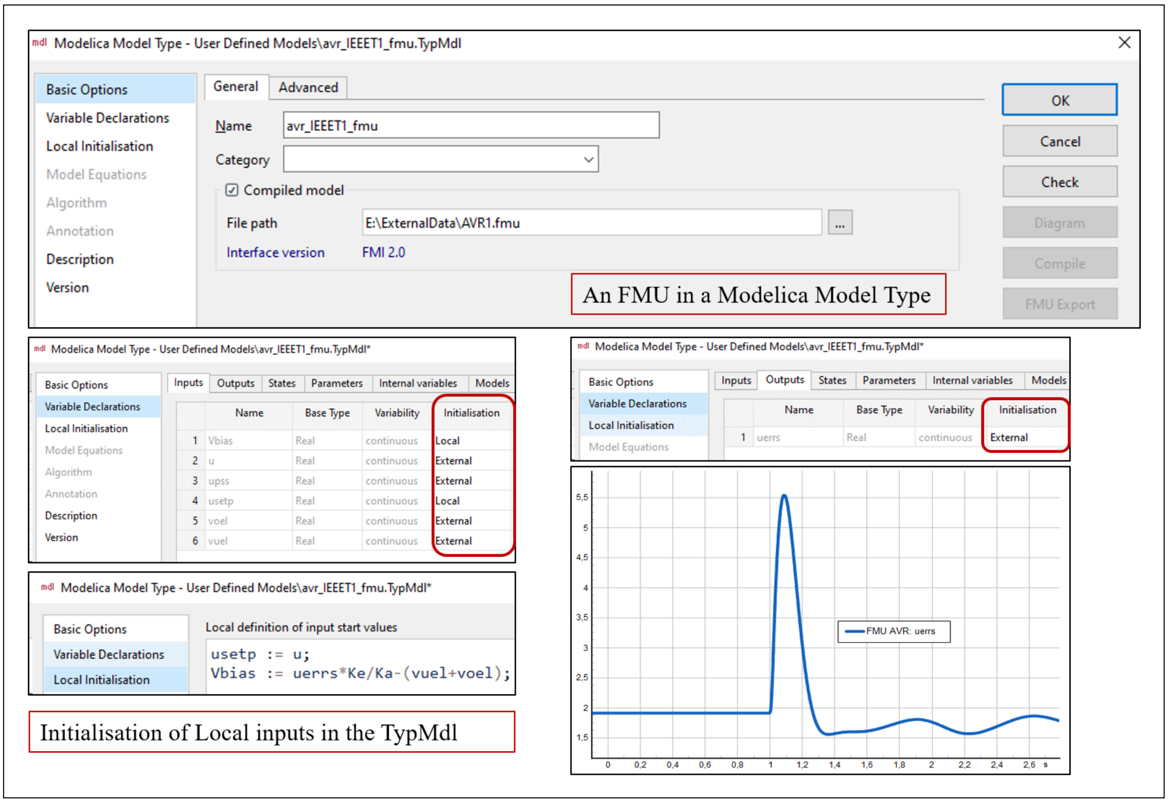



Figure 1.12: Backward initialisation of an FMU

### 1.3.4 Enable or disable the execution of components triggered by a Boolean input signal

Instances of the clocked Modelica Model Type (*TypMdl*) may now be conditionally turned on or off during initialisation or time-domain simulation. Figure 1.13 shows an illustrative example where the components (instances of a *TypMdl*) “ControlA” and “ControlB” are conditionally executed. This option can be used through a Boolean scalar input, and it can be added by selecting the option *Add Boolean enable input* on the page *Variable Declarations* → *Enable* (see Figure 1.13) in a clocked *TypMdl*. If this Boolean input is true, the component algorithm is executed; otherwise, it is not.

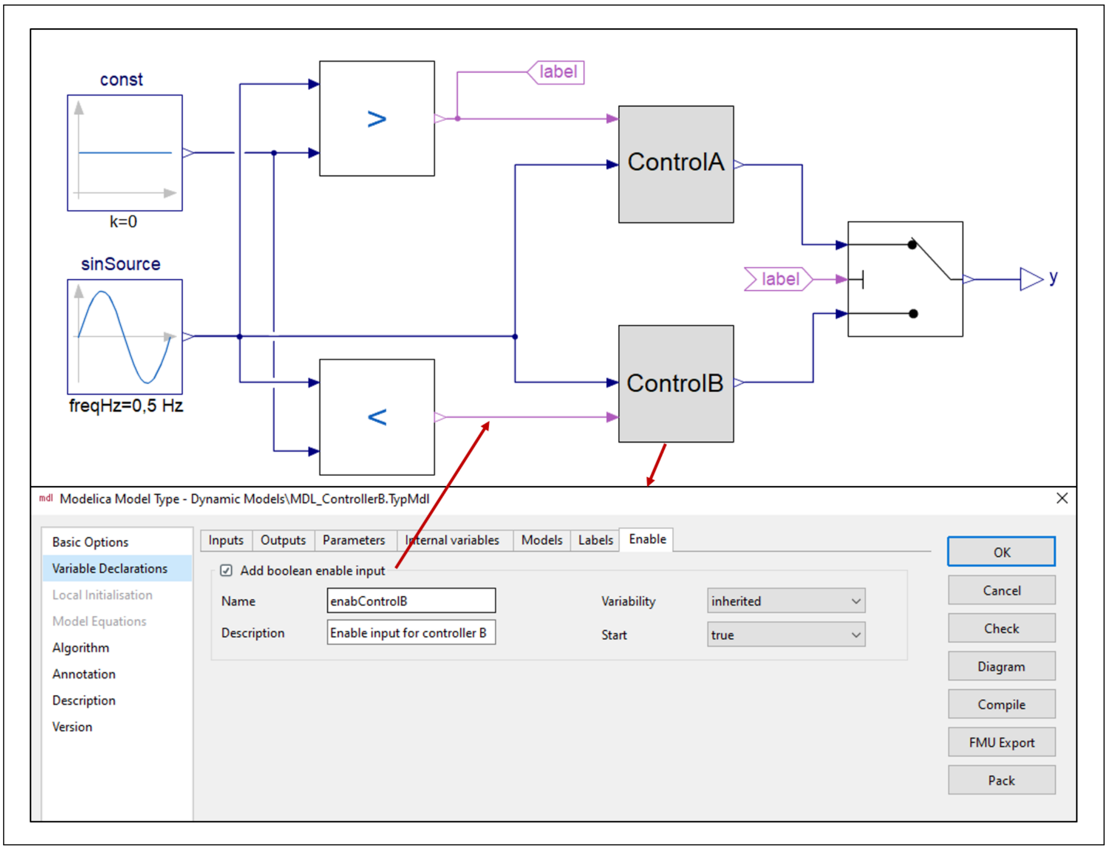



Figure 1.13: Enable or disable execution of components using input

### 1.3.5 Hybrid modelling of dynamic systems with Modelica

*PowerFactory 2025* further enhances the dynamic modelling capabilities of Modelica by introducing the hybrid modelling approach (first as pilot version). Hybrid modelling is the capability to represent continuous-time and discrete-time components within a single modelling environment, as shown in Figure 1.14.

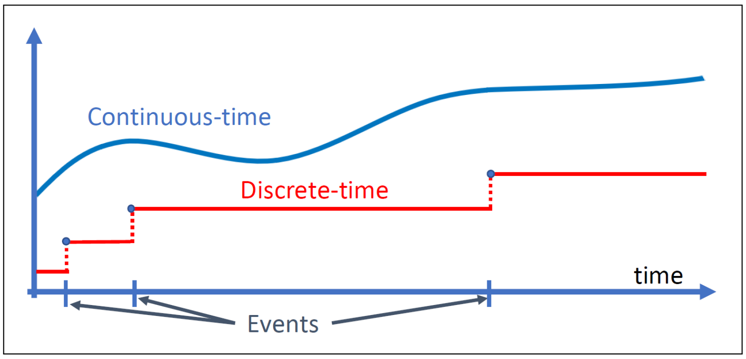



Figure 1.14: Hybrid modelling using Modelica

Using the new hybrid modelling approach in Modelica, it is now possible to create complex non-linear time-continuous and time-discrete systems. This can be done either using Modelica code or graphically, with block diagrams. The *Hybrid* model type is enabled within the Modelica Model Type object (*TypMdl*/*ElmMdl*) and comes as an addition to the already existing *Clocked* option that allows the creation of time-sampled dynamic models based on pre-defined clocks. As a typical use case, various power system control components can now be adequately represented for RMS- and EMTdomain dynamic simulations as non-linear time-continuous models e.g. automatic voltage regulators, governors, standardised controls (IEEE, WECC, IEC). An example of the IEEE AC7C AVR model is shown in Figure 1.15, which has been implemented using the *Hybrid* model type.

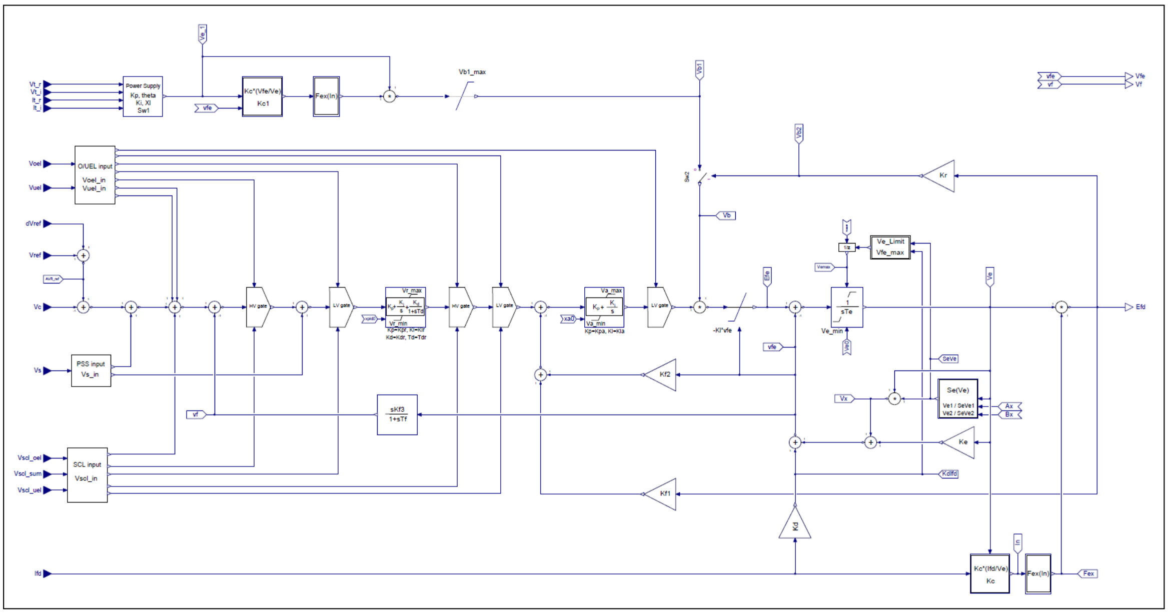


Figure 1.15: *IEEE AC7C* Automatic Voltage Regulator Model

Hybrid modelling comes with a built-in library of basic components, such that models can be easily created graphically.

The scope of Modelica's hybrid modelling in *PowerFactory* covers, but is not limited to:

- support conditional statements e.g. `if` and `when`
- support multiple data types e.g. Boolean, Integer and Real
- discrete and continuous signals
- scalar and array variables
- derivative operator `der` for defining differential equations
- discrete event iteration operator `pre`
- `initial()` keyword to specify specific equations for initialisation
- initial equations section
- equations section

As for Modelica clocked models, the syntax and design follows the Modelica specification. Both the export to FMI 2.0 and FMI 3.0 and the import of FMI 2.0 and FMI 3.0 models is supported for Modelica hybrid models.

### 1.3.6 *Co-simulation*

#### Load Flow options

For the co-simulation calculation functions, an extended number of load flow options are now allowed. For example, in case of the implicit method, all options for active power balancing are now available, not just "by reference machine".

## 1.4 *Cable Analysis*

### 1.4.1 New developments relating to cable sizing standards

The *Cable Sizing* function *ComCabsize* has been fully updated according to the latest editions of standards IEC 60364-5-52 and DIN VDE 0298-4, from 2009 and 2023 respectively. Among the updates of the reference methods, it is now possible to define the influence of the third harmonic. Also, the representation of some reference methods has been improved (e.g. method 4 and 60 in the IEC 60364-5-52; see Figure 1.16).

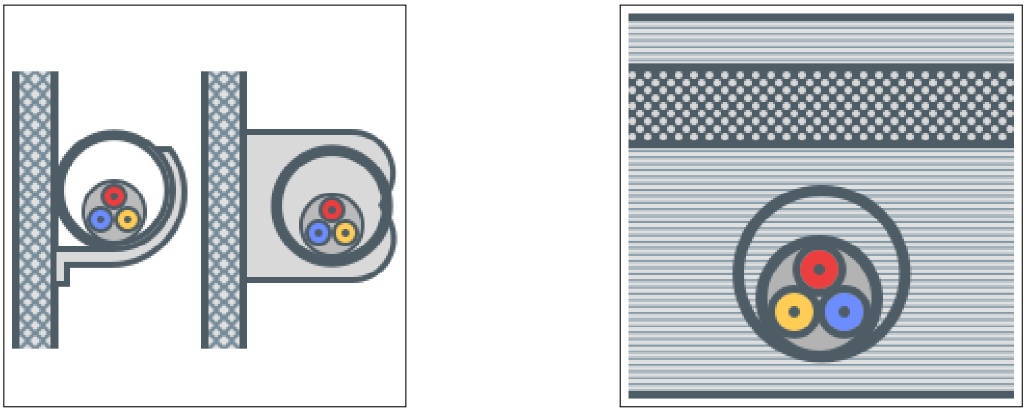


Figure 1.16: Examples of new graphical representations for cable sizing methods

In addition, the standard IEC 60502-2 (2014) for medium voltage power cables up to 30 kV is now supported. The implementation of the standard NF C 15-100 (2002) has been updated to follow the guidelines of FD C15-500 (2020). It supports new classes for the impedance calculation. A neutral conductor sizing is now possible.

### 1.4.2 *Cable Sizing* enhancements for short-circuit current and protection assessment

*Cable Sizing* according to international standards has been improved and expanded in several places. The handling of the short-circuit currents and protection settings is now supported comprehensively in the sizing process according to applied industry guidelines.

A protection assessment can be determined for the cable sizing of a line, where either existing protection devices or potential protection devices are considered. A distinction can be made between fuses, circuit breakers in the domestic sector and circuit breakers in the industrial sector.

The reports have therefore been expanded and show results for short circuit calculation and protection-relevant data. All data from the applied industry guidelines for the cable sizing and protection scheme in Figure 1.17 are now part of the report. Cable-related data are shown above and protection-related data below the line.

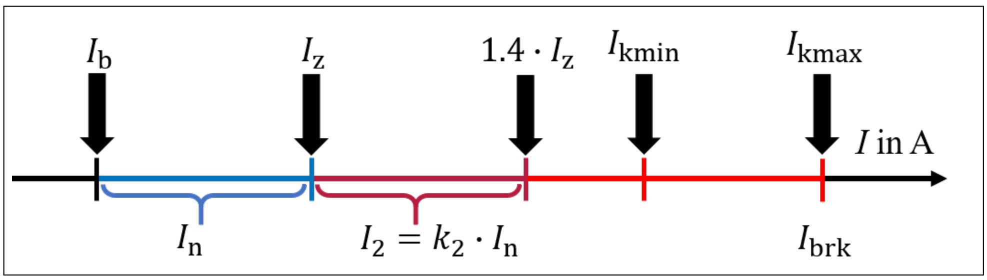



Figure 1.17: Cablesizing and protection scheme

The nominal breaker current $I_n$ needs to be between the load current $I_b$ and the current-carrying capacity $I_z$ of the sized line. The conventional tripping overcurrent $I_2$ is between $I_z$ and 1.4 $\cdot I_z$. The minimal short-circuit breaking current $I_{brk}$ is set to the value of the maximum short circuit current $I_{kmax}$. The output of the maximum thermal stress energy and time,and the maximum protected length, form part of the new report.

## 1.5 *Power Quality and Harmonics Analysis*

### 1.5.1 Operating-point-dependent harmonic analysis and frequency sweep

Due to new type container objects for harmonic spectrum definitions and new container characteristic objects, harmonic analyses and frequency sweeps can now be carried out in a manner that is specific to the operating point. For more information about the new container objects, see section 4.6.2.

### 1.5.2 Impedance Loci script

The *Impedance Loci* script is part of the global *DIgSILENT Library* and is used to analyse the harmonic distortion at a PCC (point of common coupling), considering frequency dependent impedance loci of an external network. The script has received major updates regarding its functionality and handling (Version v003.0).

**Loci Definition:**

- The definition can now be done by X-R value pairs in addition to the existing format (X-Rmin-Rmax), which makes the definition for the user much easier.
- The configuration of relevant frequency ranges for each defined locus has also been improved to make it easier and more flexible.

**Calculation:**

- The investigated X-R points can now be defined by a dedicated input parameter of the script. This allows the user to specify the exact number of points (e.g. 1000) which are to be investigated. The script determines the required resolution for the loci to distribute all points uniformly.
- Harmonic limits can now be considered in the calculation to determine which X-R points violate their frequency-dependent limits.
- The script logic has been adapted to improve the performance.

**Results:**

- Plots can now be created to display the loci border and all investigated X-R points for each calculated harmonic order. The X-R points can optionally be coloured to visualise the harmonic distortion at the PCC in relation to the considered harmonic limits (see Figure 1.18).
- In addition to the results in the Output Window, a tabular report can now be created to display for each investigated harmonic order the maximum harmonic distortion value, along with the corresponding X-R point of the locus.
- Additional result objects with all calculation quantities are stored in the content of the script, and so can be easily exported and used for further analysis.

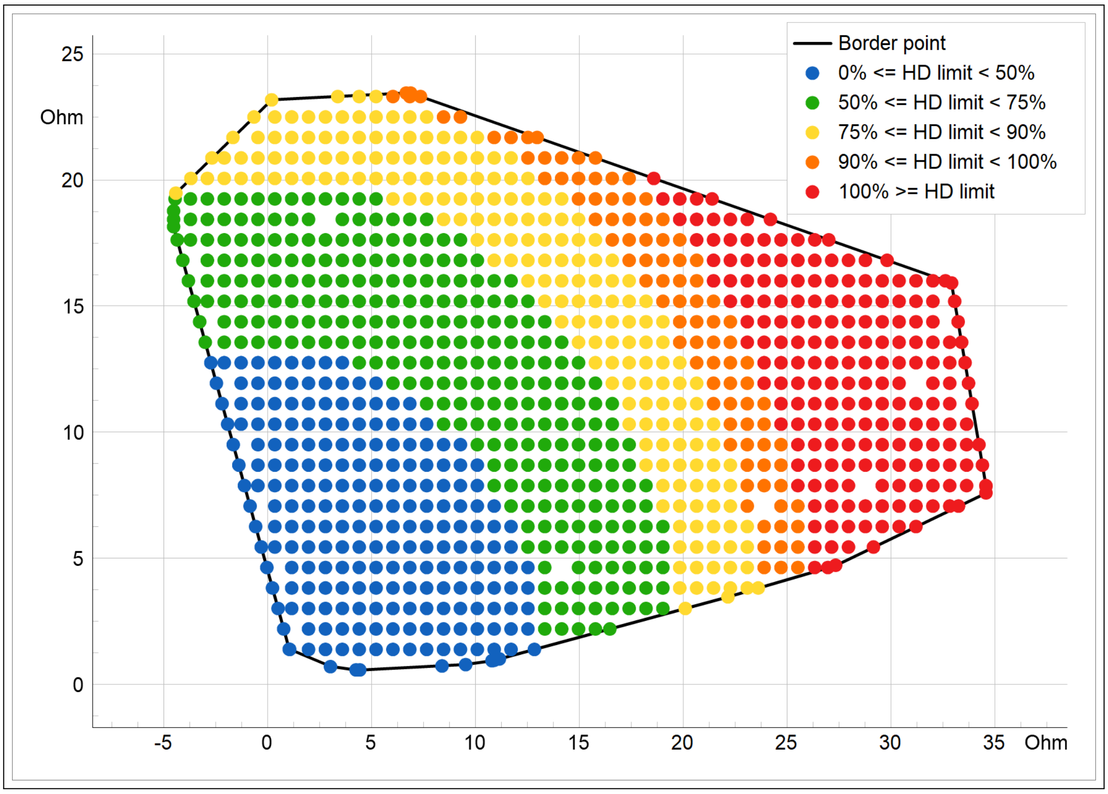



Figure 1.18: *Impedance Loci* result plot of harmonic order h with 1000 X-R points

## 1.6 *Connection Request Assessment*

### 1.6.1 Updates according to guidelines

Version 2023 of the VDE-AR-N 4110 guideline, which applies to connection requests in medium-voltage networks, has been added to the *Connection Request Assessment* command.

### 1.6.2 Consideration of Connection Request element (*ElmConreq*) in load flow and short-circuit calculations

The way in which Connection Request elements (*ElmConreq*) are taken into account in load flow and short-circuit calculations has been improved. In the Connection Request elements, you can now directly select the guideline from which the power values and short-circuit contributions that have been entered are to be used in other calculations.

In addition, it is now possible to apply individual cos($\varphi$)-characteristics (capacitive or inductive) to load and generation. Either the value calculated from load and generation components or a specified total value can be used to define the cos($\varphi$) of *ElmConreq* elements.

## 1.7 *Unit Commitment and Dispatch Optimisation*

The *Unit Commitment and Dispatch Optimisation* tool has been enhanced in *PowerFactory 2025* to support the optimisation of reactive power operating and additional redispatch costs based on reactive power changes or voltage setpoint changes for generators and HVDCs. In addition, it is now possible during the optimisation for the circuit breaker of a shunt to be controlled, in order to switch the shunt off and on.

Voltage problems in the grid occur due to a lack or surplus of reactive power. To manage such problems in the network, grid operators have a variety of options at their disposal to bring the voltages at all buses back into the normal operating range. For example, shunts can be switched or stepped or the reactive power of generators can be changed. However, efforts should be made to minimise both the number of measures and the costs for the required reactive power. The enhancement of *Unit Commitment and Dispatch Optimisation* is intended to support grid operators in selecting the most cost-effective measures.

For example, the number of measures can be reduced through fixed costs for setpoint changes of generators and HVDCs or costs for switching shunts on and off in the cost optimisation. The interaction between the reactive power input from shunts and generators can be determined cost-efficiently via the optimisation.

Another option is the minimisation of reactive power supply, or in other words the maximisation of reactive power reserves of generators by defining operating costs, where the lowest costs are defined for 0 Mvar (see Figure 1.19).

Additional redispatch costs can now be defined not only based on reactive power changes, but also based on changes to the voltage setpoints of controllers. This means that the costs incurred in reality for measures to change the setpoint can be taken into account.

For this enhancement, several settings have been added to the *Unit Commitment and Dispatch Optimisation* command and to some network elements. The tabular reports have been extended to show the reactive power operating costs.

The following subsections give more detail about reactive power operating costs and the shunt controls, together with a worked example.

### 1.7.1 Reactive power operating costs

Reactive power operation costs have now been introduced for generators (including VREs) and HVDCs. Figure 1.19 shows an example. As with the operating costs for the active power, different costs can be defined for different operating points of the reactive power and the points can be connected via different approximations. The operating costs can be used to minimise the use of reactive power or to maximise the reactive power reserves of a generator.

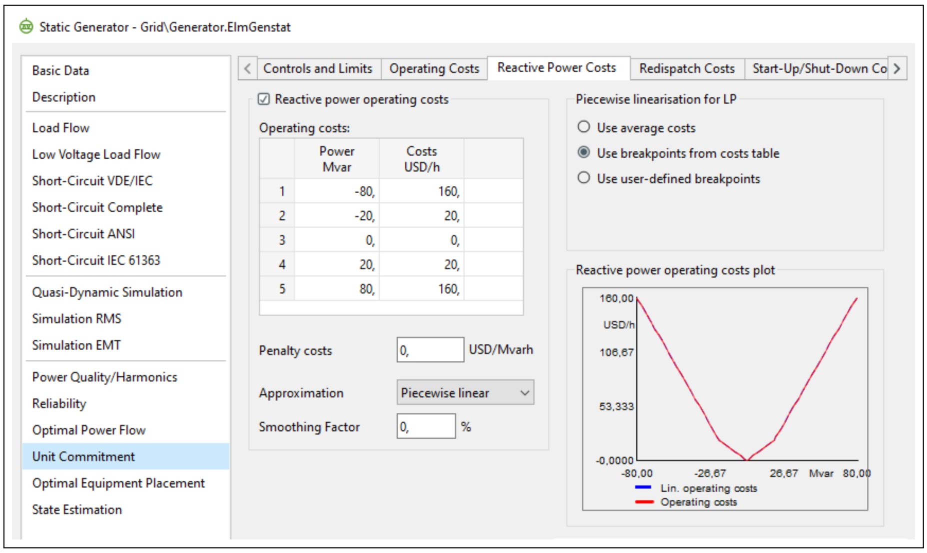



Figure 1.19: Reactive Power Operating Costs

### 1.7.2 Shunt controls

The optimisation capabilities for shunts in the Unit Commitment have been enhanced. In previous versions of *PowerFactory*, it was possible to define penalty costs per tap deviation. Now, it is possible to specify a flexible range of tap positions to be used. Another improvement is that switching the entire shunt on or off can be considered with user-definable costs. There may be situations where it is more cost effective to switch the shunt off at a high tap position and on again later, rather than reducing the tap position by several positions and increasing it back to the original position.

### 1.7.3 Reactive power optimisation example

The following example demonstrates a possible use case: Figure 1.20 shows a part of a grid with a busbar (BB) to which a generator, two shunts and a converter (HVDC) are connected. The voltage at the busbar fluctuates over the course of a day and should be kept within specified limits by regulating the reactive power of the connected elements. The reactive power operating costs shown in Figure 1.19 are defined for the generator. Reactive power operating costs are also defined for the converter, but the costs for its reactive power are lower. The two shunts have the same penalty costs per tap deviation, but the reactor (Shunt L) is cheaper to switch on or off. Initially, both shunts are switched off.

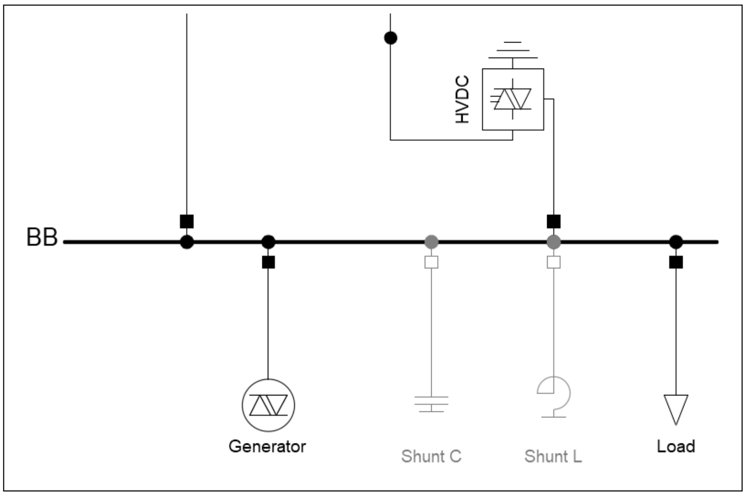



Figure 1.20: Example: Part of the network, in which *Unit Commitment and Dispatch Optimisation* is used to optimise the reactive power operating and penalty costs under consideration of voltage constraints

The objective function of *Unit Commitment and Dispatch Optimisation* is to minimise the reactive power operating costs and the penalty costs for the shunts. The generator, the HVDC and the shunts can be controlled. The results of a simulation over one day are shown in Figure 1.21. In the upper left plot, it can be seen that the voltage before the optimisation (blue dotted curve) is sometimes outside the limits of 0.97 p.u. and 1.03 p.u. (shown as red dashed lines). By using the shunts (upper right plot), the HVDC (lower left plot) and the generator (lower right plot), the voltage (green curve) can be brought back into the limits. As the capacitor (Shunt C) is the most favourable, it is used the most, followed by HVDC. However, since the HVDC reaches its minimum reactive power limit of -50 Mvar at 14:00, the reactor (Shunt L) is switched on and set to its maximum tap position of 1. The remaining missing reactive power to bring the voltage into the limits is taken from the generator.

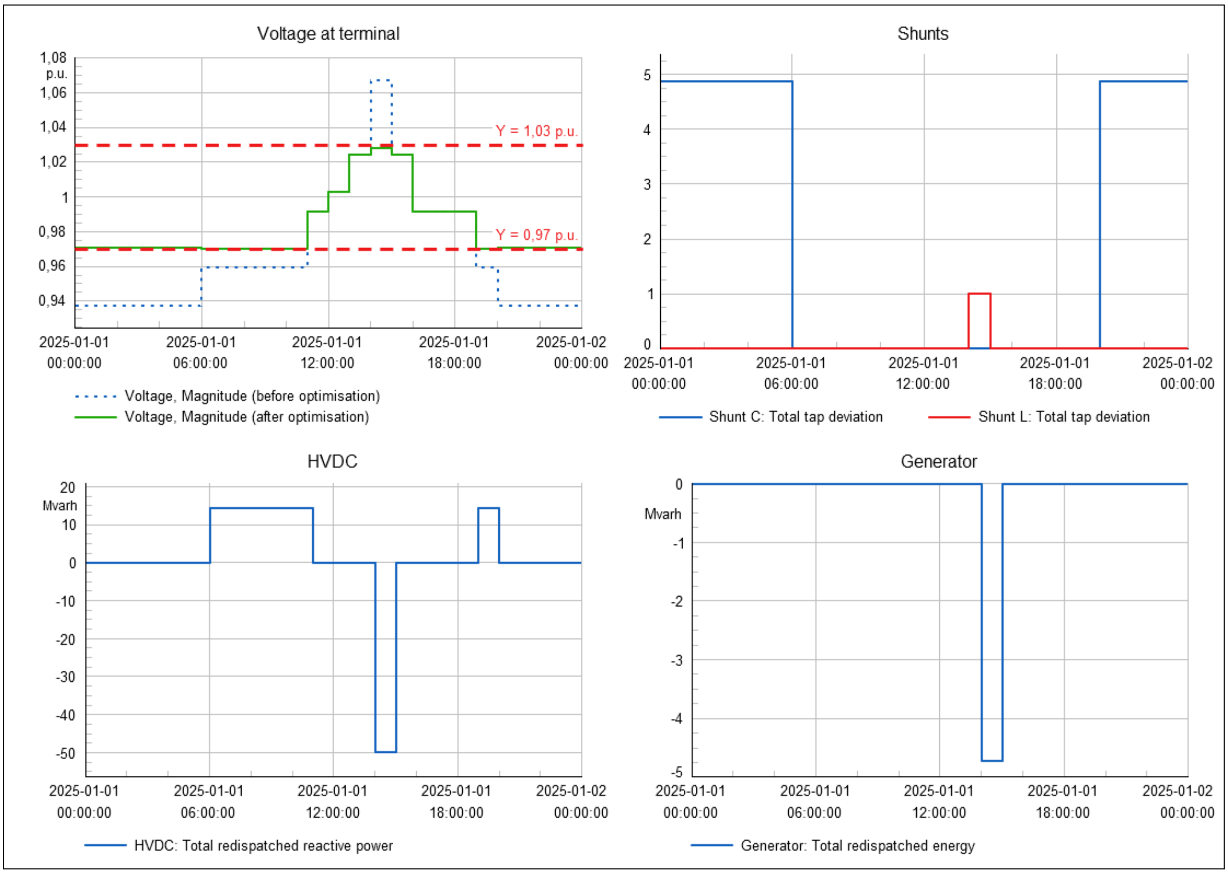



Figure 1.21: Example: Results of a reactive power optimisation under consideration of voltage constraints over one day using *Unit Commitment and Dispatch Optimisation*

## 1.8 *Distribution Network Tools*

### 1.8.1 *Low Voltage Load Flow*

#### Coincidence calculation for generation units

Just like electrical loads, generation units show coincidence effects when multiple units operate simultaneously. For example, PV modules installed with different orientations and with varying degrees of ageing and soiling won't produce their peak power at the same time. Therefore, the possibility to apply Coincidence Definitions (*IntCoincdef*) has been added to Static Generators (*ElmGenstat*) and PV Systems (*ElmPvsys*).

#### Separate calculation scenarios for consumption and production case

With the introduction of Coincidence Definitions for generation units, the *Low Voltage Load Flow Calculation* has been enhanced to allow a separate calculation of production and consumption cases, see Figure 1.22. Users can now select coincidence calculations either for loads (the consumption case, reflecting the lowest voltages) or for generation units (the production case, reflecting the highest voltages). Additionally, global scaling factors enable to consider custom amounts of generation within the consumption case or loads within the production case, ensuring greater flexibility.

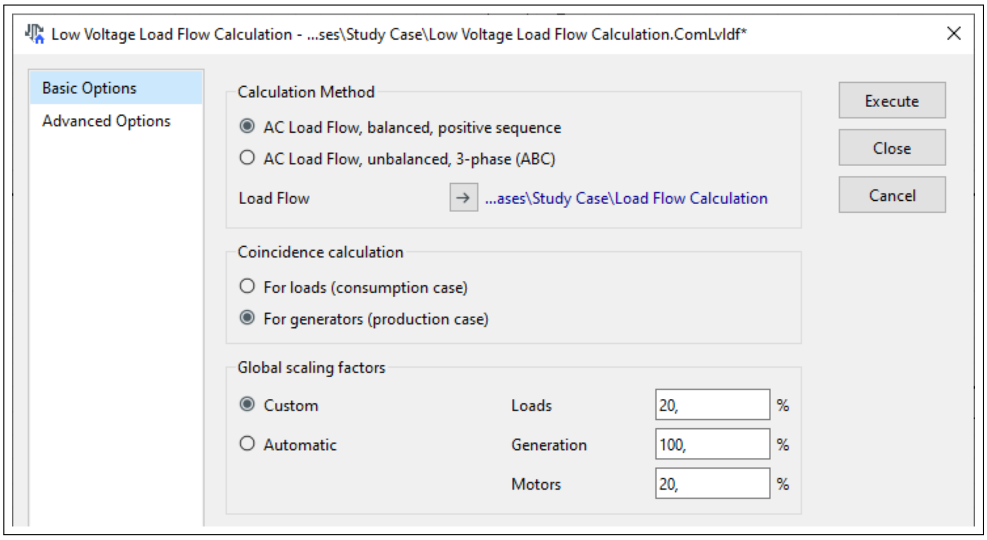



Figure 1.22: *Low Voltage Load Flow Calculation* command dialog

## 1.9 Gurobi Solver

A number of optimisation functions in *PowerFactory* offer the possibility of using external solvers to provide a faster solution to these inherently computational-intensive calculations. One option is the use of the Gurobi solver. In *PowerFactory 2025*, Gurobi versions up to and including version 12 are supported.

# 2 Network Diagrams and Plots

## 2.1 Diagrams

### 2.1.1 Filter layers

A new dimension has been added to the existing graphical Layers concept, with the introduction of filter layers. In *PowerFactory*, objects shown in diagrams are assigned to different layers, such as Network Elements, Annotations and Labels. And users already had the possibility to move network elements into user-defined layers, for example according to voltage level or type of element. Although this enables certain elements to be shown or not as required, there are limitations to this approach: elements can only be in one layer, and assigning elements to layers takes some work.

The new functionality of filter layers allows objects to be assigned to a layer based on attributes of the network elements. Figure 2.1 shows a filter layer being created. If the *Generate* button is used, the user is presented with a standard set of options, such as Voltage or Owner. With these standard options, the relevant attributes are already selected in the filter and the user just has to define the criteria. There is also a Custom option, allowing the possibility of free selection of attributes on which to filter.

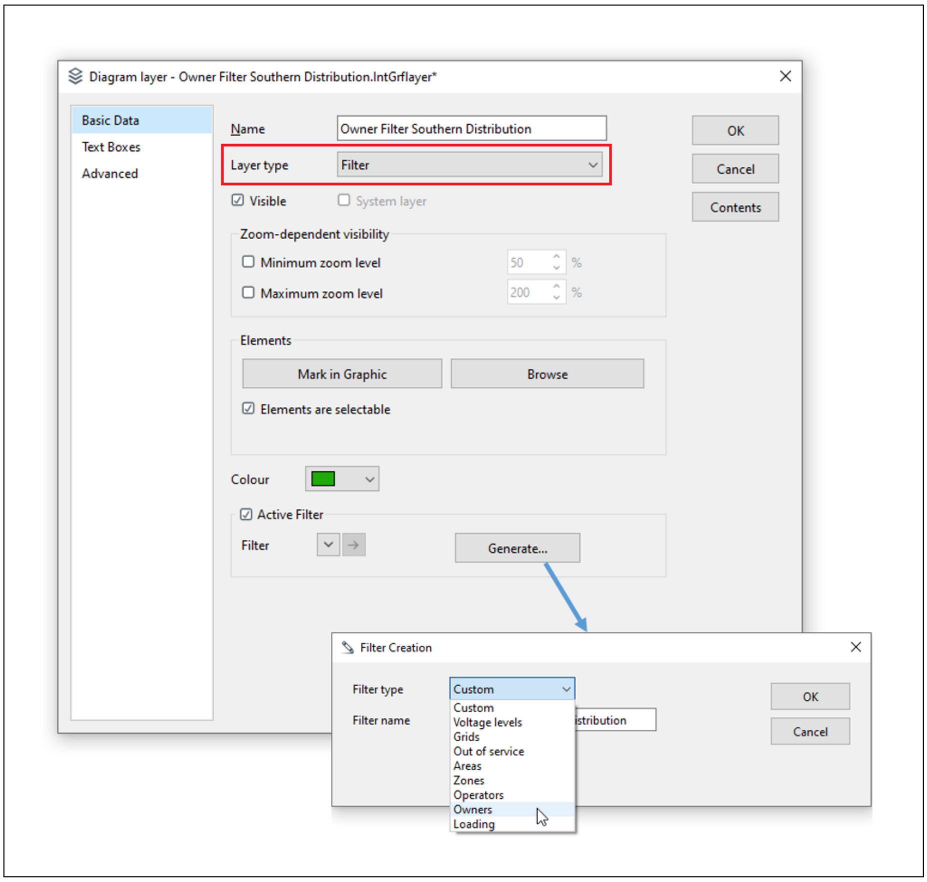



Figure 2.1: Defining a filter layer

Once filter layers are defined, they can be turned on and off as required. The Net Elements layer (if turned on) will continue to show any elements that are not in any filter layer. Note that elements that are assigned to filter layers can't then manually be assigned to other layers.

The advantages of the filter layers are that:

- they are easy to configure;

- elements can belong to multiple filter layers;
- they provide an alternative to diagram colouring, as illustrated in Figure 2.2 below: rather than having the diagram coloured according to Owner, the feeder colouring can still be used and the Owner filter then applied to see the part of the network of interest.

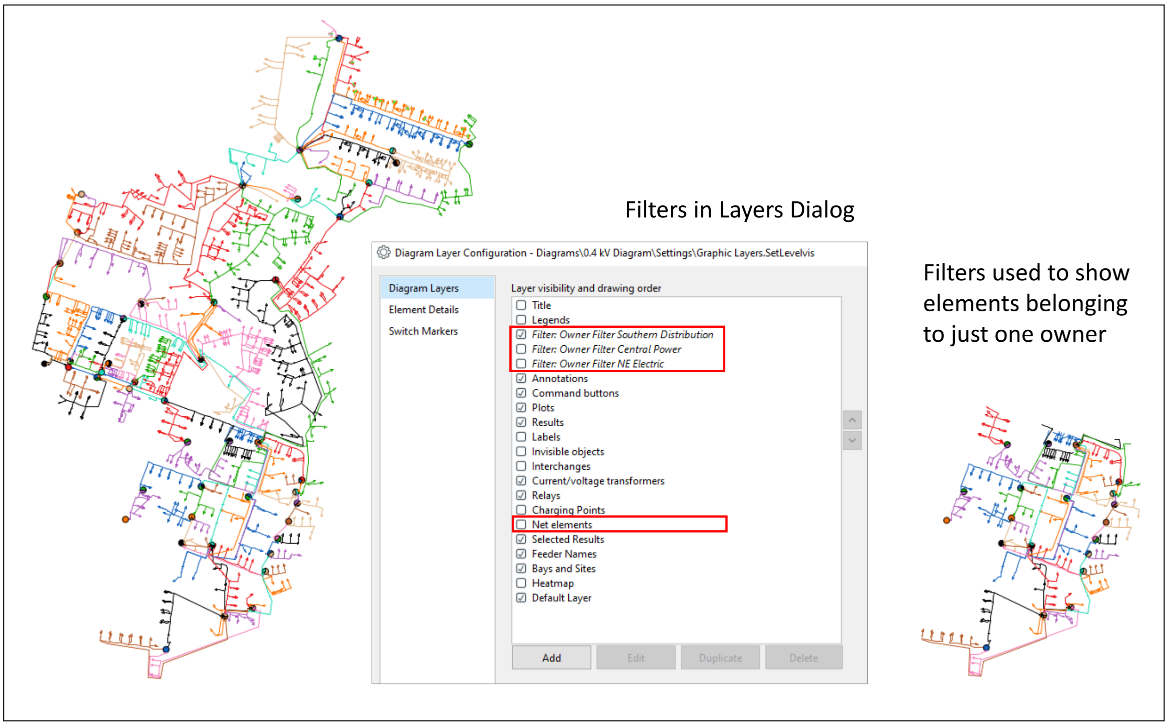



Figure 2.2: Selecting a filter layer

### 2.1.2 Measurement tool

Geographic diagrams now offer a measurement tool (also available in *PowerFactory 2024* service packs). Similar to features found in GIS systems, it allows the lengths of potential new circuits to be easily estimated without the need to make any additions to the network model.

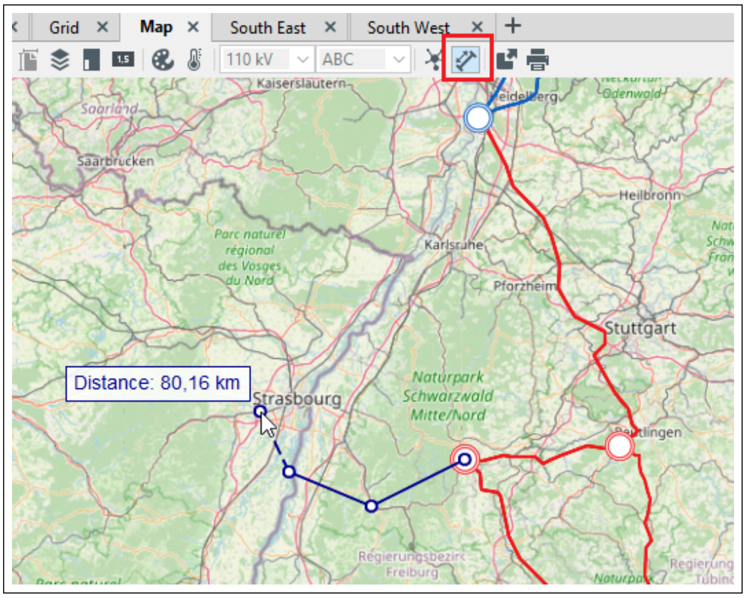



Figure 2.3: Estimating line lengths

### 2.1.3 Optimisation of single-line diagrams based on geographic diagrams

The functionality to generate single line diagrams based on geographic diagrams can be very useful. However, it can result in some areas being sparse and others too dense. An option to expand dense areas or shrink sparse areas is introduced in *PowerFactory 2025*, to help to create more usable single line diagrams.

Figure 2.4 shows an example of this functionality. On the left side is the single line diagram as generated from the geographic diagram and on the right is the diagram after adjusting the density of the nodes.

The node density adjustment is accessible from the context menu of the single line diagram.

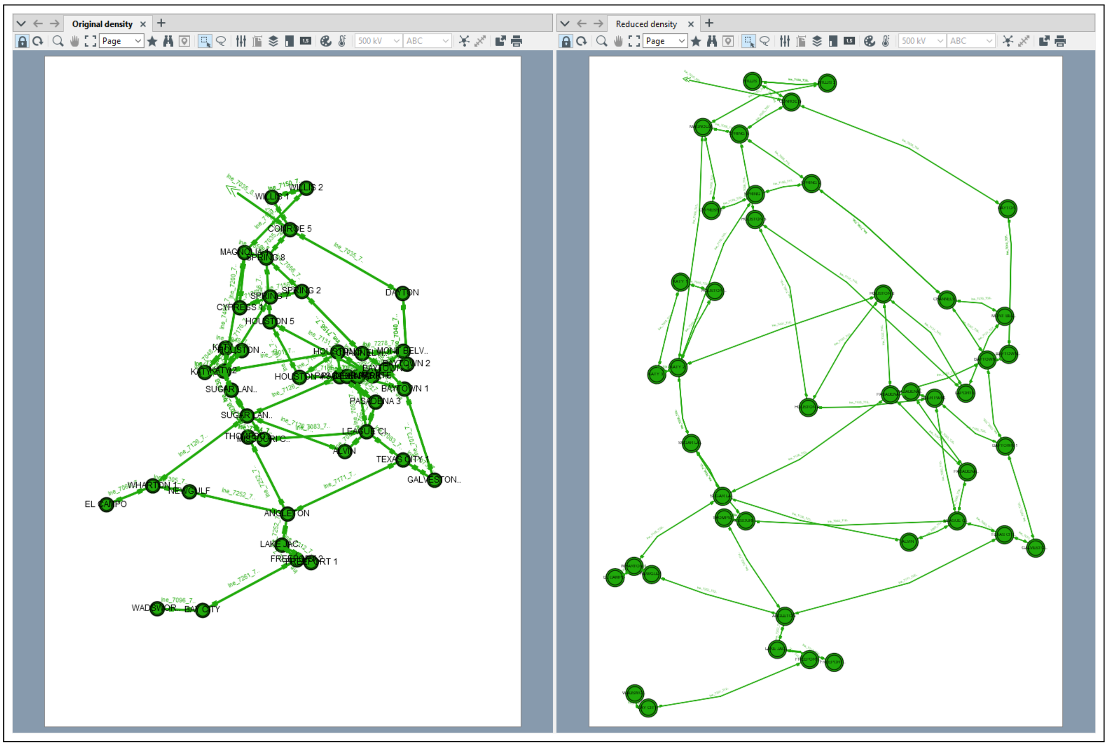



Figure 2.4: Single line diagram before and after optimising the node density

### 2.1.4 Iterative neighbourhood expansion

Working with large grid models can be quite difficult if the model lacks a good single line diagram. To facilitate working with these grid models, *PowerFactory 2025* offers a new neighbourhood expansion function. With this new function, the current graphic can easily be extended via right-click to a selected next substation, giving the user a visual overview of the flows in the neighbourhood of a specific node. An example is shown in Figure 2.5.

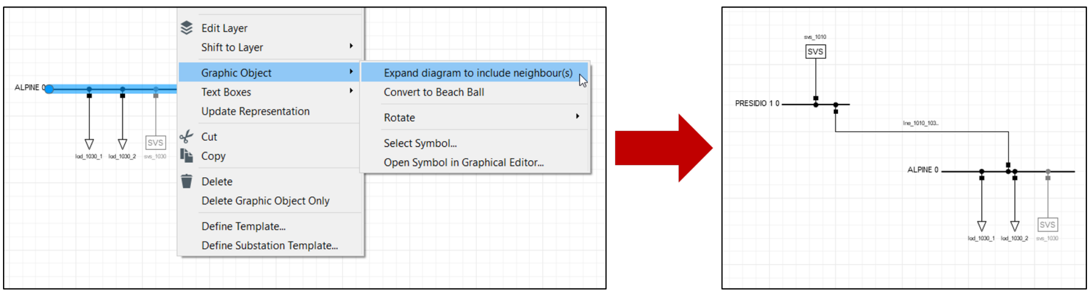



Figure 2.5: Expand diagram to the next substation

### 2.1.5 Line splitting with substation

Substations can now be inserted into lines and branches. A line will be automatically split at the selected length and connected to the free bays of the inserted substation. For branches, the branch itself will be split, as well as the relevant line within the branch. (This features is also available in *PowerFactory 2024* service packs.)

## 2.2 Plots

### 2.2.1 Re-design of R-X plots

The redesign of the plot functionality has now been extended to include distance relay R-X plots. The new *PltImpedancerx* R-X plot shown in Figure 2.6, replaces the existing *VisDraw* plots and uses independent object dialogs to configure relay and path selection as well as axis, title and legend settings. The Relay Operational Limits plot (*PltPowerpq*) has similarly been updated.

In addition to existing functionality that users will already be familiar with, the new R-X plot offers extra features.

Users can now add different kinds of constant to the plot and choose different colour palettes, harmonising the plot functionality with that of other plots available in *PowerFactory*.

The fault loop impedance markers can be illustrated with different symbols with a user defined tolerance band displayed around each marker and different zones can be more flexibly included or excluded.

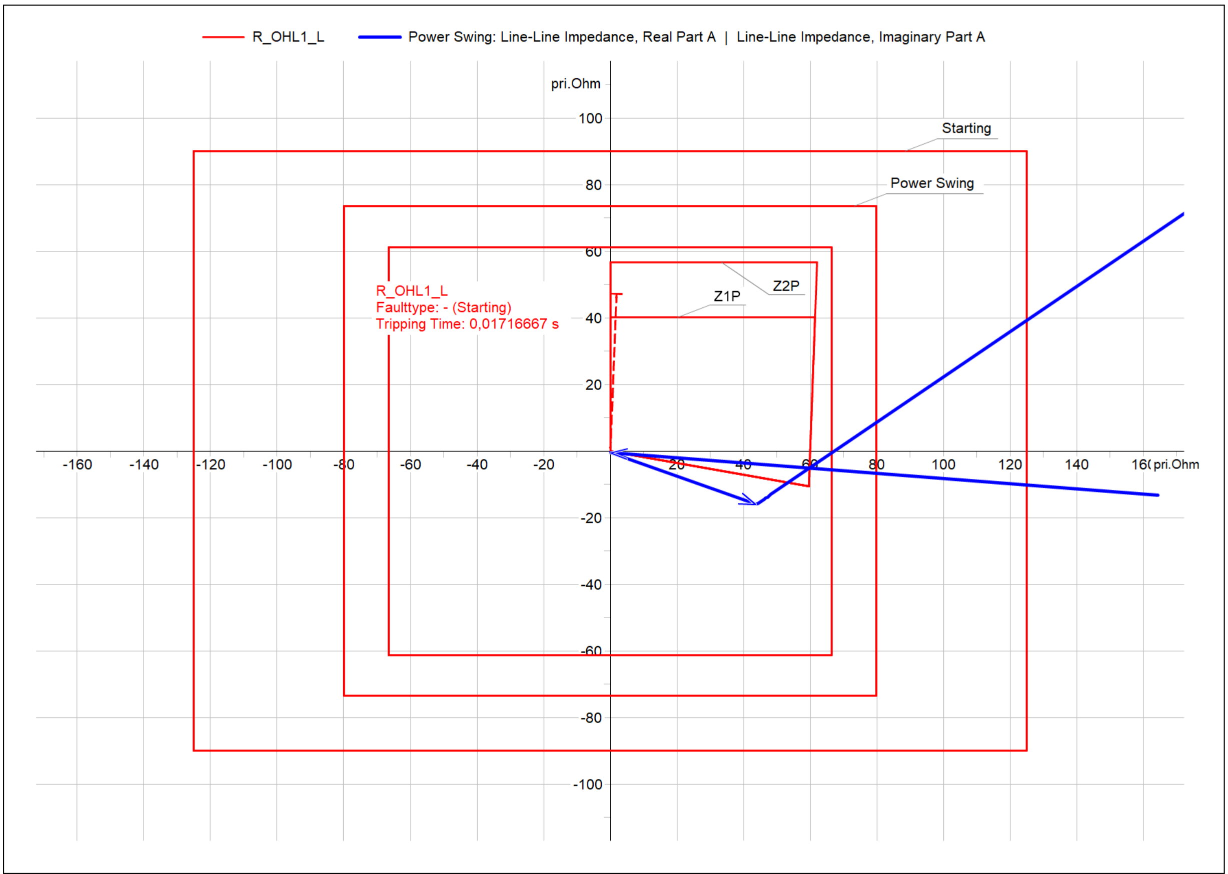



Figure 2.6: New R-X plot

### 2.2.2 Improvements to time-overcurrent plots

It is now possible to display a tolerance band around current results. The feature is configured on the Drawing Options page of the Time Overcurrent Plot Definition *PltOvercurrent* using the *Display results* and *Tolerance* setting parameters.

An improved implementation of the grading margin functionality that was present in previous versions of the software is now available. By right clicking on the plot area when a calculation is active, it is possible to choose the *Grading Margins* option from the context sensitive menu. A special constant is then added to the plot at the clicked location displaying the grading margins between the tripping times of the displayed relays based on the results of the active calculation.

In Figure 2.7; 5% tolerance bands are shown around each of the current result constants and grading margins are shown on the rightmost constant of the diagram.

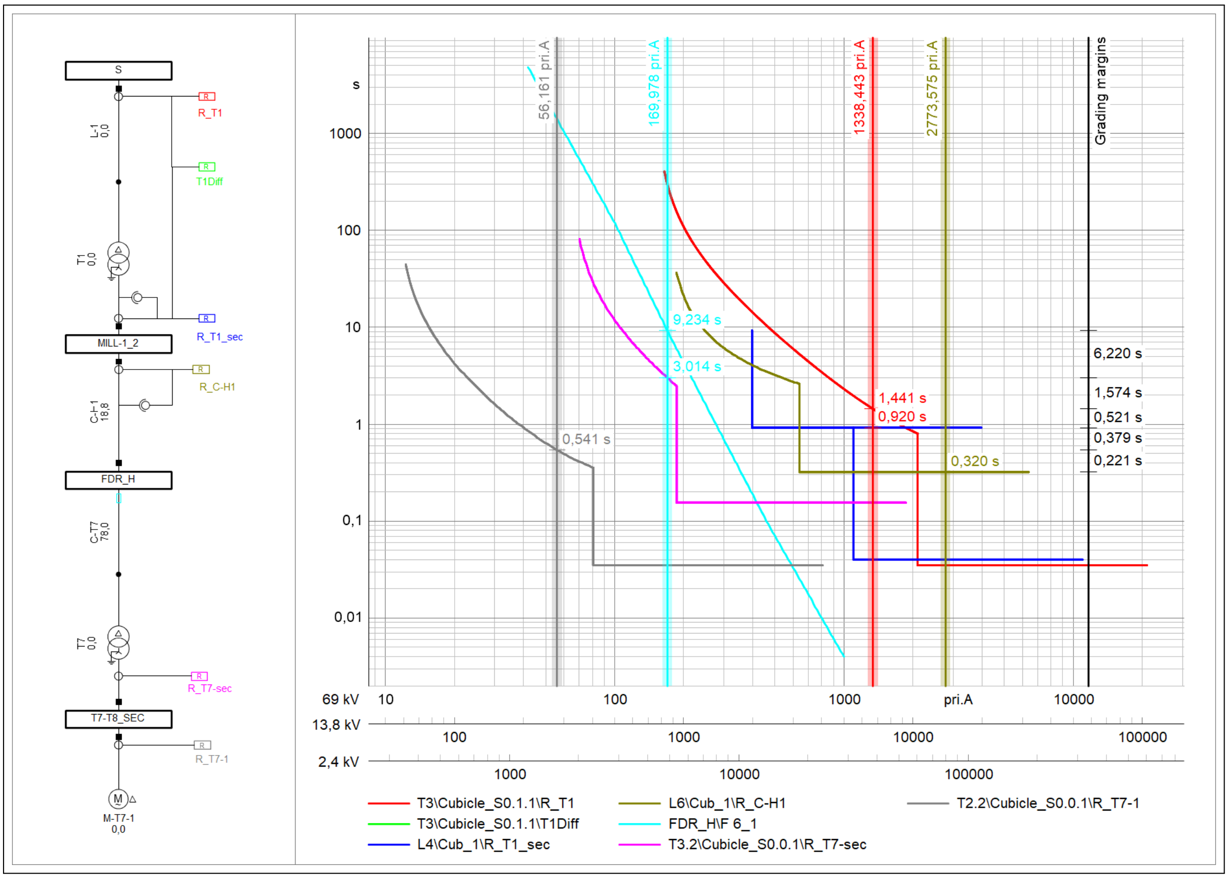



Figure 2.7: Current tolerances and grading margins

# 3 Handling and Data Management

For information regarding databases and Python versions supported in *PowerFactory 2025*, please refer to the 2025 *Advanced Installation and Configuration Manual*.

## 3.1 Dark Mode

*PowerFactory* can now be run in “dark mode”. This is selected via the User Settings.

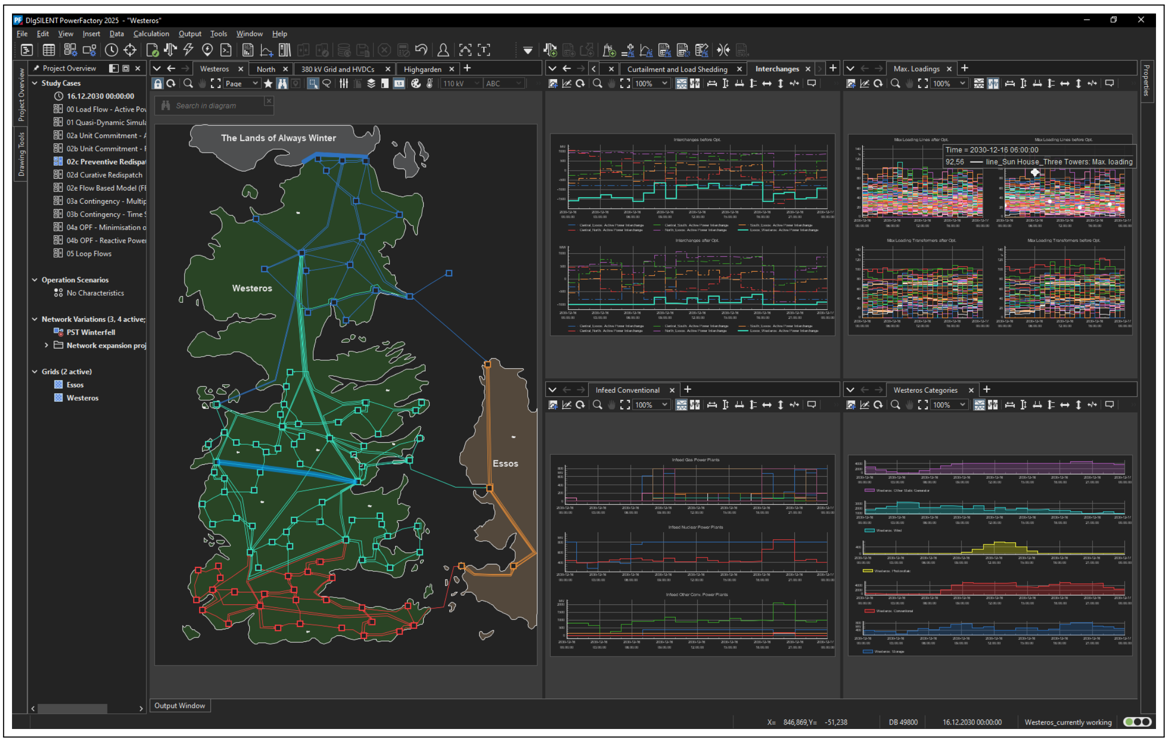



Figure 3.1: Dark mode

## 3.2 Windows and Tabs

### 3.2.1 Output Window

The Output Window is a valuable source of information, not only about data handling and validation but also about the progress and outcomes of calculations. Nevertheless, regular users of *PowerFactory* may not need to routinely check the Output Window, particularly if they are carrying out well-understood tasks where the reports from executed calculations will provide all the information that they need.

Formerly, the user had the option to close the Output Window altogether, but as this carries with it the risk of missing important information, an improved solution has been developed.

The Output Window will normally be “collapsed”. As shown in Figure 3.2, a tally of unread messages will be shown, and these can be viewed at any time, by clicking on the tally. The Output Window can then be hidden again by simply clicking elsewhere.

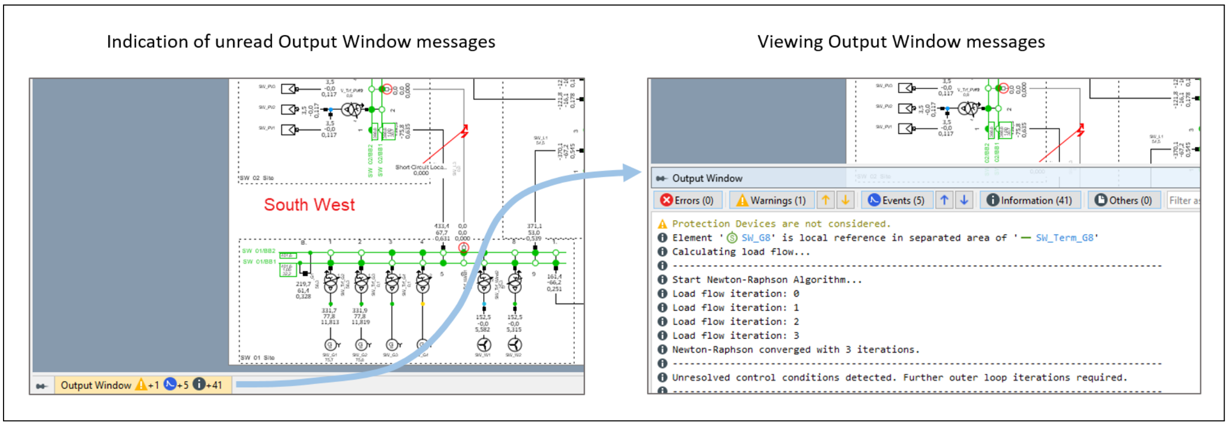



Figure 3.2: Output Window messages

By default, the Output Window will pop up automatically if an error is reported. This is configurable in the user settings. In addition, a "pin" icon allows the user to have the Output Window permanently visible, if this is preferred.

The Drawing Tools and Project Overview windows, by default placed at the left of the display, can also be unpinned in a similar way, and just accessed when needed.

### 3.2.2 Split-screen working

The existing split-screen functionality has been extended, giving flexibility to split the screen both horizontally and vertically, as shown in Figure 3.3.

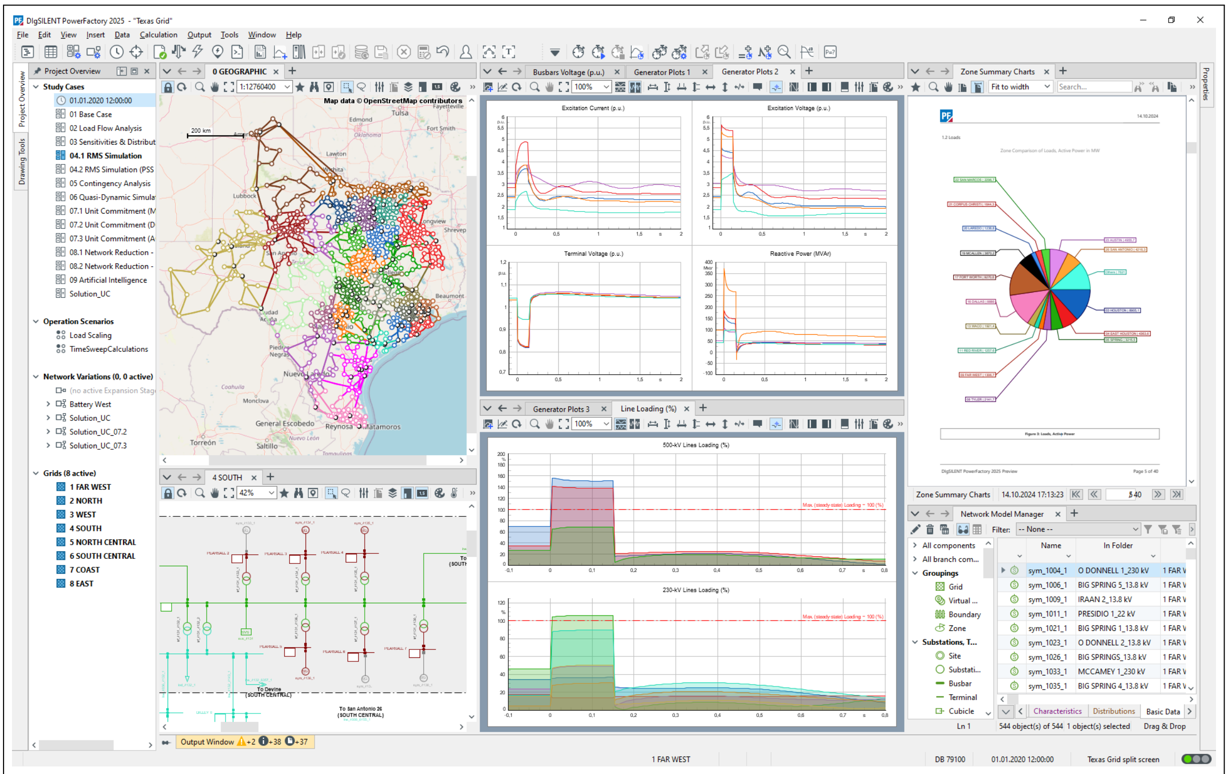


Figure 3.3: Flexible split-screen working

## 3.3 Working with External Files

External files are used in conjunction with *PowerFactory* to supply data that are not held within the *PowerFactory* database. A common example is the referencing of external files that contain time-varying demand data for Parameter Characteristics. Whenever such files are used, the sharing of projects with other users requires the data files to be shared too. Previously, this could be done by defining an external data directory in the *PowerFactory* Configuration command, and using this reference within the project.

Now a more comprehensive solution has been developed, that of a Project Directory.

**Project Directory**

With the *PowerFactory* Workspace, each project has its own folder, named using the ID of the project in the database. Figure 3.4 below illustrates the changed Workspace.

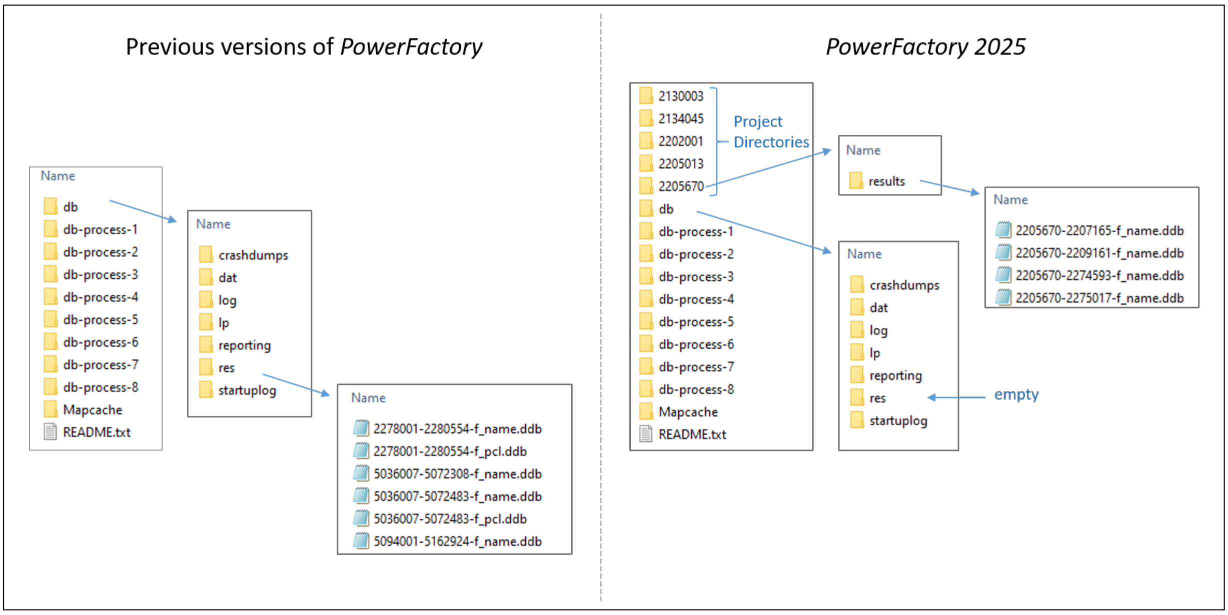



Figure 3.4: Introduction of Project Directories into the Workspace

These individual folders for each project are the Project Directories. The Project Directory is now the default location for the storage of external files, although other locations can still be used. In addition, results files are now stored in the Project Directories.

***PowerFactory Data with external files* (pfdx)**

Together with the development of the Project Directory, there is an extension to the existing project export functionality. It is still possible to export a project as a pfd file, as before, but there is a new option: if a project is exported as pfdx, the result will be a file that contains not only the pfd data but also the external files referenced by the project.

This process is illustrated in Figure 3.5 below. The pfdx file includes the Project Directory, which contains a csv file that provides values for a Time Characteristic. If the project also uses external files that are *not* in the Project Directory, subfolders will be created to store these data; in this example, folder DF6FB7C88D6EE23617EB contains some external files that were held in a different location.

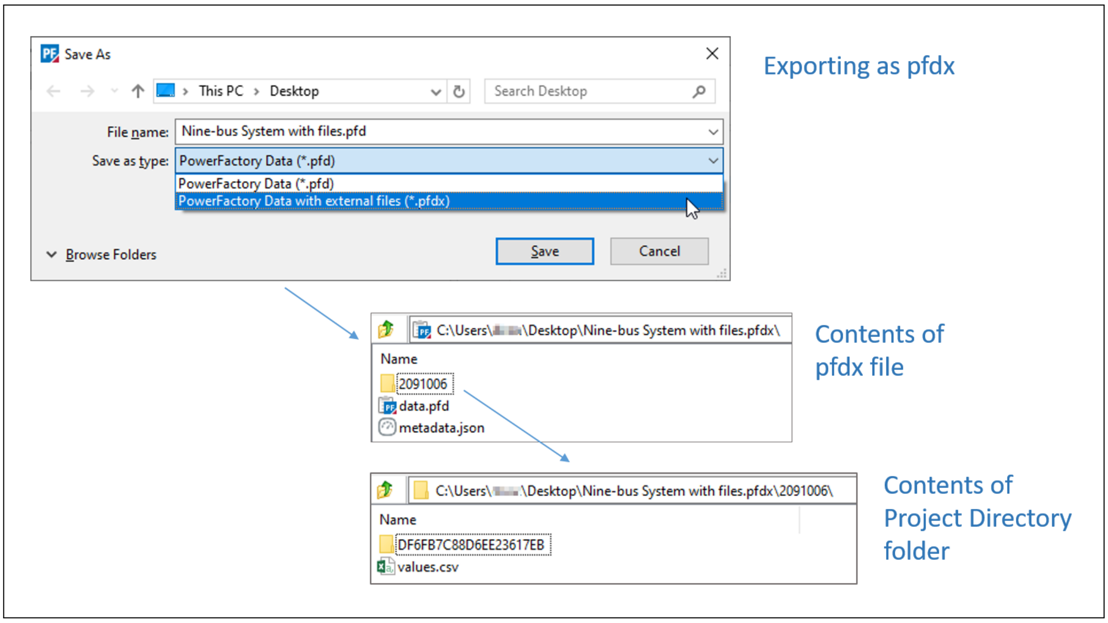



Figure 3.5: The pfdx file

All this makes it easier to ensure that projects being exported to share with other *PowerFactory* users carry with them all the necessary data. In addition, *PowerFactory* automatically adjusts the file paths in objects that reference the external data, and keeps them in synch with the file locations.

**Data security considerations**

When exporting and sharing projects, users need to be careful about the data being shared, and also careful about exactly what sort of data they are importing into their own databases. The following features are included:

- In the export process, the user has full flexibility to include or exclude files from the set of external data being exported.
- The pfdx is a zip archive whose content can be viewed by the user and can easily be examined by virus scanners or similar tools.
- The Administrator user has a new option under *Administration* → *Security and Privacy* called *File Exchange Settings*. Here, the Administrator can block the import and/or export of files of specified type or name.

## 3.4 Parameter Characteristics

There are several developments that offer greater flexibility when working with Parameter Characteristics.

### 3.4.1 Extension to Time Scales (*TriTime*) to allow UTC or Unix times

Time Scales (*TriTime*) are used in conjunction with Vector Characteristics in order to assign values according to the Study Case time. The existing Time Scales offered a range of different units such as Hour of Day, Month of Year, Year. Now this has been extended with two further options:

- **UTC time:** the Scale Values are specified as UTC timestamps in a prescribed format. These will be converted into local time automatically when they are used.

- **Unix time:** The Scale Values are specified as integers that are Unix times. Unix time is defined as the number of non-leap seconds which have passed since 00:00:00 UTC on Thursday, 1 January 1970.

These two options can make it easier to work with time series data that cover days when daylight saving clock adjustments occur.

### 3.4.2 Use of UTC in files for Time Characteristics

Time-varying data are commonly applied in *PowerFactory* via a Time Characteristic (*ChaTime*). If the data for the Characteristic are held outside *PowerFactory* in a file, they will be time-stamped within the file. Previously, the time-stamp was always interpreted as local time, but now the user has the option via a selection box in the Time Characteristic to specify that the timestamps in the file are in fact in UTC.

### 3.4.3 Extended functionality for Time Characteristics using databases

It is possible for Time Characteristics (*ChaTime*) to be defined using data held in an external database. Two developments have been made to this functionality:

- **Default value:** It can often be the case that values are missing in database data, and these values can be covered within the day by using extrapolation of the existing data. However, for days where no data at all exists, these null values will default to zero. Now, the user has the option to specify a default value to be used instead of zero for replacing these missing values.
- **Day-based data representation**: There is now the possibility to use data from a database where the representation is in the form of a single row of data for each day, with a number of columns containing data according to the chosen subdivision, e.g. 24 hours per day.

### 3.4.4 Triggers container in Study Case

One way of applying varying values to attributes is the Scale and Trigger concept. The Scale contains a set of possible values to be used by the Characteristic. In the Study Case, a Trigger object (*SetTrigger*) is used to determine which value out of the set of values should be taken. This basic functionality isn't changed in *PowerFactory 2025*, but it has been recognised that some users have very large numbers of such Triggers in their Study Cases. To better manage this, Triggers will now all be stored in a dedicated folder inside the Study Case. The folder is automatically created when required.
**NOTE:** Triggers placed outside the Triggers folder will be ignored. Projects migrated from lower versions will automatically have existing Triggers moved into a folder; however, it should be noted the new location may necessitate changes to existing automated processes.

## 3.5 *Variation Manager*

The Variation Manager in *PowerFactory 2025*, shown in Figure 3.6, includes a new tab called *Object States* that summarises the number of states where an object was handled. An error is shown if none of the existing delta objects in the expansion stages actually modifies the object, i.e. if an object was “touched” but not modified. These not-required delta objects can be directly deleted from the variation manager, if the corresponding variation is not active, facilitating the clean-up of the network data.

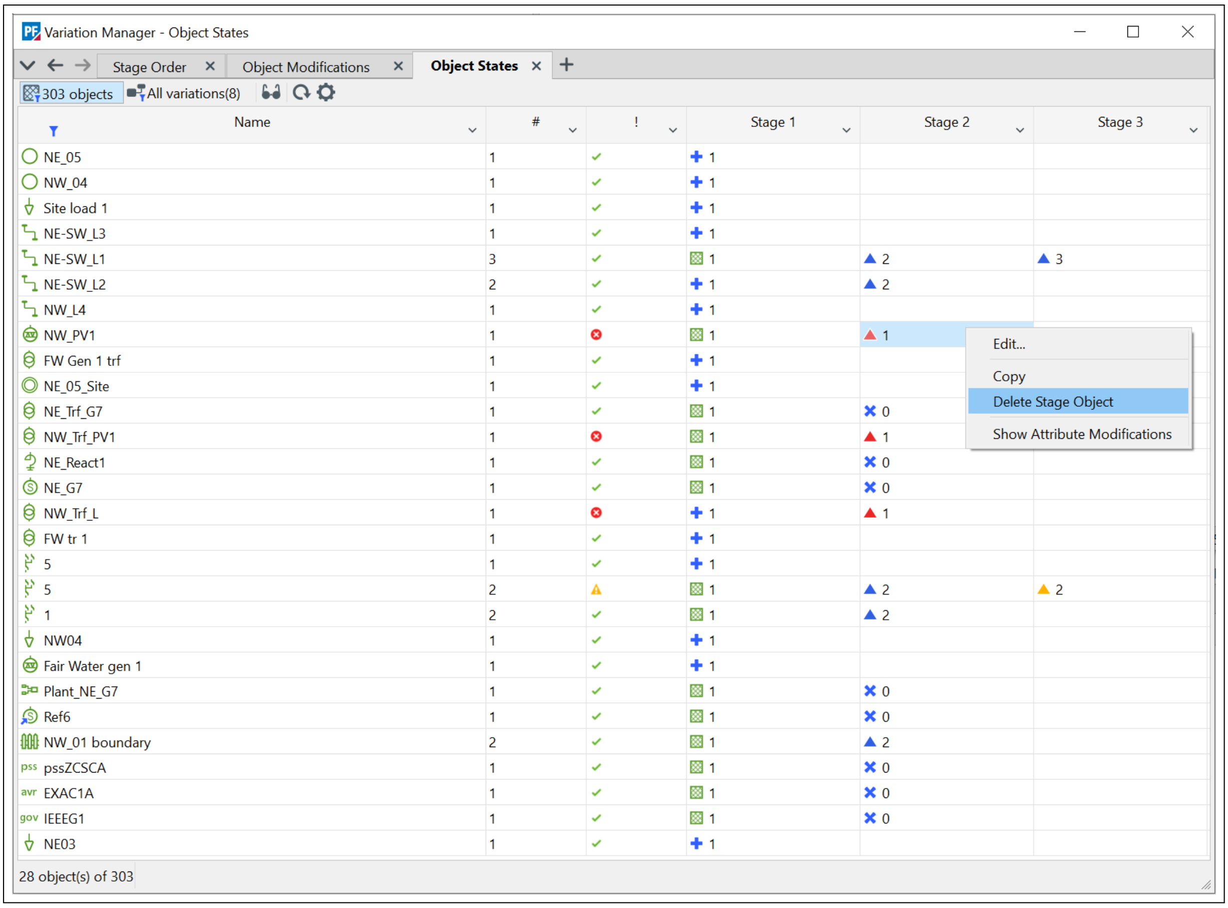



Figure 3.6: Variation Manager. *Objects States*

# 4 Power Equipment Models

## 4.1 New Models

### 4.1.1 STATCOM

In *PowerFactory 2025*, a new Static Synchronous Compensator (STATCOM) model (*ElmStatcom*) has been added. A STATCOM is a shunt-connected FACTS (Flexible AC Transmission System) device used for reactive power compensation within AC networks. The new STATCOM model represents a Modular Multilevel Converter (MMC) STATCOM in full-bridge configuration.
The MMC STATCOM has three phase legs, which can be configured with a Y or a $\Delta$ connection. Each phase leg consists of a phase leg reactor, multiple full-bridge MMC submodules and a start-up resistor with a bypass switch, connected in series.

For load flow calculations, several control modes are supported:

- Const. V
- Const. Q
- Voltage Q-droop
- Q(V)-characteristic
- Voltage Iq-droop

For power quality assessments (Harmonic Load Flow calculation, Impedance Frequency Sweep), the STATCOM can be represented by a Thevenin or Norton equivalent, with the options to enter a harmonic voltage or current spectrum and the frequency-dependent characteristic of the impedance (i.e. of inductance and resistance).

For RMS/EMT simulations, input signals for dynamic control of the STATCOM are available. The MMC models *Controlled voltage source* and *Detailed equivalent circuit* can be selected and a detailed submodel can be linked to the STATCOM network element for use in EMT simulations.

## 4.2 Lines, Cables and Series Impedances

### 4.2.1 DC lines

**Frequency-dependent PI model**

A high performance and easy-to-use DC line lumped model is now available for RMS and EMT simulations. The model includes a frequency dependence of the series resistance and inductance parameters. This allows the damping of transient oscillations to be captured with more accuracy compared with the traditional lumped PI model.

The new DC line model is characterised by a lumped PI-circuit where the series R/L parameters are represented by equivalent circuits consisting of series or parallel connections of lumped resistive and inductive components.

The new model does not allow the representation of propagation delays between sending and receiving ends.

**Distributed constant parameter (Bergeron) model**

The distributed constant parameter (Bergeron) model has been implemented for EMT simulations for DC lines, towers and cable systems.

### 4.2.2 Towers, Tower Types and Tower Geometry Types

The Tower Geometry Type object (*TypGeo*) now has a visual representation of the geometry, similar to that already found in Tower Type objects (*TypTow*). In addition, in both these types, a Description column has been added to the table of line circuits; these descriptions are automatically transferred to the related Tower elements.

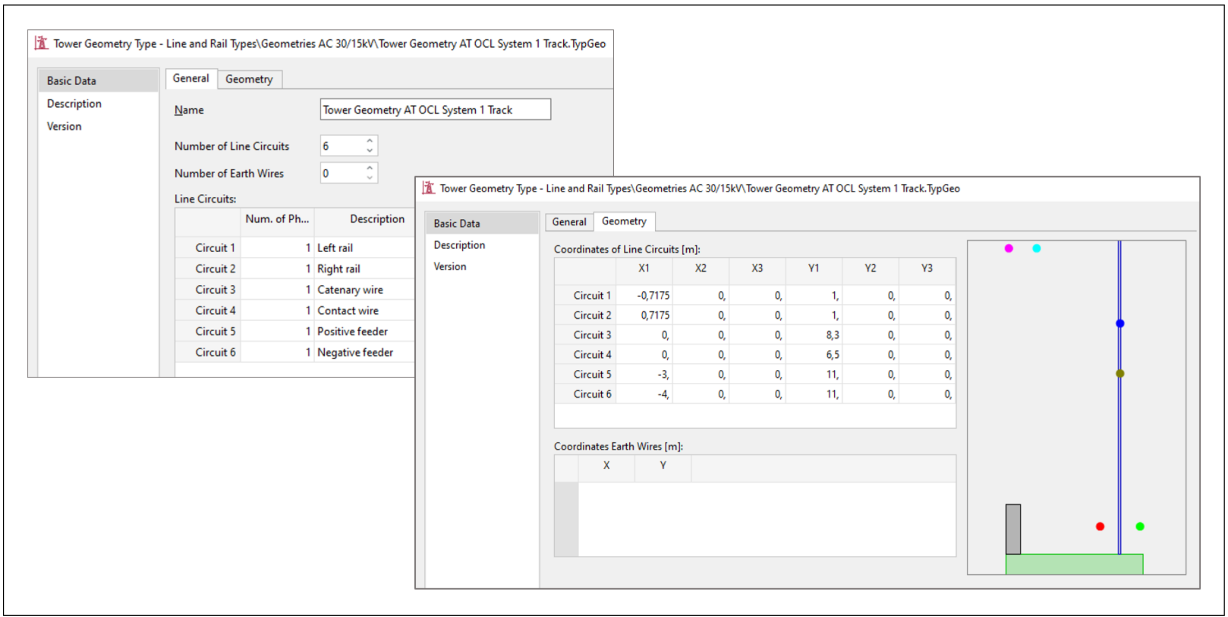



Figure 4.1: Tower Geometry Type

## 4.3 Controllers

### 4.3.1 Station Controllers

To better integrate shunts into voltage regulation strategies, it is now possible to create mixed Station Controllers *ElmStactrl* that regulate generators and shunts together. The shunt element is primarily used for the voltage regulation, while the generator is only used for fine tuning or when the shunt capability is exceeded.

## 4.4 Generators, Loads and Sources

### 4.4.1 Synchronous Machines

The Machine (i_mot) attribute of Synchronous Machines (*ElmSym*) has been extended with an additional option, *Condenser*, and an equivalent flag added to the type object to indicate the use as condenser. Selecting these options simplifies the configuration of such machines, for example by setting the active power limits to zero, and ensuring consistency of attribute settings.

### 4.4.2 “Grid-forming” flag

A new flag for Static Generators (*ElmGenstat*), PV Systems (*ElmPvsys*) and PWM Converters (*ElmVsc*, *ElmVscmono*) has been introduced to indicate whether their control strategy is “grid-forming” or “grid-following”. As well as being available to provide information about the machine, it is taken into account if the reference machine is determined automatically: A Static Generator, PV System or PWM Converter can be selected be selected as a reference machine if the option “Grid-forming” is enabled. A detailed description of this methodology can be found in the Load Flow Analysis chapter of the User Manual.

### 4.4.3 Static Generators and PV Systems

For *Harmonic Load Flow* calculations, Static Generator elements (*ElmGenstat*) and PV System elements (*ElmPvsys*) can now be modelled as Thevenin equivalent, using the Harmonic Source Type *TypHmcvolt*. The harmonic voltage angle of the internal source of the Thevenin equivalent can be associated with the fundamental frequency voltage.

A separate development for Static Generator elements (*ElmGenstat*), relating to RMS and EMT simulations, is described in section 4.5.2.

### 4.4.4 Power-plant categories

An additional CIM profile called LTDS is now supported, as described in section 6.1.2. For this purpose, the plant categories and subcategories of generating units have been extended with the following selectable items being added:

**New categories**

- Biomass
- Geothermal
- Waste
- Other biofuel
- Other fossil fuel
- Advanced fuel

**New subcategories**

- for Storage
  - Battery
  - Compressed air
  - Flywheel
- for Biogas
  - Anaerobic gas
  - Landfill gas
  - Sewage gas

### 4.4.5 Current Sources

Both the single terminal *ElmIac* and two-terminal *ElmIacbi* AC Current Source models have been enhanced for *Harmonic Calculations* so that frequency dependencies can be specified for their internal admittances using characteristics. Different characteristics can be defined for both conductance and susceptance parameters and can additionally be differentiated according to symmetrical component sequence. The new Operating-point-dependent Frequency Characteristic *ChaOpfreq* described in section 4.6.2 is also supported for these parameters.

### 4.4.6 External Grids and Voltage Sources

For the External Grid (*ElmXnet*) and the Voltage Source (*ElmVac*), the harmonic spectrum definition can be configured using either the Harmonic Voltages (*TypHmcvolt*) type or the new Operation Dependent Harmonic Voltages (*TypHmcopvolt*) type.

The definition of frequency dependencies has also been improved, not only for the External Grid and the Voltage Source but also for the Static Synchronous Series Compensation element (*ElmSssc*). It is now possible to enter the frequency characteristics as reactance characteristics. In addition, a zero-sequence capacitance parameter can now be entered for the External Grid.

## 4.5 Power Electronic Devices

### 4.5.1 "Grid-forming" flag

See section 4.4.2 above.

### 4.5.2 PWM Converter developments

The PWM Converter (*ElmVsc*, *ElmVscmono*) and Static Generator (*ElmGenstat*) models have been enhanced with a new flag to "Enable operation if part of an isolated area" for RMS/EMT simulations. This makes switching between the grid parallel operation and island operation during the simulation more convenient. In the event of an islanding event, it can be switched to a new set of control inputs, even some time after the switch event.

For PWM Converters (*ElmVsc*, *ElmVscmono*), the type "IEC 61000" for harmonic voltage sources (*TypHmcvolt*) is now supported. In addition, for the harmonic models "const.V" and "const.V (deprecated)", a frequency dependency can now be defined for the positive sequence, negative sequence and zero sequence impedance.

## 4.6 Harmonic Sources

### 4.6.1 Unbalanced Harmonic Current Sources in sequence components

The input option for Harmonic Current Sources (*TypHmccur*) has been extended so that an unbalanced phase-correct source can now also be entered in sequence components.

### 4.6.2 Operating-point-dependent harmonic definitions and impedance characteristics

Elements that can be defined as Harmonic Current or Voltage Sources now also support an operating-point-dependent assignment of several harmonic spectrum definitions. There are new objects (*TypHmcopcur*, *TypHmcopvolt*) that can be assigned to those elements, in which the operating points can be defined and the harmonic spectrum definitions (*TypHmccur*, *TypHmcvolt*) can be assigned. The operating point can be defined for active power, reactive power, bus voltage or a combination of these. Figure 4.2 shows an example setting for a Harmonic Current Source with different harmonic spectrum definitions (*TypHmccur*) for special operating points.

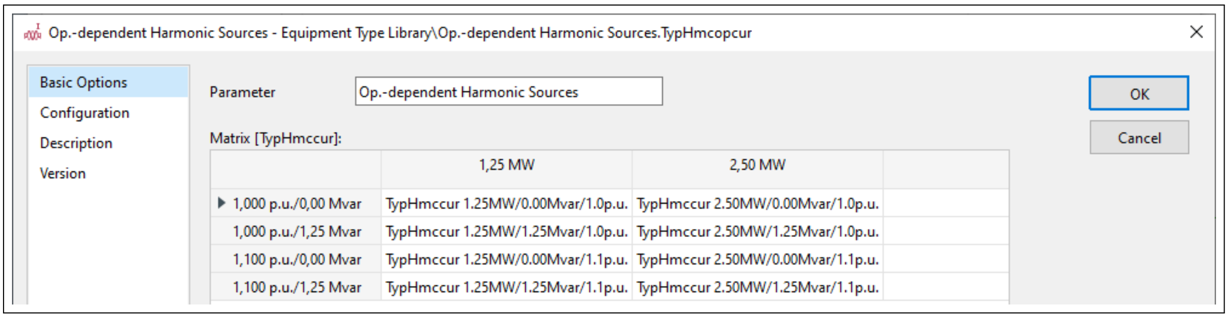



Figure 4.2: Example of the new operating point dependent harmonic definition

Similarly, these elements can now have an operating-point-dependent frequency-dependent characteristic. There is a new object (*ChaOpfreq*) that can be assigned to those elements, in which the operating points can be defined and the characteristics (*ChaPol*,*ChaVec*,*ChaMat*) can be assigned. The operating point can be defined for active power, reactive power, bus voltage or a combination of these. The implementation is analogous to the operating-point-dependent harmonic spectrum definition.

## 4.7 Protection Devices

The section describes the changes to the protection block functionality. Detailed information about the newly implemented and existing protection block functionality can be found in the updated technical references.

### 4.7.1 Harmonisation and enhancement of the voltage memory functionality of the Overcurrent and Distance Direction Determination Blocks

The existing voltage memory triggering functionality of the Overcurrent Direction Determination block *(RelDir)* has been substantially brought into line with a more sophisticated approach used by the existing Distance Polarising Block *RelZpol*. The new function replicates the *Activated by Threshold* approach, offering the same configuration settings and facilitating the usage of the block for the modelling of modern directional overcurrent relays.

Additionally, both classes of direction determination block have been enhanced so that the voltage memory utilises fallback settings which more explicitly define the behaviour to be applied when the voltage memory function is triggered. In the case of the Distance Direction Determination block, this replaces the existing 3 Phase Fault Direction Holding setting. The new, more flexible fallback logic can be triggered on current, voltage or expiration signals from the polarising block (the latter, only in the case of the Distance Direction Determination block). The logic can be configured so as to apply either a predefined direction or to seal in the last direction that was measured before triggering.

### 4.7.2 Refactoring and enhancement specific to the Distance Direction Determination Block

A number of manufacturer-specific configurations of the 6-phase version of the block that were previously available have been rationalised into a more general and user-friendly 6-phase configuration. Furthermore, the previously selectable Single and Double Directional characteristic types, that were used to define the way in which the directional areas were specified, have been renamed as Operating Sector and Limit Angles respectively for the Input parameter located in the range definitions field of the dialog. These changes have been implemented in order to better describe the setting's real functionality. The main difference between the alternative manufacturer's approaches concerns the way in which the Directional Angle (Phi) setting is specified for relays where the newly renamed Limit Angle Input option is applicable. This difference can still be replicated, but is now achieved through the selection of a simple checkbox which rotates the specified angle through $+90°$.

The block can now be explicitly configured, using the Method parameter, as to whether it carries out the directional determination calculation using phase comparison of the operating current and polarising voltage vectors or by analysing the sign of the computed impedances, as is possible with modern numerical devices.

The signals available for connection of the block within the wider relay model have also been rationalised and refactored. All possible block configurations now have loop signals and phase-wise directional output signals available. Both phase to phase and phase to ground phase-wise directional signals are available in the 6-phase configuration of the block. In the case of the loop signals these have been rationalised into a single forward loop signal and a single reverse loop signal where the nature of the fault loop is encoded into the signal value.

### 4.7.3 Refactoring and enhancement specific to the Overcurrent Direction Determination Block

In addition to the voltage memory developments described in section 4.7.1, the Direction Determination block *(RelDir)* used by directional overcurrent relays has also been refactored and enhanced.

The dialog controls have been rearranged so that the characteristic angle is now clearly displayed as a major input on the basic data page. Overall, the dialog now more clearly indicates which inputs are required or can be considered when setting up the directional block.

The list of available polarisation methods in the *(TypDir)* is now filtered to only display methods which are relevant to the selected Type setting. Where the Type setting is set to 3-Phase, an additional cross polarisation method where no phase shift is applied can now be considered. This new method matches an existing method already used by the distance polarising block. The cross polarisation method with $30°$ phase shift has been removed, since this was not used by any of the relays modelled in the library and was therefore considered to be redundant. The existing method including a $90°$ phase shift continues to be available.

### 4.7.4 Refactoring and enhancement of the distance polarising block model

The Distance Polarising block model *RelZpol* has been updated in order to improve usability and correctness.

In particular, a lot of development has been focussed on the voltage memory functionality:

- The voltage memory is now always evaluated per-loop, ensuring that un-faulted loops are not negatively impacted by memory activation that may occur in the faulted phases.
- The voltage memory now uses the prospective polarisation voltage for the memory activation threshold check, leading to fewer unnecessary activations.
- Using voltage memory for impedance signals is no longer supported, since this was often applied erroneously resulting in incorrect relaying behaviour.
- Delay (always on) voltage memory has been renamed as Continuous voltage memory and has been further enhanced, allowing the polarisation calculation to be carried out using a mixture of measured values and memory values, allowing the block to more faithfully reproduce the real behaviour of some modern relays.
- “Circular Voltage Memory”, which was superfluous, is no longer supported.
- New user definable thresholds for Memory Activation and Memory synchronisation have been included when the Polarisation Method is selected to Adaptive.

Additionally, the following changes have been implemented:

- Earth Factor and Mutual Earth Factor functions are now separately configurable, excludable and more consistently available across all relevant Polarisation Unit configurations.

- It is now possible to specify an alternative polarisation method to be applied in cases where the memory has expired. This method can be specified based on the combination of two separately defined polarising methods.
- Where two polarising methods are combined, either for the main polarisation calculation or where the memory has expired, then this combination will now always use relative logic. The previously available additive logic which was superfluous is no longer supported.
- The “Self, ground compensated” and “User Defined” polarising modes are no longer supported.
- The impedance calculation options are activated when the unit is required to provide additional impedance signals to other units within the relay have been rationalised down to 2 choices:
  - Classical
  - RMD, as utilised by some Siemens relays.
- The “Adaptive” polarisation options no longer automatically results in the signal layout of a Phase-Phase/Phase-Earth polarisation with impedance signals.

### 4.7.5 Detailed modelling of the EMT simulation behaviour of different fuse technologies

The behaviour of the fuse model *RelFuse/TypFuse* during EMT simulations has been enhanced so that different kinds of fuse technology can now be considered. Both current limiting fuses (where the arc energy is absorbed by a powder or sand filler) and expulsion type fuses (where the arc is lengthened and extinguished after being blown from the fuse tube ends by gas pressure created by the fuse arc itself) can now be modelled. These models consider the different time-phases of the fault in detail and are offered in addition to the existing *Ideal Switch* model. The representation of current limiting effects has been given special emphasis and further supports *Complete Method Short Circuit calculations* in addition to RMS simulation. More details on the Current Limitation developments can be found in section 4.7.6.

A new technical reference has additionally been created for the fuse model, which describes the different static and dynamic behaviours of the model in detail.

### 4.7.6 Modelling of current-limiting effects of fuses

Many fuses are designed to be current limiting. Such fuses are capable of acting extremely quickly. When subjected to sufficiently high magnitudes of current they can even act before the first peak of the alternating current flowing in the fuse has occurred. By preventing the short circuit current from increasing to the high magnitudes that would otherwise arise in the fuse’s absence, it is possible to reduce the thermal and mechanical stresses experienced by supplied equipment. This potentially allows more economical, reduced rating equipment to be selected downstream.

The *PowerFactory* Fuse model (*RelFuse/TypFuse*) has now been significantly enhanced so that it is capable of modelling these effects during both static *Complete Method Short Circuit Calculations* and dynamic *RMS and EMT simulations*.

The let-through characteristic of the fuse, typically provided by the manufacturer, which relates the prospective (RMS) short circuit current to the limited peak current, can be specified in the type of the fuse (*TypFuse*) using three simple coordinate pairs, as illustrated in Figure 4.3.

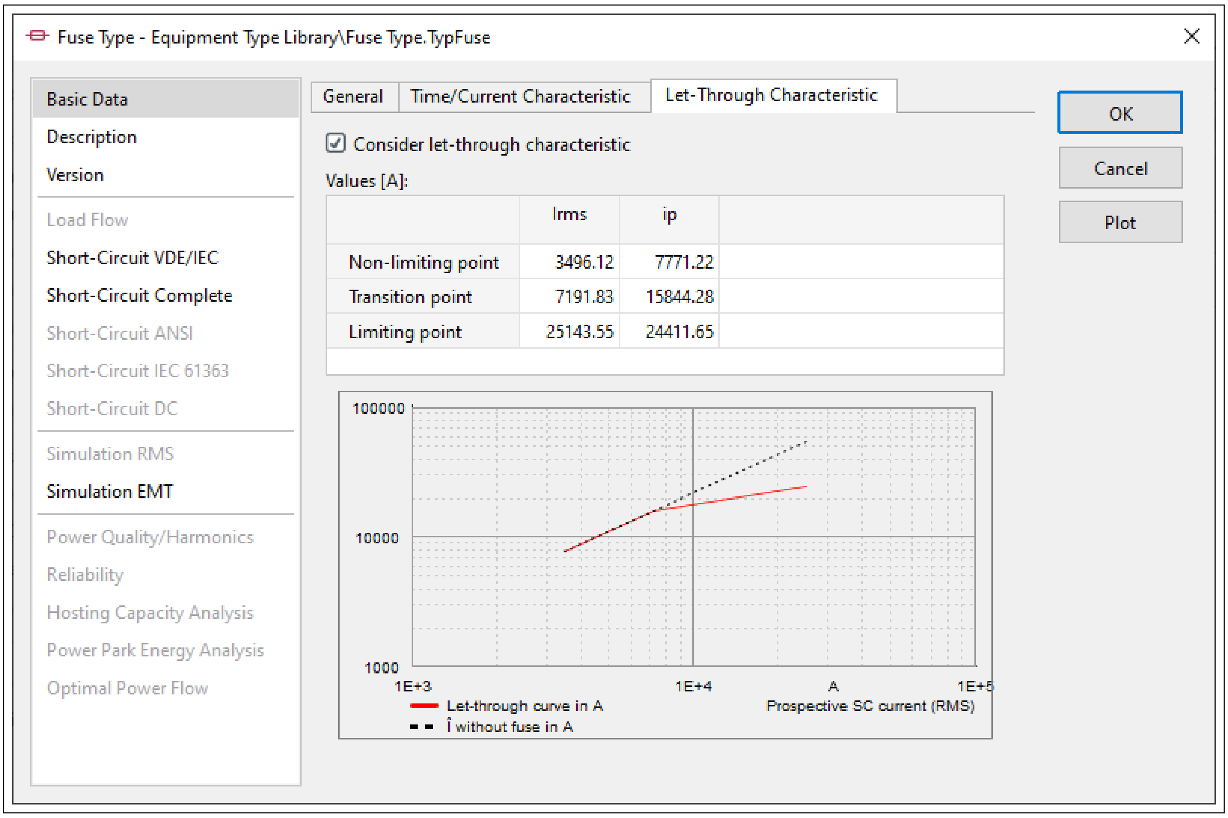



Figure 4.3: Specification of the let-through characteristic

The approach to modelling the current limiting effects of the fuse depends on the type of calculation being carried out and on the input parameters selected, but detailed descriptions of all models are provided in the new fuse technical reference. Some highlights from the modelling approaches are described below.

For EMT simulation the following time-phases of the fault are considered in the model:

- Heating (pre-melting) phase
- Melting phase
- Arcing phase
- Open state after fault clearing

By considering these time-phases of the fault in detail, more accurate modelling of series combinations of fuses becomes possible, potentially allowing a detailed analysis of their selectivity.

A visual summary of the worst case fault clearing behaviour of the fuse for EMT simulation is provided in the *TypFuse* as shown in figure 4.4.

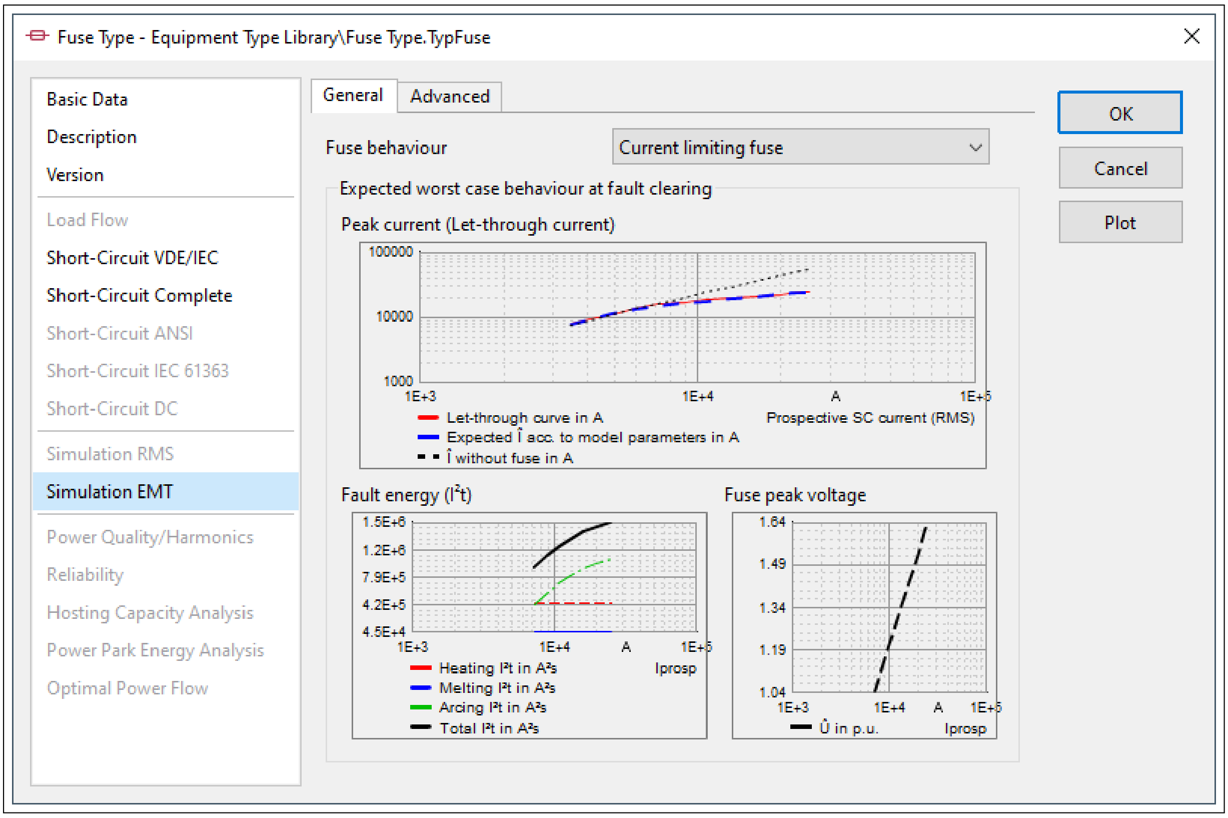



Figure 4.4: Specification of the let-through characteristic

Advanced arcing parameters can be considered for the EMT model using an arc parameter fitting tool located on the Advanced EMT tab of the fuse type (*TypFuse*). This tool fits the fuse resistance to the given or assumed voltage peak and prospective fault current.

For RMS simulation, where the different time-phases of the fault cannot be modelled in the same level of detail as is achieved with EMT simulation, special consideration has been given to more accurately represent the series combination of fuses. This is so that the overall impedance of the fuses that is calculated does not become too high, which would lead to smaller current magnitudes than expected.

For consideration in the Complete Short Circuit Calculation an iterative approach is required in order to determine a fuse impedance which limits the current to the targeted value determined by the let-through characteristic. In order to facilitate this the Current Iteration option in the Short Circuit calculation command should be activated by the user.

## 4.8 QDSL models

Until now, it has been possible to use QDSL models with *balanced* and *unbalanced AC Load Flow* calculations. With *PowerFactory 2025*, the *DC Load Flow* is also supported. In addition, the dialog of *TypQdsl* has been restructured so that it is now possible to either use the same or different scripts depending on the load flow calculation method, as shown in Figure 4.5.

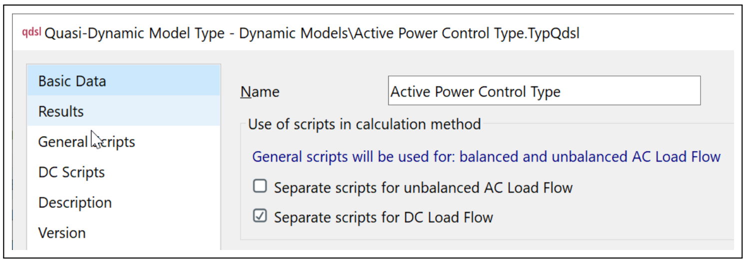



Figure 4.5: Basic Data page of *TypQdsl*

To simplify the creation of calculation-specific or general scripts, the possibility to filter input and output variables by calculation method has been added in the *Load Flow Equations*, as can be seen in Figure 4.6.

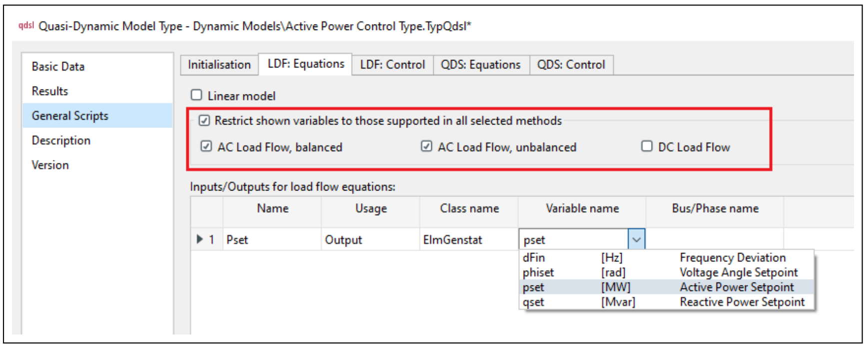



Figure 4.6: Calculation method filter

# 5 Scripting and Automation

## 5.1 Remote Scripts and Command Configuration

DPL and Python scripts can not only be executed directly or via the *Execute Script* command, but also via tools in the User-defined Tools toolbar or via a button on a diagram (*VisButton*). These last two options are particularly useful when users wish to have scripts made available in a central location, remote from the active project. By default, using such remote scripts results in a local copy of the script being created in the active Study Case, which is not always desirable. In *PowerFactory 2025*, an option is now provided to avoid this: the local copy of the script will be generated in the temporary commands folder instead, which avoids cluttering up the Study Case with unwanted command objects. In Figure 5.1, the new options for the Tools Configuration and the Command Button are shown.

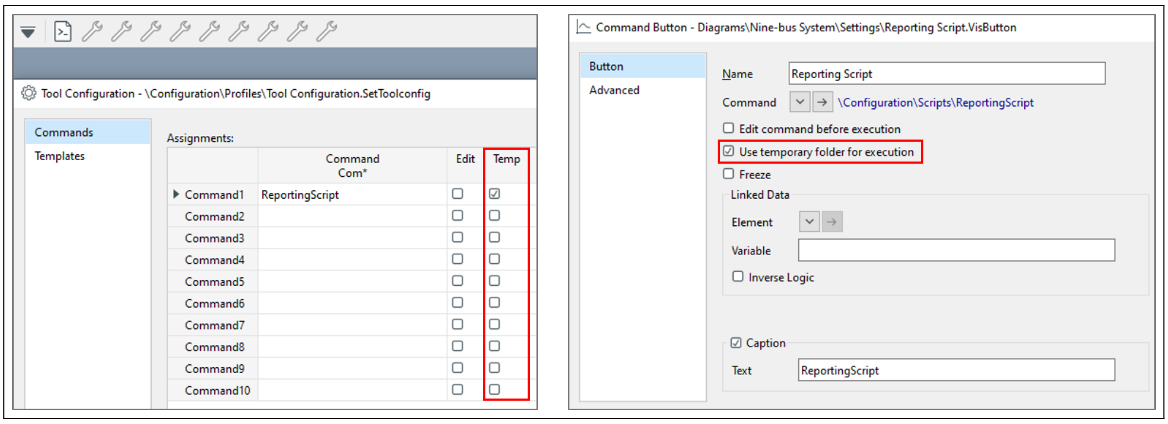



Figure 5.1: Tools Configuration and Command Button options for remote scripts

## 5.2 *Task Automation*

Selecting calculation commands from different Study Cases within the *Task Automation* is now easier and faster. The *Task Automation* configuration command has been enhanced to include a new button for selecting calculation commands from different Study Cases; see Figure 5.2. This is very helpful if you have configured multiple Study Cases to represent different network states and then want to perform a calculation for each case.

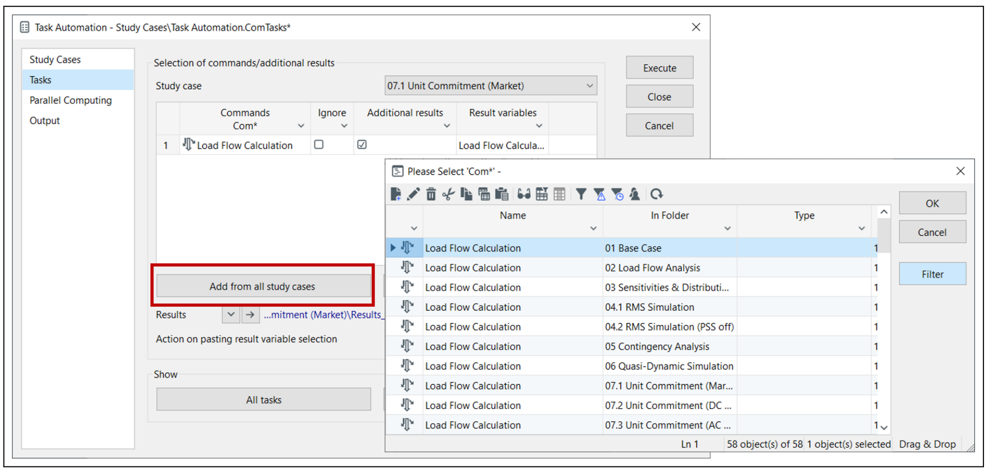



Figure 5.2: Selecting commands from different Study Cases

There is also an improvement for the parallel computation of the *Task Automation*: a new option to write back specific information from the parallel processes. One possible use case for this new feature is to set up different Operation Scenarios using the parallel computation. Instead of transferring the entire sub-processes back, which might take some time for large projects, there is now the option of only transferring certain information back, e.g. the Operation Scenarios.

# 6 Interfaces and Converters

## 6.1 CIM CGMES Converter

### 6.1.1 CGMES 3.0 Conformity Assessment

Work is now ongoing to achieve conformity for CGMES 3.0 for *PowerFactory 2024*. The confirmation of conformity is expected in the next few months.

### 6.1.2 LTDS CIM profile

In addition to supporting the CGMES profiles 2.4.15 and 3.0.0, *PowerFactory* now supports CIM import and export using a new LTDS profile. LTDS stands for “Long Term Development Statements”; these are statements that electricity distributions companies in Great Britain are required to publish, detailing the characteristics and development of their networks. A revision to this process means that there will be an additional requirement for network models to be published in CIM format, using a dedicated CIM profile known as LTDS. See also section 4.4.4 for related model changes.

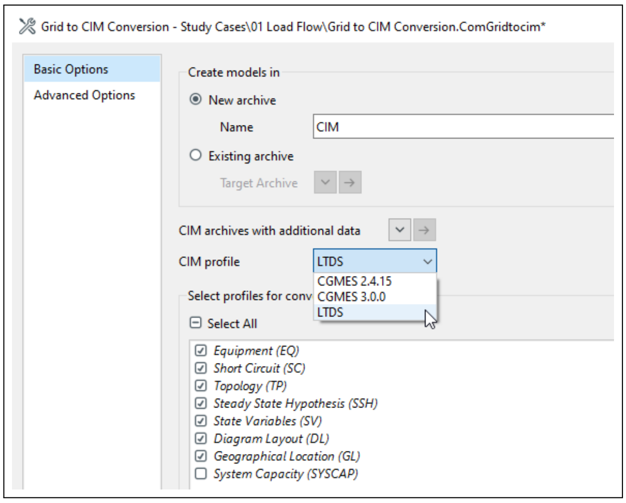



Figure 6.1: LTDS option for Grid to CIM Conversion

## 6.2 COMTRADE file exchange

*PowerFactory* can read and write COMTRADE (**Com**mon format for **Tra**nsient **D**ata **E**xchange for power systems) files in order to exchange data. Data are read into *PowerFactory* via *IntComtrade* and *ElmFile* objects, and written via the Export command *ComRes*. Previously, the 1999 version of the COMTRADE standard was supported, but now the 2013 version is also supported, and can be selected when exporting data.

## 6.3 ANAREDE/ANAFAS Converters

The ANAREDE and ANAFAS Import converters now support the import of diagrams (LST files). From these, single line diagrams are created in *PowerFactory*.

# ABOUT DIGSILENT

DIgSILENT was founded in 1985 and is a fully independent and privately owned company located in Gomaringen close to Stuttgart, Germany. DIgSILENT continued expansion by establishing offices in Australia, South Africa, Italy, Chile, Spain, France, the USA and Oman, thereby facilitating improved service following the world-wide increase in usage of its software products and services. DIgSILENT has established a strong partner network in many countries such as Mexico, Malaysia, UK, Colombia, Brazil, Peru, China and India. DIgSILENT services and software installations are used in more than 170 countries.

## POWERFACTORY

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

## STATIONWARE

StationWare is a central asset management system for primary and secondary equipment. In addition to handling locations and devices in a user-definable hierarchy, the system allows manufacturer-independent protection settings to be stored and managed in line with customer-specific workflows. It facilitates the management of a wide variety of business processes within a company and centralises the storage of documents. StationWare can be integrated seamlessly into an existing IT environment and the interface with PowerFactory enables the transfer of calculation-relevant data for protection studies.

## MONITORING SYSTEMS

Our Power System Monitoring PFM300 product line features grid and plant supervision, fault recording, and power quality and grid characteristics analysis. The Grid Code Compliance Monitoring PFM300-GCC system also offers compliance auditing of power plants with respect to grid code requirements. This monitoring and non-compliance detection provides the complete transparency and assurance required by both plant operators and utilities.

## TESTING AND CERTIFICATION

The DIN EN ISO/IEC 17025 accredited DIgSILENT Test Laboratory for NAR Conformity carries out measurements in accordance with FGW TR3 on the operational type 1 generation plant (directly coupled synchronous machines). These measurements are carried out in accordance with the "individual verification procedure" as required by the German grid connection guidelines VDE-AR-N 4110/20/30. DIgSILENT has many years of international expertise in the field of generation and consumption/ load systems testing. The in-house developed and produced measuring systems enable the testing laboratory to offer customised measuring solutions for a wide range of power plants and applications.

## SERVICES

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

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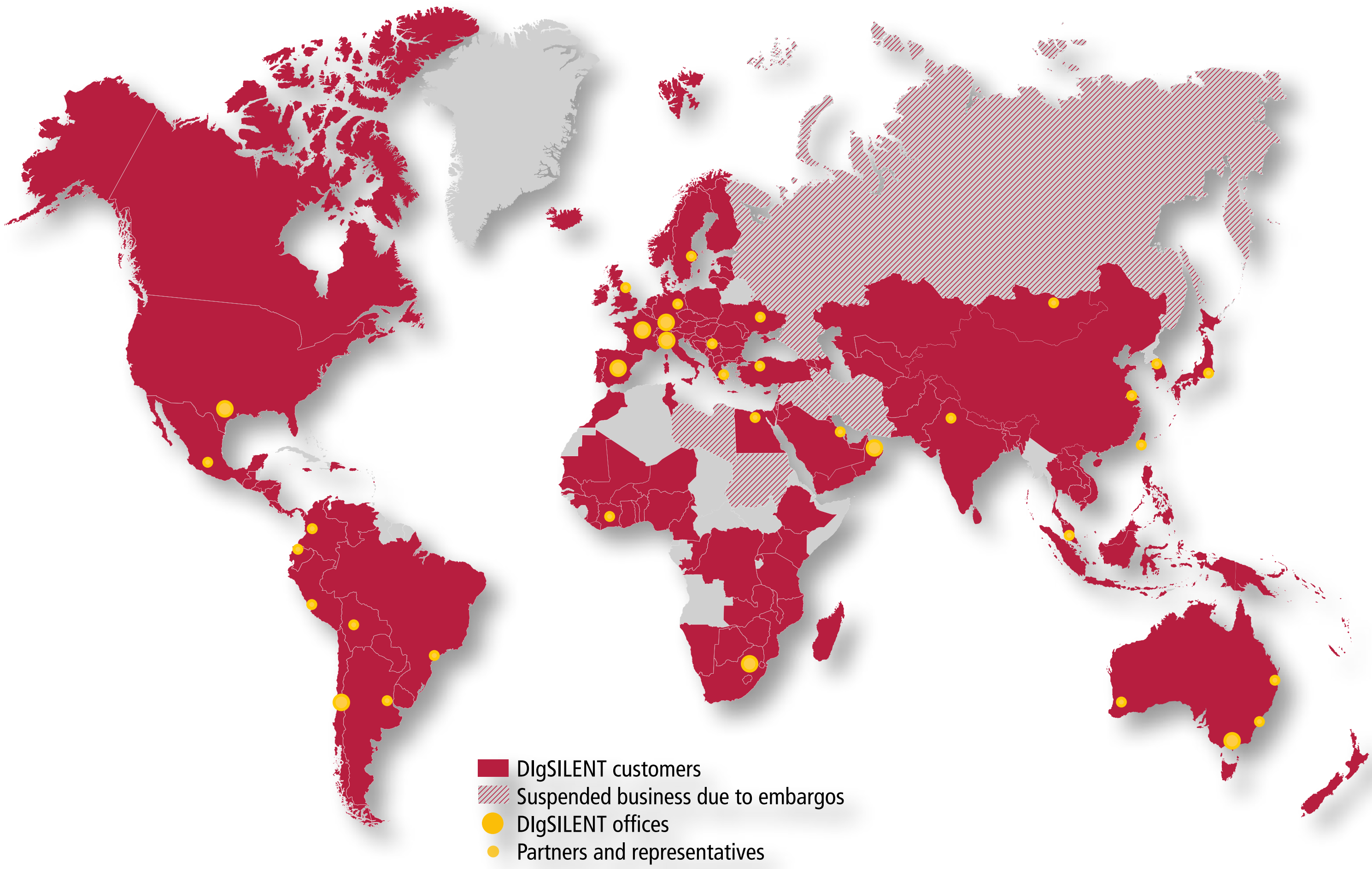


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