POWERFACTORY

PowerFactory 2022

OPC Data Access (DA) Guide

PF2022

POWER SYSTEM SOLUTIONS
MADE IN GERMANY

Publisher:
DIgSILENT GmbH
Heinrich-Hertz-Straße 9
72810 Gomaringen / Germany
Tel.: +49 (0) 7072-9168-0
Fax: +49 (0) 7072-9168-88
info@digsilent.de

Please visit our homepage at:
`https://www.digsilent.de`

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Contents

1 Preliminaries

This document demonstrates the ability of *DIgSILENT* ***PowerFactory*** to exchange operational data with an OPC[1] DA[2] server.

The first part of this document guides through the example provided with this document. This will give an impression on how ***PowerFactory*** collaborates with an OPC server.

The second part describes some details about the configuration and how ***PowerFactory*** is set up to associate data with OPC items.

2 OPC Example

2.1 Requirements

For reproducing the provided example, the following software must be installed on your computer:

- DIgSILENT ***PowerFactory*** V14.0 Build 515 or newer
- MatrikonOPC Server for Simulation V1.2.4 or newer
- MatrikonOPC Explorer (part of Simulation Server installation package)
- for x64 systems OPC Core Components Redistributable

"MatrikonOPC Server for Simulation" is freeware and can be downloaded from Matrikon's website[3]. It is recommended to use default options for installation.

If running on a 64bit system (x64), the "OPC Core Components" from OPC foundation needs to be installed in addition. They can be downloaded from the OPC foundation website[4] for free. (Not required for 32bit systems).

Additionally, on Microsoft Windows XP SP2, some DCOM settings must be changed. Please refer to the instructions provided in "Using OPC via DCOM with Microsoft Windows XP Service Pack 2"[5].

For Microsoft Windows Vista users, please apply the DCOM settings as required for XP SP2. According to our experiences, after installation, a re-registration of the OPC server is required. Please open a command prompt with administrator privileges (*cmd.exe*) and execute the following statements (path to OPC executables might be different):

```
C:/Program Files/Matrikon/OPC/Simulation/OPCSim --unregserver
C:/Program Files/Matrikon/OPC/Simulation/OPCSim --regserver
C:/Program Files/Matrikon/OPC/Simulation/OPCSim --service
```

[1] OPC = Open Platform Communication

[2] DA = Data Access

[3] Matrikon's download area can be found at `http://www.matrikonopc.com/downloads`

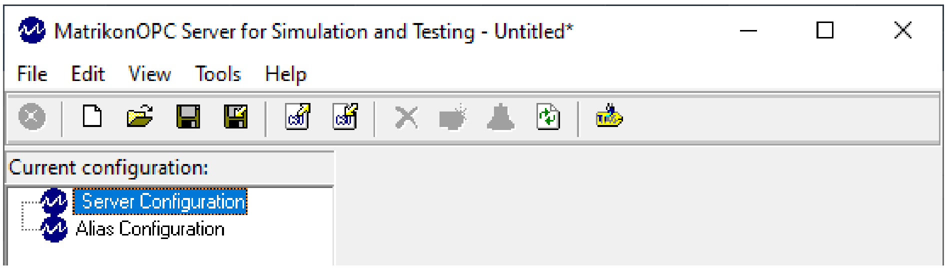
[4] "OPC Core Components 3.00 Redistributable (x64)" are available at the OPC foundation site `https://opcfoundation.org/developer-tools/samples-and-tools-classic/core-components/`

[5] Document can be downloaded from `http://www.matrikonopc.com/downloads/types/whitepapers/index.aspx`

2.2 OPC Server Setup

1. Start MatrikonOPC Server for Simulation (via group “MatrikonOPC/Simulation[6]” from Windows start menu).

   New versions of the server come up with a small control panel window. Please click *configure* there to get to the configuration dialog. (Alternatively, chose *configure* from context menu of the traybar icon.) Older versions of the server automatically open that configure page on application start-up.



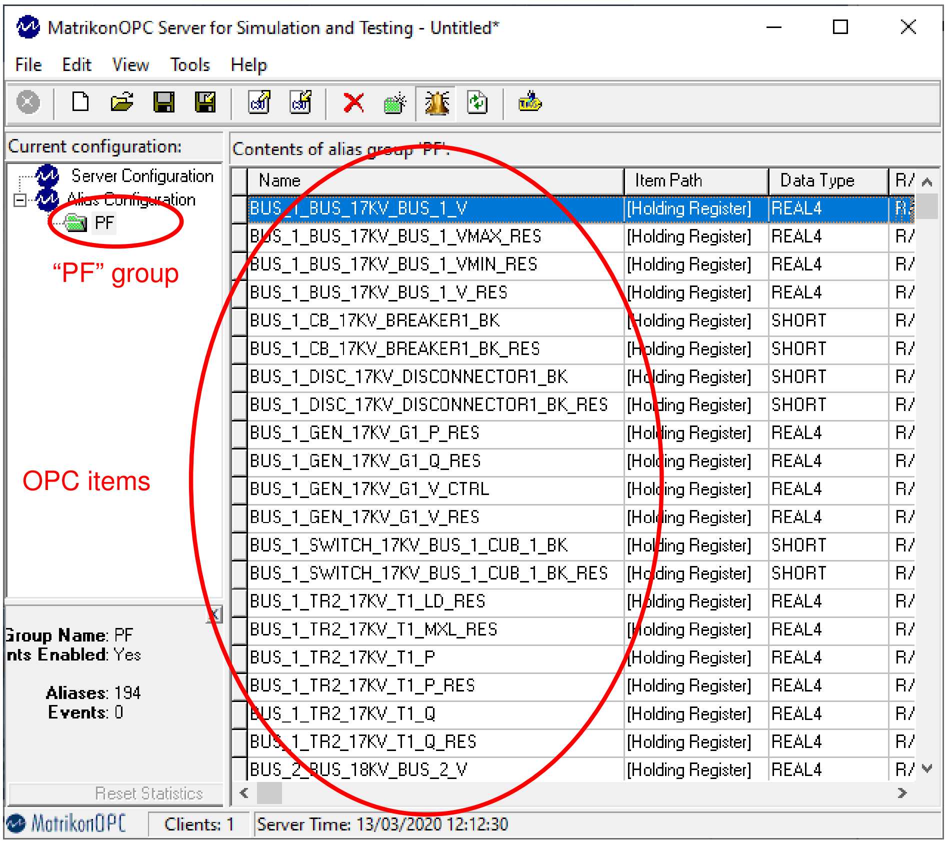
MatrikonOPC Server for Simulation and Testing - Untitled*

Current configuration:

- Server Configuration
- Alias Configuration

2. Import the pre-configured OPC tags from csv file:
   - Select Menu *File* → *Import Aliases...*
   - Choose csv file “OPCServerCfg.csv” (Note: The file must be located on a local drive, the import will produce a general error if importing from a network path or from a virtual drive.)

3. The application window should now show an alias group “PF” containing OPC tag items.



MatrikonOPC Server for Simulation and Testing - Untitled*

Current configuration:

- Server Configuration
- Alias Configuration
  - PF

Contents of alias group 'PF':

Name	Item Path	Data Type	R/
BUS_1_BUS_17KV_BUS_1_V	[Holding Register]	REAL4	R/
BUS_1_BUS_17KV_BUS_1_VMAX_RES	[Holding Register]	REAL4	R/
BUS_1_BUS_17KV_BUS_1_VMIN_RES	[Holding Register]	REAL4	R/
BUS_1_BUS_17KV_BUS_1_V_RES	[Holding Register]	REAL4	R/
BUS_1_CB_17KV_BREAKER1_BK	[Holding Register]	SHORT	R/
BUS_1_CB_17KV_BREAKER1_BK_RES	[Holding Register]	SHORT	R/
BUS_1_DISC_17KV_DISCONNECTOR1_BK	[Holding Register]	SHORT	R/
BUS_1_DISC_17KV_DISCONNECTOR1_BK_RES	[Holding Register]	SHORT	R/
BUS_1_GEN_17KV_G1_P_RES	[Holding Register]	REAL4	R/
BUS_1_GEN_17KV_G1_Q_RES	[Holding Register]	REAL4	R/
BUS_1_GEN_17KV_G1_V_CTRL	[Holding Register]	REAL4	R/
BUS_1_GEN_17KV_G1_V_RES	[Holding Register]	REAL4	R/
BUS_1_SWITCH_17KV_BUS_1_CUB_1_BK	[Holding Register]	SHORT	R/
BUS_1_SWITCH_17KV_BUS_1_CUB_1_BK_RES	[Holding Register]	SHORT	R/
BUS_1_TR2_17KV_T1_LD_RES	[Holding Register]	REAL4	R/
BUS_1_TR2_17KV_T1_MXL_RES	[Holding Register]	REAL4	R/
BUS_1_TR2_17KV_T1_P	[Holding Register]	REAL4	R/
BUS_1_TR2_17KV_T1_P_RES	[Holding Register]	REAL4	R/
BUS_1_TR2_17KV_T1_Q	[Holding Register]	REAL4	R/
BUS_1_TR2_17KV_T1_Q_RES	[Holding Register]	REAL4	R/
BUS_2_BUS_18KV_BUS_2_V	[Holding Register]	REAL4	R/

Group Name: PF
nts Enabled: Yes

Aliases: 194
Events: 0

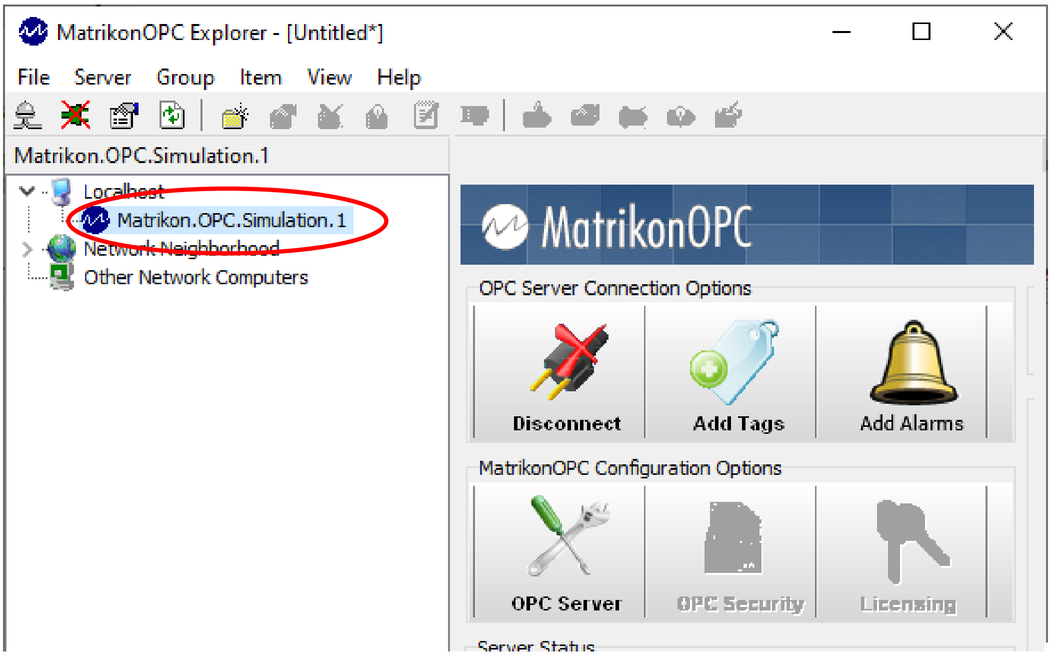
MatrikonOPC Clients: 1 Server Time: 13/03/2020 12:12:30

[6] This name is used in default installation

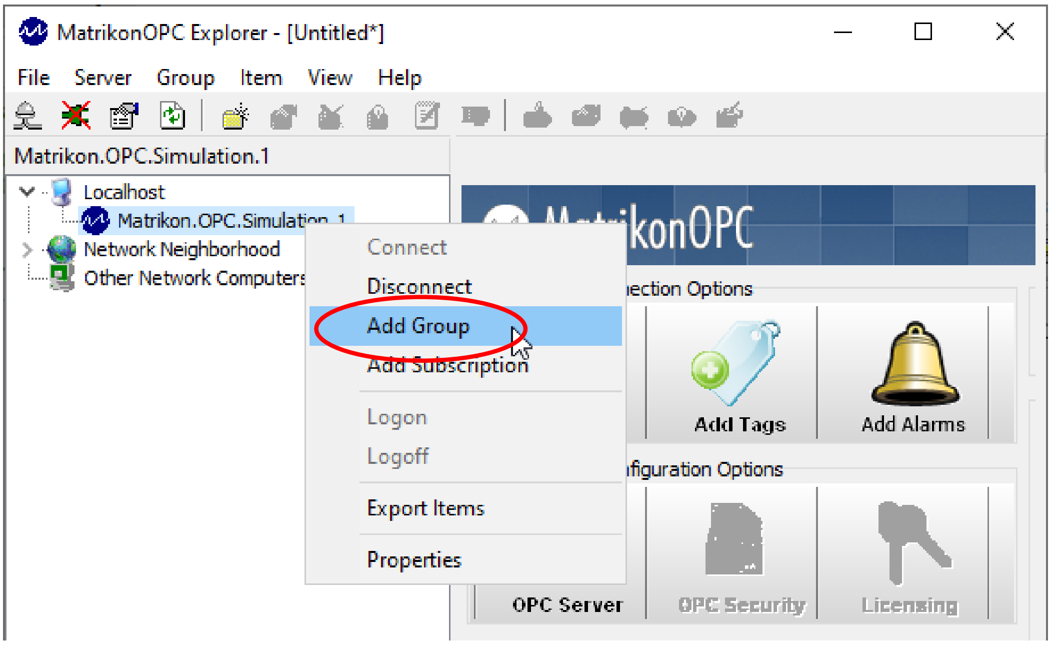
2.3 Exploring OPC items

The MatrikonOPC Server for Simulation comes with an OPC explorer that allows displaying and changing the values of OPC items.

1. Start the *MatrikonOPC Explorer* from Windows start menu.
2. On the left side of the explorer window, a list of available OPC servers is displayed. After expanding the entry “localhost”, the running MatrikonOPC server should be listed as “Matrikon.OPC.Simulation.1”.


MatrikonOPC Explorer - [Untitled*]
File Server Group Item View Help
Matrikon.OPC.Simulation.1
Localhost
Matrikon.OPC.Simulation.1
Network Neighborhood
Other Network Computers
MatrikonOPC
OPC Server Connection Options
Disconnect
Add Tags
Add Alarms
MatrikonOPC Configuration Options
OPC Server
OPC Security
Licensing
Server Status

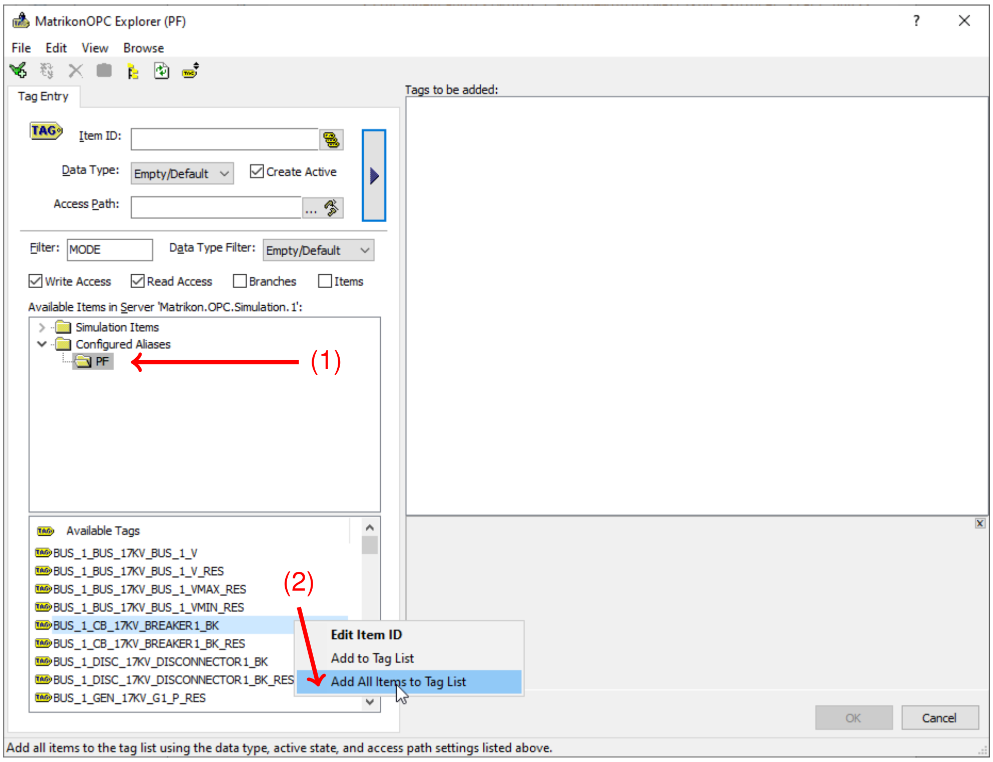
3. Double click the item “Matrikon.OPC.Simulation.1” to establish a connection to the server. The icon will change to a blue Matrikon icon.
4. Add a group where the OPC items can be added to. Right click the connected server and select *Add Group*. The name of the group is not important and can be set to *PF*. Leave other settings as default.



5. Subscribe to all available OPC items by right clicking the newly created group and selecting *Add Items* from the context menu.

   A new dialog will be opened.

   - First select the server group *PF* in (1) (by left mouse click).
   - Then right click in the list (2) and select *Add All Items To Tag List* from context menu.
   - Close the dialog by *OK* or in the menu *File* → *Update and return*



Data Type: Empty/Default ☑ Create Active

Filter: MODE Data Type Filter: Empty/Default

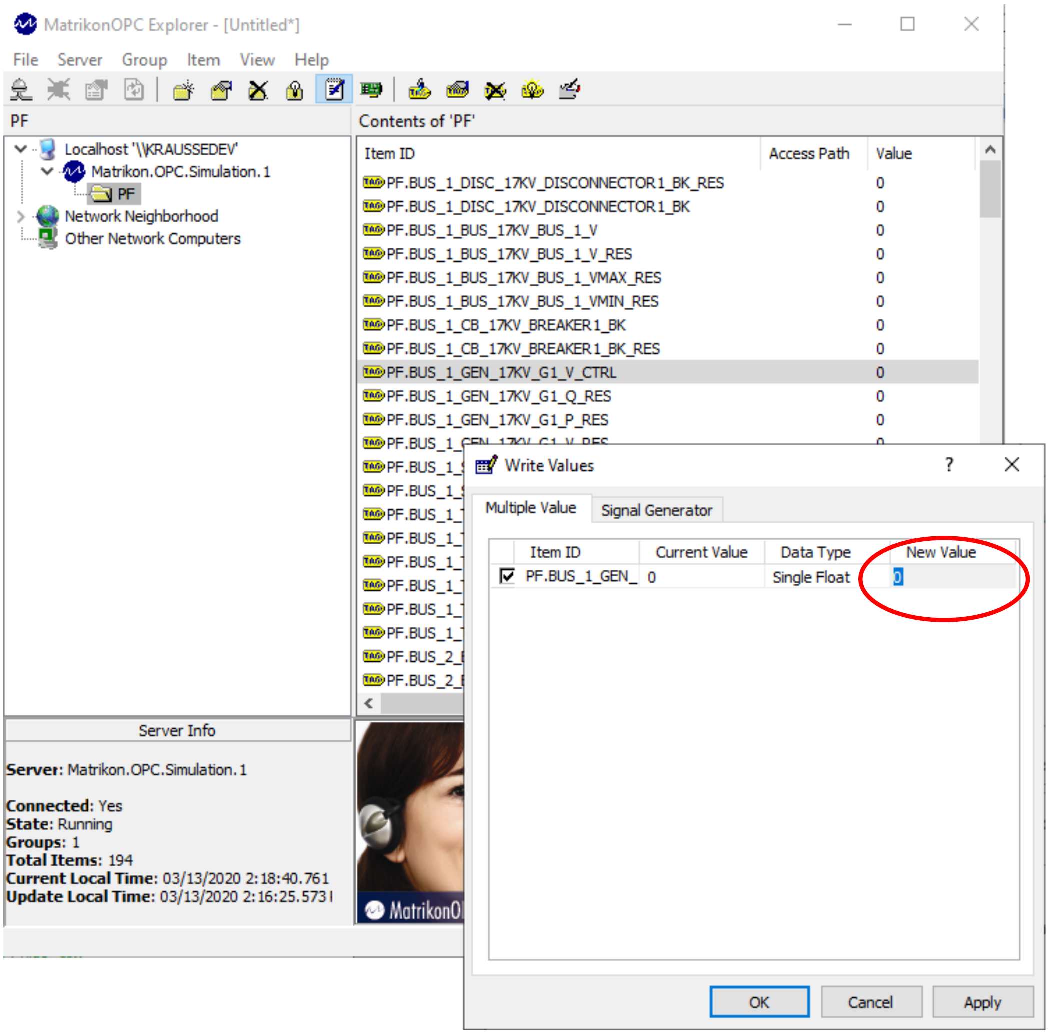
☑ Write Access ☑ Read Access □ Branches □ Items

BUS_1_BUS_17KV_BUS_1_V
BUS_1_BUS_17KV_BUS_1_V_RES
BUS_1_BUS_17KV_BUS_1_VMAX_RES
BUS_1_BUS_17KV_BUS_1_VMIN_RES
BUS_1_CB_17KV_BREAKER1_BK
BUS_1_CB_17KV_BREAKER1_BK_RES
BUS_1_DISC_17KV_DISCONNECTOR1_BK
BUS_1_DISC_17KV_DISCONNECTOR1_BK_RES
BUS_1_GEN_17KV_G1_P_RES

Add all items to the tag list using the data type, active state, and access path settings listed above.

6. All available items are now displayed in the explorer's main window. In the column *Value*, the actual value for each item can be seen.

7. To change any value manually, select *Write Values* from the context menu of an item. By changing the value and pressing *Apply* or *OK*, the new value is sent to the OPC server and propagated to all clients.



Item ID	Access Path	Value
PF.BUS_1_DISC_17KV_DISCONNECTOR1_BK_RES		0
PF.BUS_1_DISC_17KV_DISCONNECTOR1_BK		0
PF.BUS_1_BUS_17KV_BUS_1_V		0
PF.BUS_1_BUS_17KV_BUS_1_V_RES		0
PF.BUS_1_BUS_17KV_BUS_1_VMAX_RES		0
PF.BUS_1_BUS_17KV_BUS_1_VMIN_RES		0
PF.BUS_1_CB_17KV_BREAKER1_BK		0
PF.BUS_1_CB_17KV_BREAKER1_BK_RES		0
PF.BUS_1_GEN_17KV_G1_V_CTRL		0
PF.BUS_1_GEN_17KV_G1_Q_RES		0
PF.BUS_1_GEN_17KV_G1_P_RES		0

Server: Matrikon.OPC.Simulation.1

Connected: Yes
State: Running
Groups: 1
Total Items: 194
Current Local Time: 03/13/2020 2:18:40.761
Update Local Time: 03/13/2020 2:16:25.573

	Item ID	Current Value	Data Type	New Value
☑	PF.BUS_1_GEN_	0	Single Float	0

2.3.1 Naming Convention

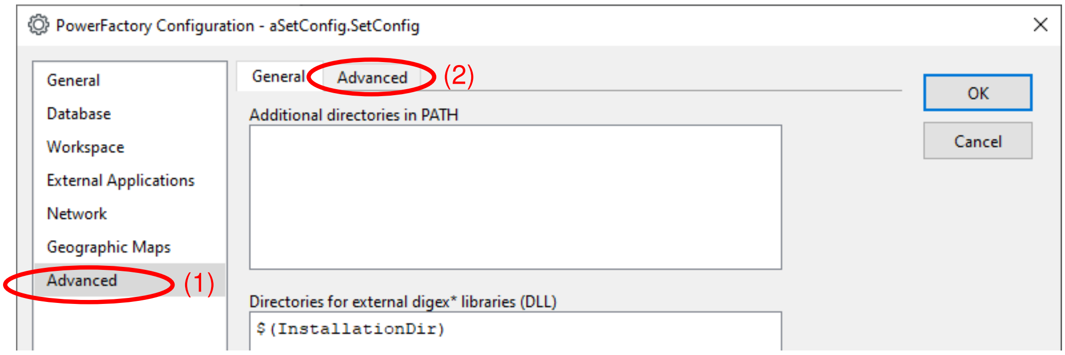
In the ***PowerFactory*** example, each OPC item is only used either for input or output. This is incorporated in the following naming convention used for OPC items:

- IDs ending with "_RES" are used to display results. These values are outputs of ***PowerFactory***.
  For example, the item "BUS_1_GEN_17KV_G1_V_RES" holds the voltage, "BUS_1_GEN_17KV_G1_P_RES" the active power, "BUS_1_GEN_17KV_G1_Q_RES" the reactive power of generator 1.
- IDs ending with "_CTRL" are used for controlling. These items are inputs of ***PowerFactory***. For example, by increasing the value of item "BUS_4_TR2_T1_TAP_CTRL" by "1", the tap setting on transformer T1 will also be increased by "1".
- All other items are used as input for ***PowerFactory*** .

2.4 *PowerFactory* Configuration

Now, that the OPC server is configured, please set up ***PowerFactory*** to connect to this server.

1. Start ***PowerFactory*** from Windows start menu, program group *PowerFactory...*
2. If required, log in with your ***PowerFactory*** user name and password
3. From main menu, select *Tools* → *Configuration...* to open the configuration dialog. At the configuration dialog, please first switch to tab *Advanced*. Then click on the *Advanced* tab to switch to the second page of the advanced settings.

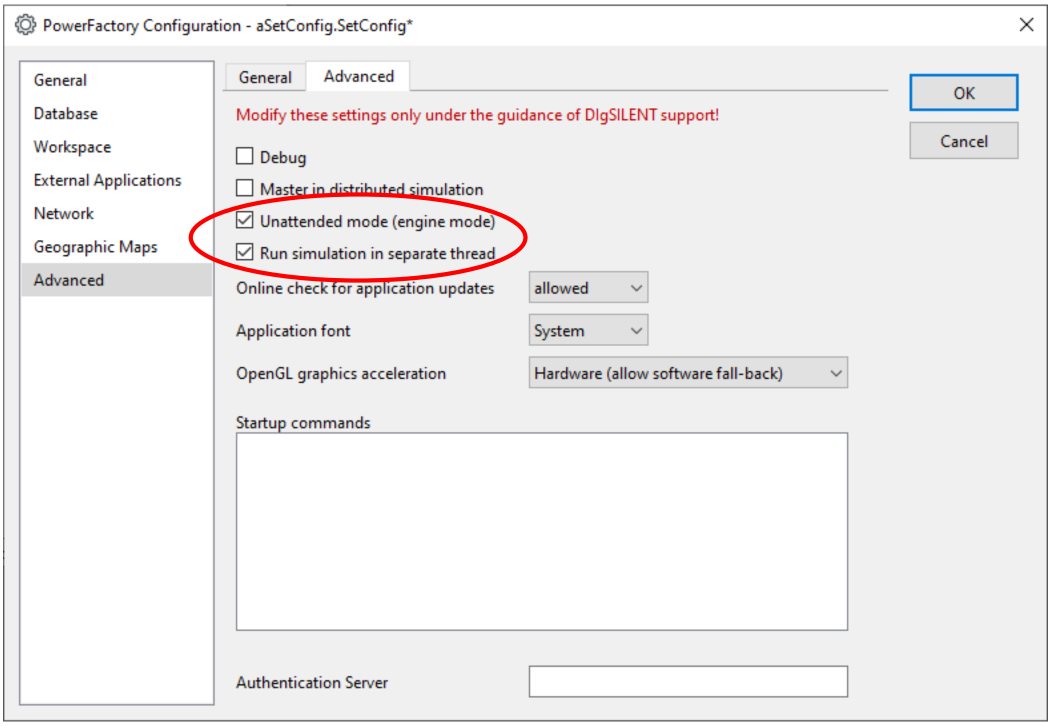


Additional directories in PATH

Directories for external digex* libraries (DLL)

`$(InstallationDir)`

4. On this page, please select the options *unattended mode* and *run simulation in separate thread* (both options are required for the OPC link to work):



Modify these settings only under the guidance of DIgSILENT support!

☐ Debug
☐ Master in distributed simulation
☑ Unattended mode (engine mode)
☑ Run simulation in separate thread

Online check for application updates: allowed
Application font: System
OpenGL graphics acceleration: Hardware (allow software fall-back)

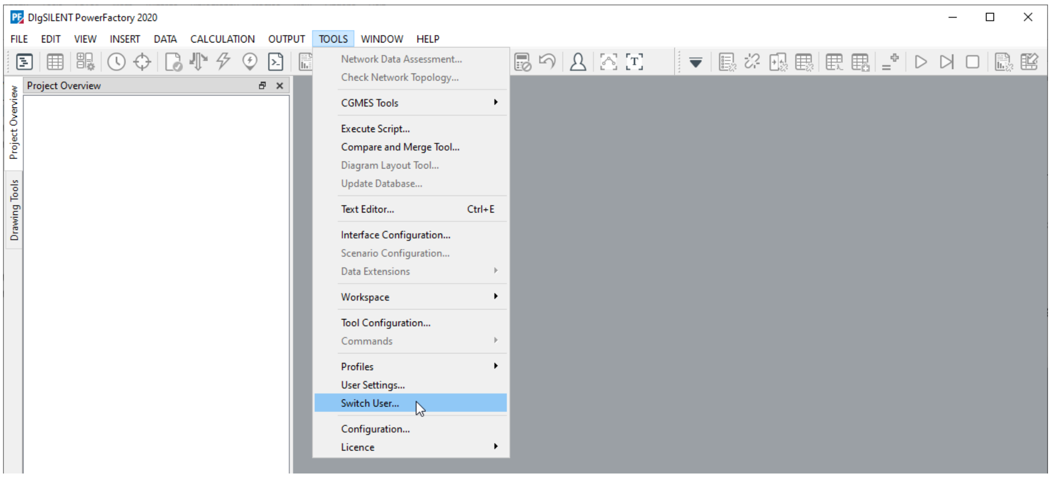
Startup commands

Authentication Server

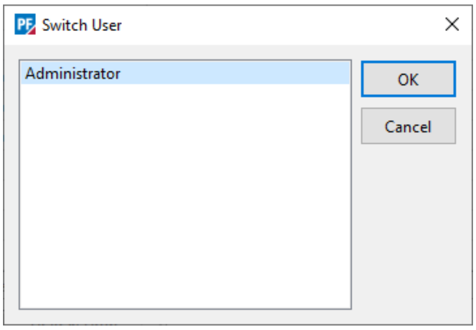
5. Close the configuration dialog by pressing *OK* to save the configuration. Please follow the dialogs to restart ***PowerFactory*** .

The next step is to enable the OPC license for the current user. This must be done in the role of the data base administrator.

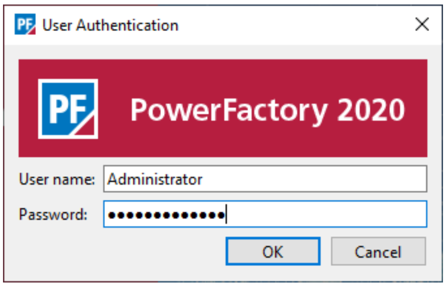
6. When ***PowerFactory*** restarts, log in as “Administrator”. If you are already logged in, then switch user by selecting in the main menu *Tools* → *Switch user*.



7. Select in the shown user list the built-in user “Administrator” and press *OK* to restart ***PowerFactory*** .

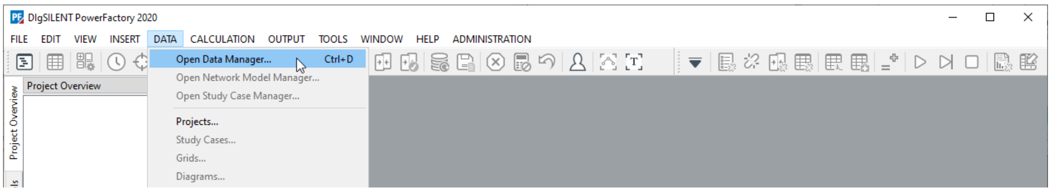


8. Login as “Administrator” and enter its password (the default password is “Administrator”).

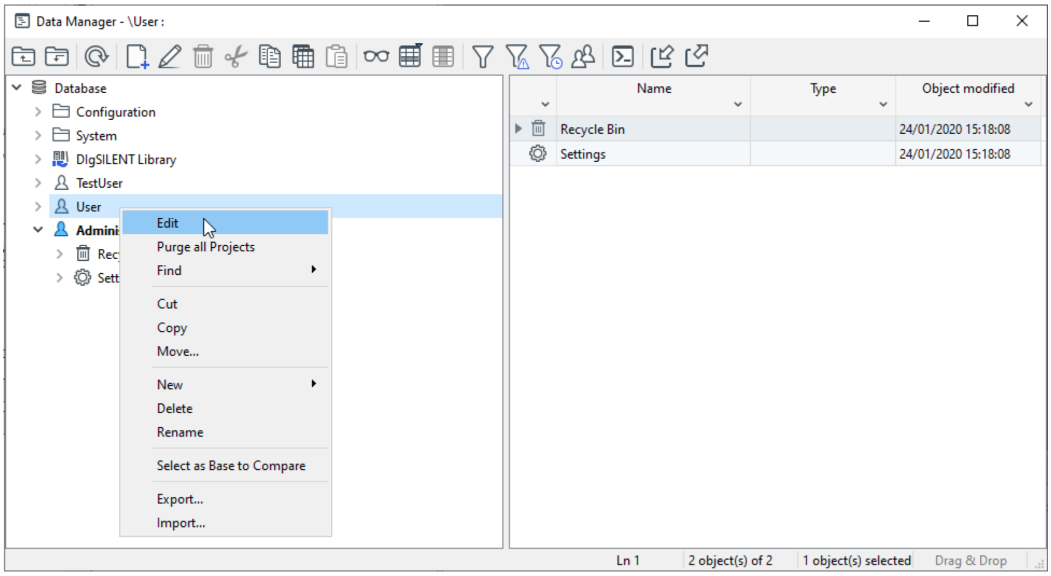


User name: Administrator
Password: •••••••••••••

9. Open the “Data Manager” by selecting *Data* → *Open Data Manager...* in the main menu.

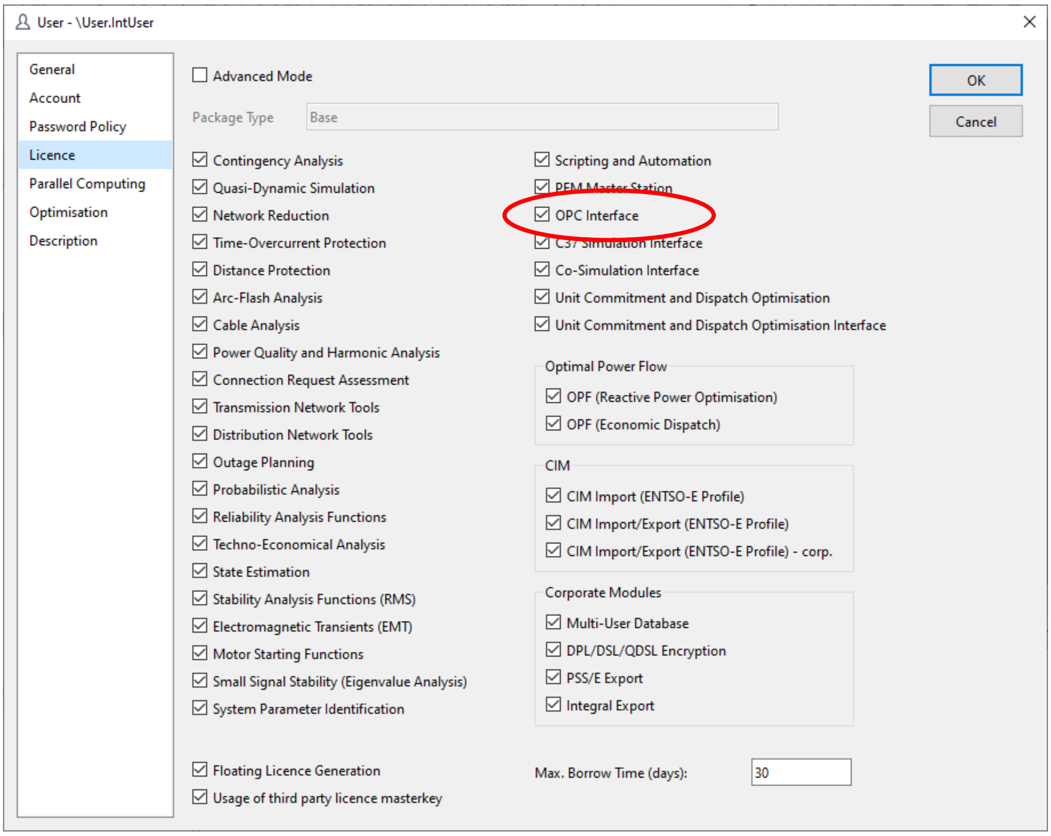

DIgSILENT PowerFactory 2020
FILE EDIT VIEW INSERT DATA CALCULATION OUTPUT TOOLS WINDOW HELP ADMINISTRATION
Open Data Manager... Ctrl+D
Open Network Model Manager...
Open Study Case Manager...
Projects...
Study Cases...
Grids...
Diagrams...
Project Overview

10. Right-click on your user account (e.g. “User”) in the left side of the “Data Manager” and select *Edit* in the context menu.



Name	Type	Object modified
Recycle Bin		24/01/2020 15:18:08
Settings		24/01/2020 15:18:08

11. Select “Licence” on the left side to edit the access privileges of that user. Depending on your licence there are different components, which you can enable or disable for that user. Enable the “OPC Interface” and press *OK* to confirm the change.



□ Advanced Mode

Package Type: Base

☑ Contingency Analysis
☑ Quasi-Dynamic Simulation
☑ Network Reduction
☑ Time-Overcurrent Protection
☑ Distance Protection
☑ Arc-Flash Analysis
☑ Cable Analysis
☑ Power Quality and Harmonic Analysis
☑ Connection Request Assessment
☑ Transmission Network Tools
☑ Distribution Network Tools
☑ Outage Planning
☑ Probabilistic Analysis
☑ Reliability Analysis Functions
☑ Techno-Economical Analysis
☑ State Estimation
☑ Stability Analysis Functions (RMS)
☑ Electromagnetic Transients (EMT)
☑ Motor Starting Functions
☑ Small Signal Stability (Eigenvalue Analysis)
☑ System Parameter Identification

☑ Scripting and Automation
☑ PFM Master Station
☑ OPC Interface
☑ C37 Simulation Interface
☑ Co-Simulation Interface
☑ Unit Commitment and Dispatch Optimisation
☑ Unit Commitment and Dispatch Optimisation Interface

Optimal Power Flow
☑ OPF (Reactive Power Optimisation)
☑ OPF (Economic Dispatch)

CIM
☑ CIM Import (ENTSO-E Profile)
☑ CIM Import/Export (ENTSO-E Profile)
☑ CIM Import/Export (ENTSO-E Profile) - corp.

Corporate Modules
☑ Multi-User Database
☑ DPL/DSL/QDSL Encryption
☑ PSS/E Export
☑ Integral Export

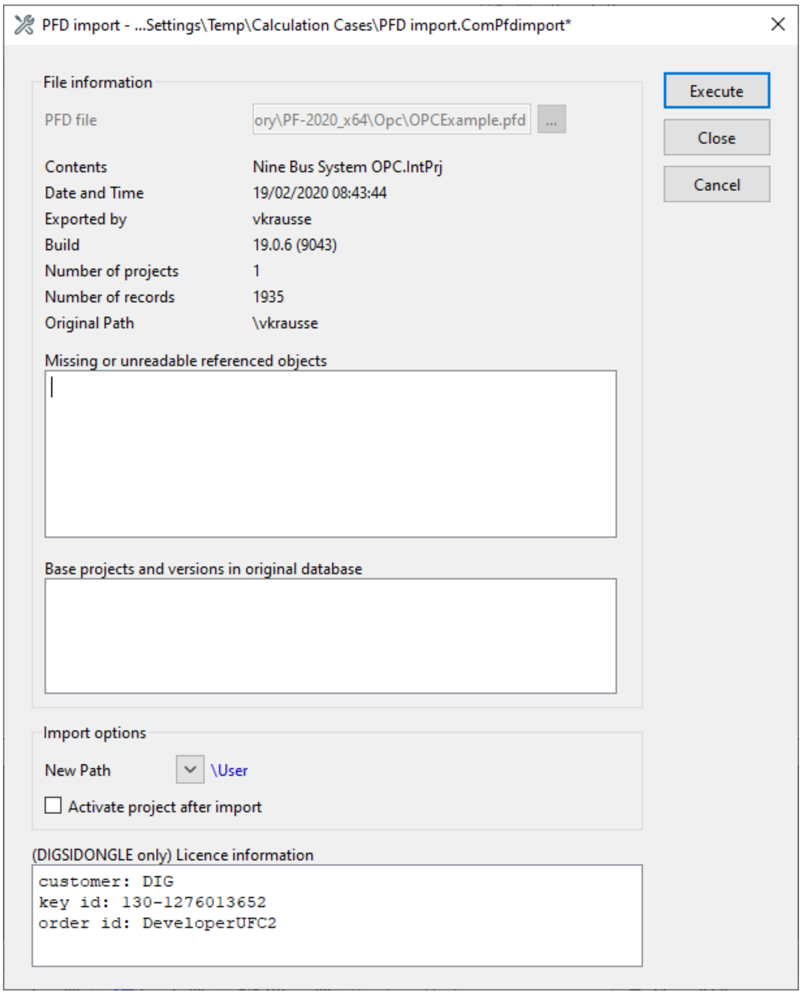
☑ Floating Licence Generation
☑ Usage of third party licence masterkey

Max. Borrow Time (days): 30

12. Please restart ***PowerFactory*** and login with your user account.

The next step is to import the provided OPC example network:

13. Select *File* → *Import*→ *Data (*.pfd;*.dz)...* from the main menu and select the provided ***PowerFactory*** project file “OPCExample.pfd”.
14. A dialog appears showing file information and the target path where to import the project. Leave everything as proposed and press *OK*. The project will now be imported.



PFD import - ...Settings\Temp\Calculation Cases\PFD import.ComPfdimport*

File information

PFD file: ory\PF-2020_x64\Opc\OPCExample.pfd

Contents	Nine Bus System OPC.IntPrj
Date and Time	19/02/2020 08:43:44
Exported by	vkrausse
Build	19.0.6 (9043)
Number of projects	1
Number of records	1935
Original Path	\vkrausse

Missing or unreadable referenced objects

Base projects and versions in original database

Import options

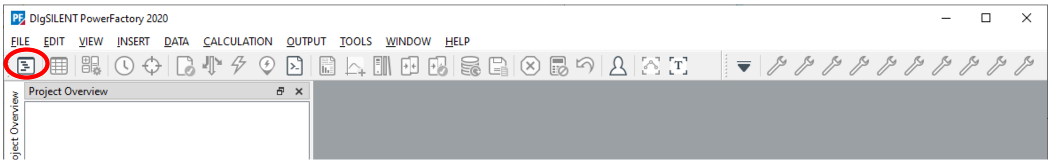
New Path \User

□ Activate project after import

(DIGSIDONGLE only) Licence information

```
customer: DIG
key id: 130-1276013652
order id: DeveloperUFC2
```

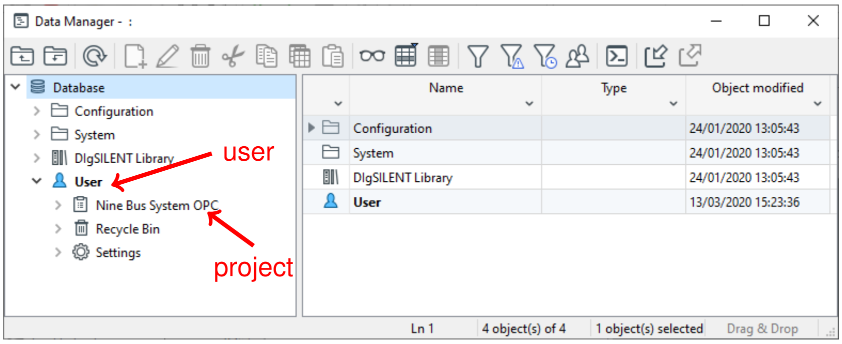
15. To activate this newly imported project, open a new “Data Manager” by clicking on the data manager icon:



DIgSILENT PowerFactory 2020
FILE EDIT VIEW INSERT DATA CALCULATION OUTPUT TOOLS WINDOW HELP
Project Overview
oject Overview

(Alternatively, a new data manager can also be created by the menu entry *Data* → *Open Data Manager....*)

A new Data Manager window will appear. On the left side, a tree hierarchy is displayed, showing the user accounts and their projects.
Navigate to your user name and expand the tree item. There, you should see your imported project called “Nine Bus System OPC”.



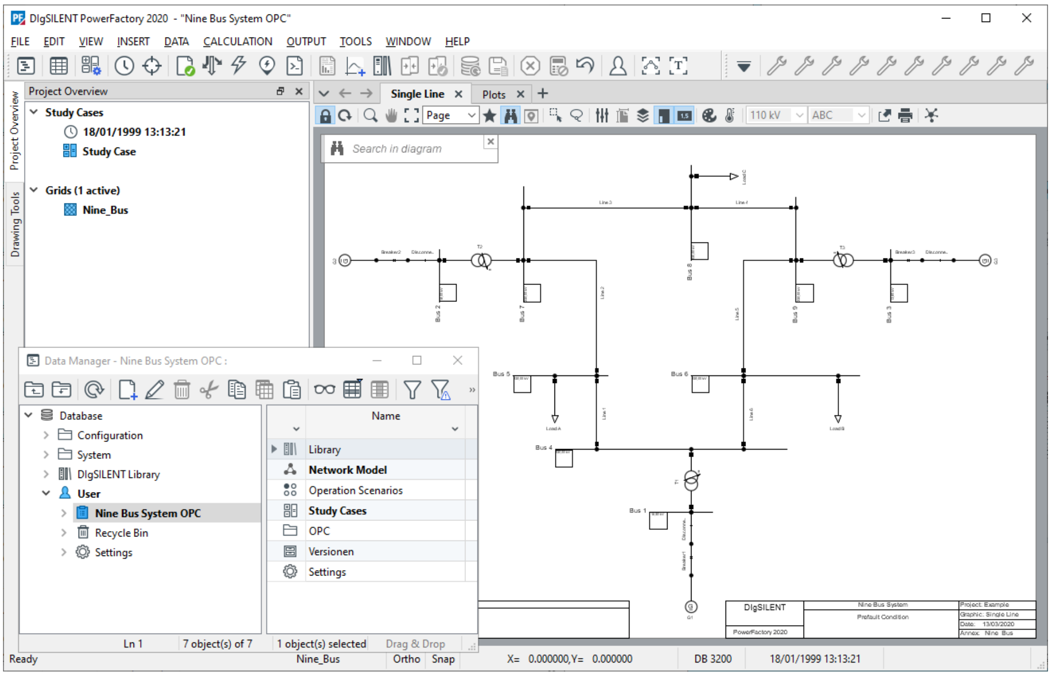
Data Manager - :

- Database
  - Configuration
  - System
  - DIgSILENT Library
  - User
    - Nine Bus System OPC
    - Recycle Bin
    - Settings

Name	Type	Object modified
Configuration		24/01/2020 13:05:43
System		24/01/2020 13:05:43
DIgSILENT Library		24/01/2020 13:05:43
User		13/03/2020 15:23:36

Ln 1 | 4 object(s) of 4 | 1 object(s) selected | Drag & Drop

Right-click on the “Nine Bus System OPC” and select *Activate* from the context menu. The project will now be activated and a single line graphics will be opened.



DIgSILENT PowerFactory 2020 - "Nine Bus System OPC"

Project Overview

- Study Cases
  - 18/01/1999 13:13:21
  - Study Case
- Grids (1 active)
  - Nine_Bus

Data Manager - Nine Bus System OPC :

- Database
  - Configuration
  - System
  - DIgSILENT Library
  - User
    - Nine Bus System OPC
    - Recycle Bin
    - Settings

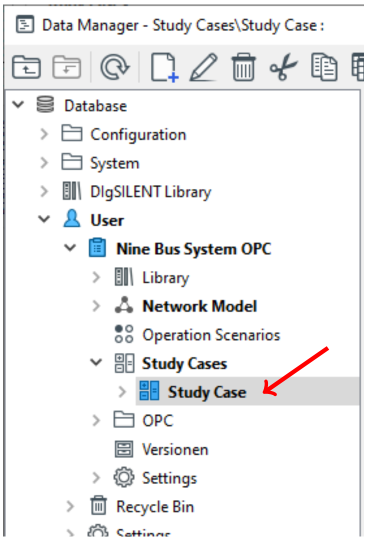
Name
Library
Network Model
Operation Scenarios
Study Cases
OPC
Versionen
Settings

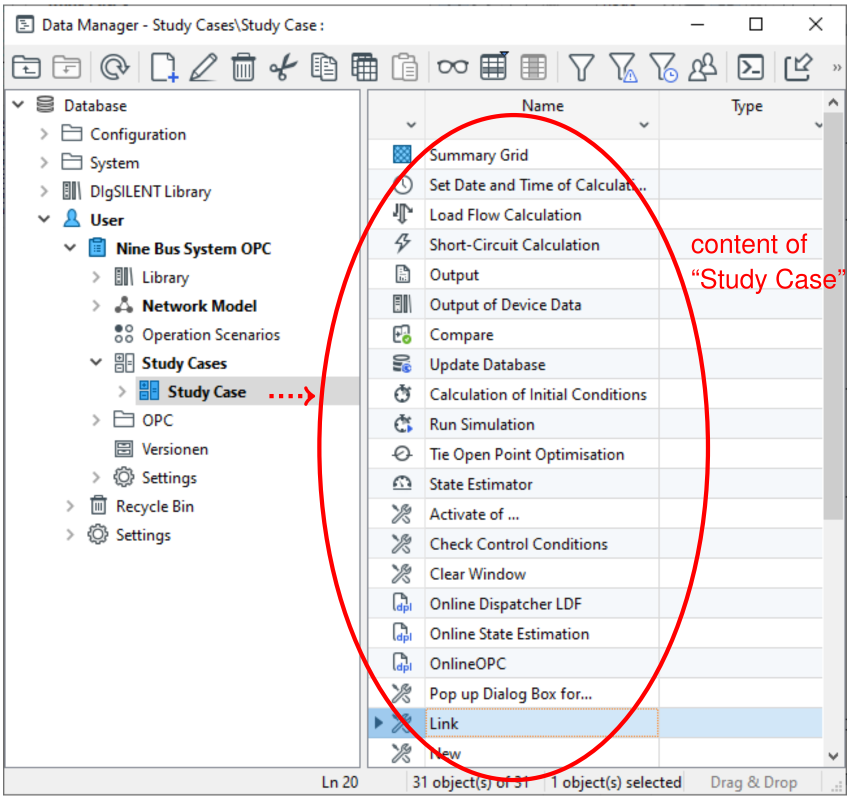
Ln 1 | 7 object(s) of 7 | 1 object(s) selected | Drag & Drop

Ready | Nine_Bus | Ortho | Snap | X= 0.000000,Y= 0.000000 | DB 3200 | 18/01/1999 13:13:21

The next step is to configure the OPC link:

16. In the Data Manager, select the folder “Study Cases” of the active project by a left mouse click. Then select the “Study Case” by a left click. This will show you the contents of “Study Case” on the right side of data manager.



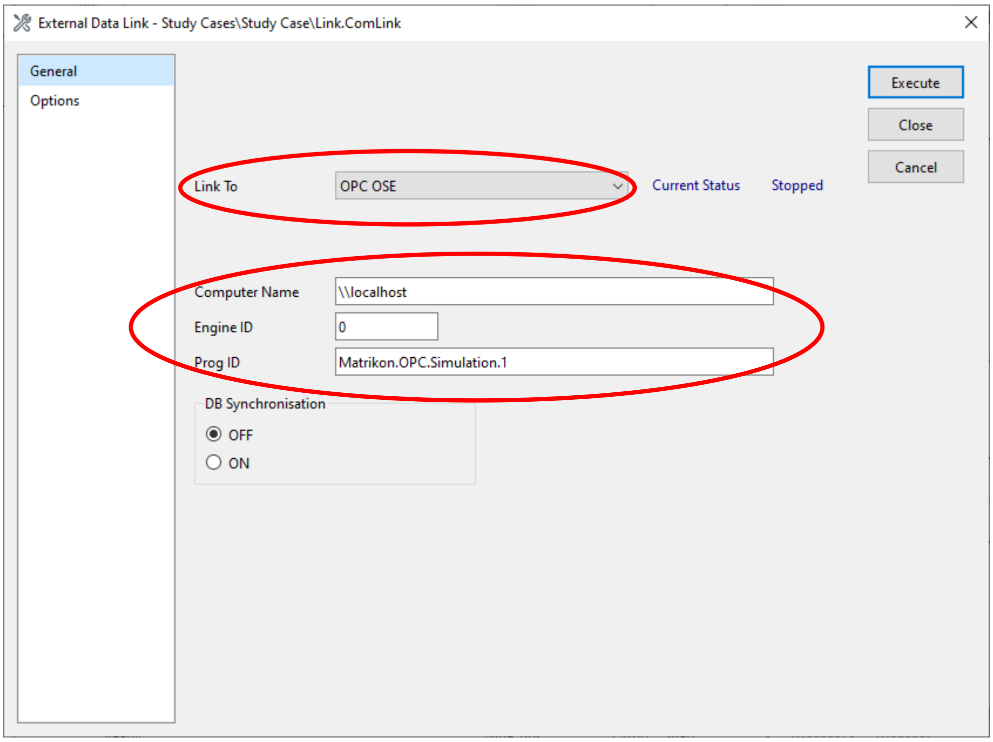


content of “Study Case”

17. Open the dialog sheet for the object named “Link” on the right side of the data manager by a double click. This “Link” object rules the communication with the external server.

18. Configure the link object as follows:

    - Link to: “OPC OSE”
      (there are three general OPC links: OPC Transnet, OPC OSE for Online State Estimation and OPC TDS for Time Domain Simulation)
    - Computer Name: “\\localhost”
      (the name of the computer where the Matrikon OPC server is running)
    - Prog ID: “Matrikon.OPC.Simulation.1”

    External Data Link - Study Cases\Study Case\Link.ComLink

    Link To: OPC OSE
    Current Status: Stopped
    Computer Name: \\localhost
    Engine ID: 0
    Prog ID: Matrikon.OPC.Simulation.1
    DB Synchronisation: ● OFF ○ ON

    For a first check, please press the *Execute* button, to see if the server settings are correct. This will establish a connection to OPC server but does not send or receive data.

19. On success, an info message will be printed to the output window containing the OPC server vendors name:

    ```
    Matrikon.OPC.Simulation.1
    Vendor 'Matrikon Inc +1-780-945-4011 http://www.matrikonopc.com'
    Initialisation done
    ```

20. Opening link’s dialog and pressing *Execute* again will terminate the connection to the OPC server.

Now the OPC link is configured and can be used to send and receive data. The example demonstrates two use cases:

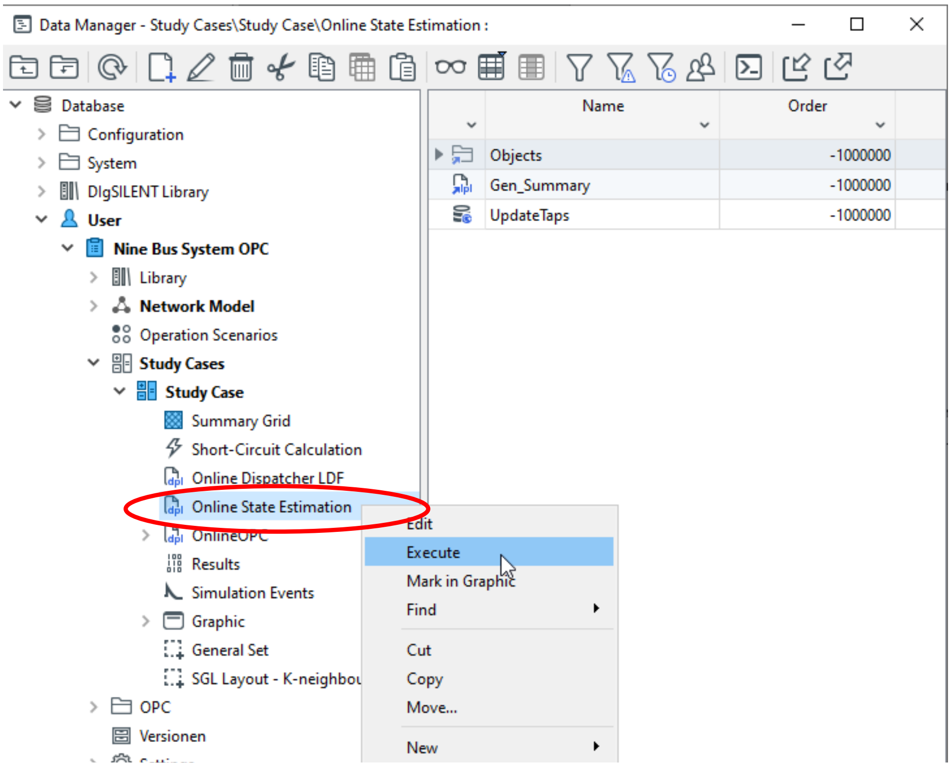
2.5 Online State Estimation and Dispatcher Load Flow

In this mode, data is read from the connected OPC server. Afterwards, a load flow calculation or state estimation is calculated and the results are sent back to the server.

The process of reading data from OPC, calculating results and sending data is done in a DPL[7] loop.

The example provides two DPL commands: “Online Dispatcher LDF” (doing load flow calculation) and “Online State Estimation” (doing state estimation). Both DPL commands are located in the “Study Case”.

Generally, to start one of these commands, first ensure that the link object is configured to use “OPC OSE” link. (Double click on object “Link” contained in “Study Case” and set “Link to” selection.) Afterwards, right click the desired script and select *Execute*. This will start the corresponding communication-calculation-loop.

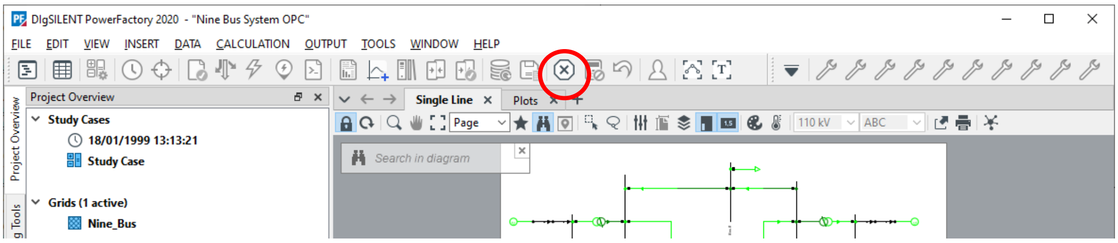


Data Manager - Study Cases\Study Case\Online State Estimation :

- Database
  - Configuration
  - System
  - DIgSILENT Library
  - User
    - Nine Bus System OPC
      - Library
      - Network Model
      - Operation Scenarios
      - Study Cases
        - Study Case
          - Summary Grid
          - Short-Circuit Calculation
          - Online Dispatcher LDF
          - Online State Estimation
          - OnlineOPC
          - Results
          - Simulation Events
          - Graphic
          - General Set
          - SGL Layout - K-neighbou
      - OPC
      - Versionen

Name	Order
Objects	-1000000
Gen_Summary	-1000000
UpdateTaps	-1000000

To stop this loop, press the DPL stop button (cross icon) in the main toolbar (see below).



DIgSILENT PowerFactory 2020 - "Nine Bus System OPC"

[7] DPL (*DIgSILENT* Programming Language) is ***PowerFactory*** ’s scripting language.

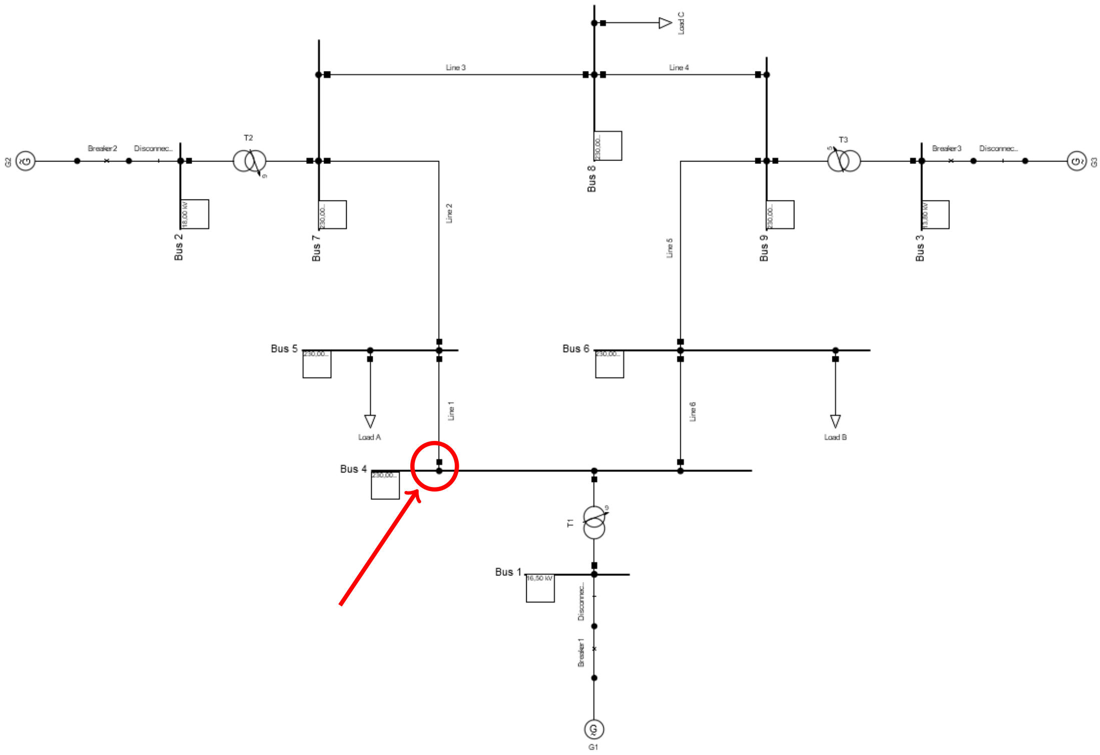
2.5.1 Online State Estimation

(Run DPL script “Online State Estimation”.)

Inputs:	active power measurements, reactive power measurement, voltage measurements, switch statuses, tap positions
Outputs:	resulting flow and voltage quantities

Note: OPC items of the measurements are all “0” in the example setup as not connected to SCADA system

Example 1: Changing the active power for a measurement point via OPC.



1. For marked cubicle in graphics above, the measured active power is read from an OPC item with tag id PF.BUS_4_LNE_230KV_LINE_1_P and the result of estimation is written into an item with tag id PF.BUS_4_LNE_230KV_LINE_1_P_RES.
2. When starting state estimation with provided default values, the estimated active power at this cubicle is about 40.20 MW. This value is set by ***PowerFactory*** into the OPC item with tag id PF.BUS_4_LNE_230KV_LINE_1_P_RES as it can be explored by “MatrikonOPC Explorer”.
3. Use “MatrikonOPC Explorer” to increase the measured value by changing the value of tag id PF.BUS_4_LNE_230KV_LINE_1_P to “40.5” (see chapter 2.3 on how to change a value of an OPC item.).
4. As you can see, the new value immediately effects ***PowerFactory*** ’s state estimation: The estimated power represented by tag id PF.BUS_4_LNE_230KV_LINE_1_P_RES will increase to about “40.37”.

Example 2: Bad measurement.

When provided enough redundant measurement points in a network, bad measurements will be detected and ignored by ***PowerFactory*** .

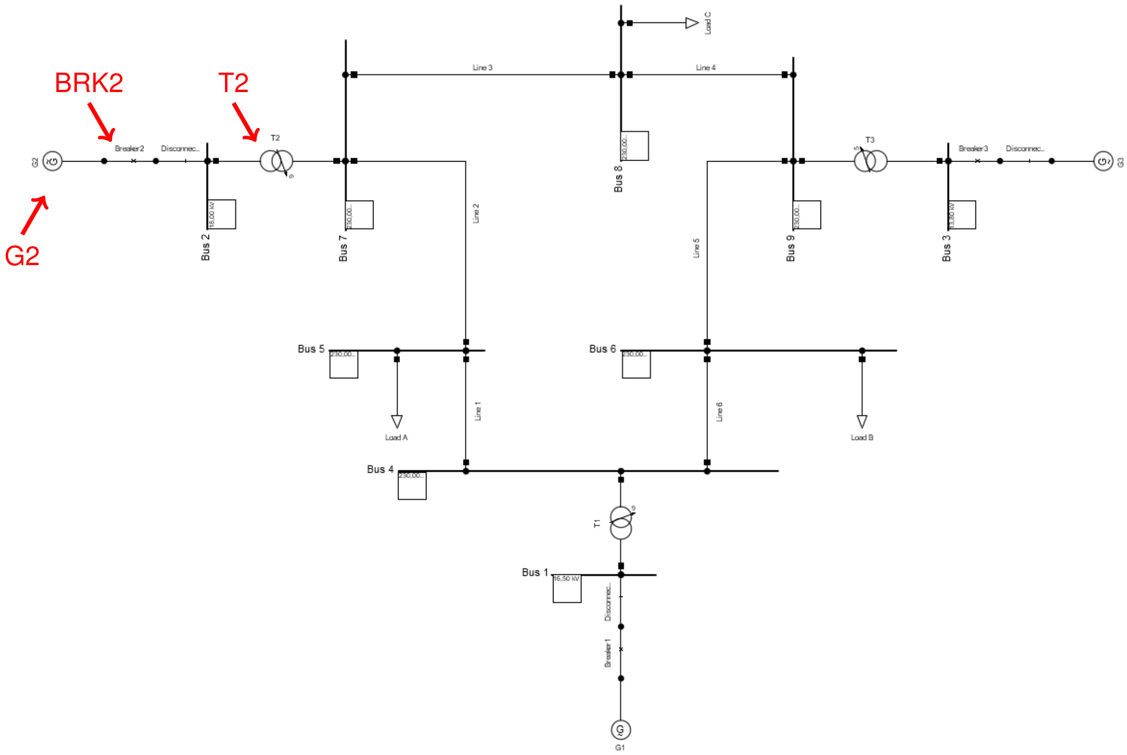
1. Use the same procedure as described in Example OSE1 to set the measurement of active power at considered cubicle to an unrealistic value of “55.0”.
2. ***PowerFactory*** will instantly detect this value as bad measurement and ignore it in state estimation. As you can see, the estimated value represented by tag id PF.BUS_4_LNE_230KV_LINE_1_P_RES will remain unchanged.

2.5.2 Load Flow Calculation

(Run DPL script “Online Dispatcher LDF”.)

Inputs: Operator Controls: generator active power setpoints, generator voltage setpoints, switch statuses, tap positions

Outputs: resulting LDF



Example 3: Changing the active power of a generator (G2 in figure above).

1. Look at the active power of generator 2. ***PowerFactory*** writes this value into OPC item PF.BUS_2_GEN_18KV_G2_P_RES and should initially be around 163 MW.

2. Increase the power of generator 2. Therefore, use the control OPC item tagged PF.BUS_2_GEN_18KV_G2_P_CTRL. Set this value to “1”. ***PowerFactory*** is configured to interpret this value incremental (not absolute) resulting in an increase of generator’s power by 1 MW.

3. As you can see, the actual power of generator 2 will increase up to 164 MW (reflected by OPC item PF.BUS_2_GEN_18KV_G2_P_RES).

Example 4: Changing the voltage setpoint of a generator (G2 in figure above).

1. Analogically, change the voltage setpoint of the generator 2. The actual voltage is always reflected by OPC item PF.BUS_2_GEN_18KV_G2_V_RES. Initially, this value is about 18,45 kV.

2. Increase the voltage setpoint of this generator by 1%. Therefore, set the corresponding voltage control item PF.BUS_2_GEN_18KV_G2_V_CTRL to value “1”.
   (Note: Voltage control is in percent of nominal voltage.)

3. The actual voltage of the generator will promptly reflect a voltage of about 18,63 kV.

Example 5: Opening a breaker (BRK2 in figure above).

1. The state of breaker 2 (BRK2) is represented by an OPC item with tag id PF.BUS_2_CB_18KV_BREAKER2_BK_RES. This value will initially be “1” indicating a closed breaker.

2. Now, open this breaker by changing its breaker state. This breaker is controlled by OPC item PF.BUS_2_CB_18KV_BREAKER2_BK.
   Change this value to “0” to open the breaker. (Note: It this value is already set to “0”, first set it to “1” and then back to “0”. This is because only modified values will be transmitted in OPC.)

3. The breaker will be opened, which is indicated by a value of “0” in PF.BUS_2_CB_18KV_BREAKER2_BK_RES and can be seen in the ***PowerFactory*** single line diagram.

Example 6: Changing the tab position of a transformer (T2 in figure above).

1. Actual tap position of transformer T2 is represented by OPC item with tag id PF.BUS_7_TR2_T2_TAP_RES.

2. Change the corresponding control item PF.BUS_7_TR2_T2_TAP_CTRL to “1”.

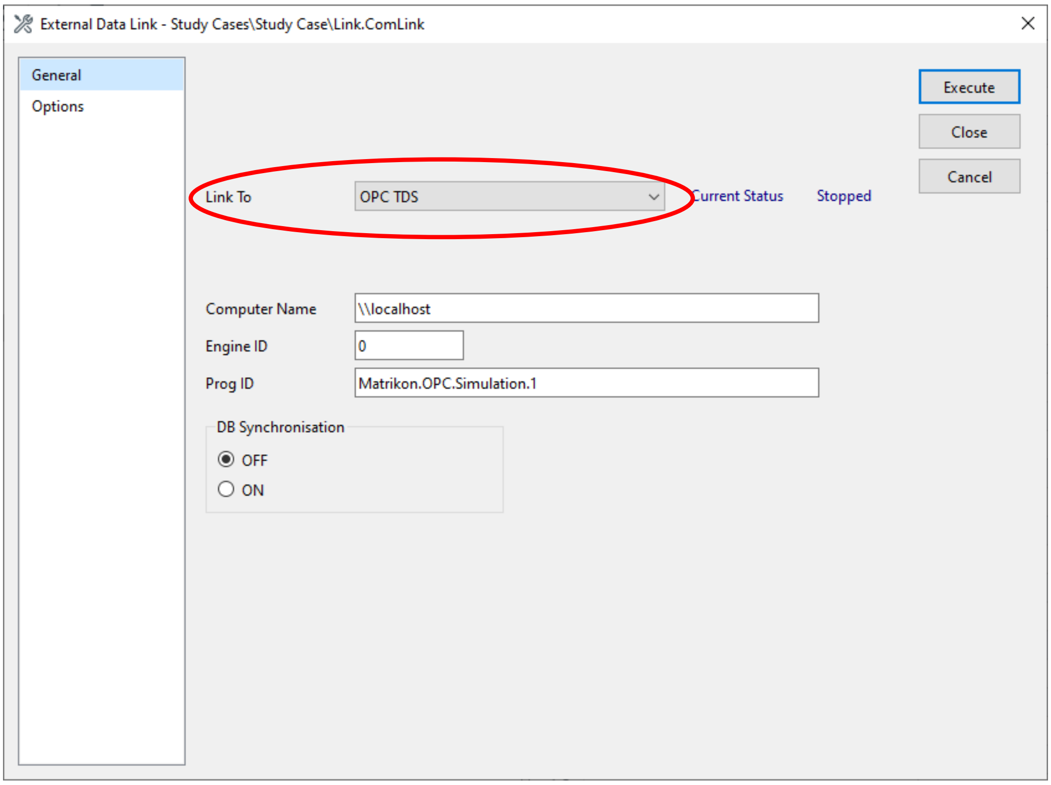
3. The tap position will be increased by “1”.

2.6 Time Domain Simulation (TDS)

TDS allows a complex simulation of dynamic behaviour of a network in time domain.

To start a TDS:

1. Establish a connection to the OPC server by setting the Link to field to “OPC TDS” in link object and execute the link. (The link object is located in the “Study Case” and named “Link”.)



External Data Link - Study Cases\Study Case\Link.ComLink

Link To: OPC TDS

Current Status: Stopped

Computer Name: \\localhost

Engine ID: 0

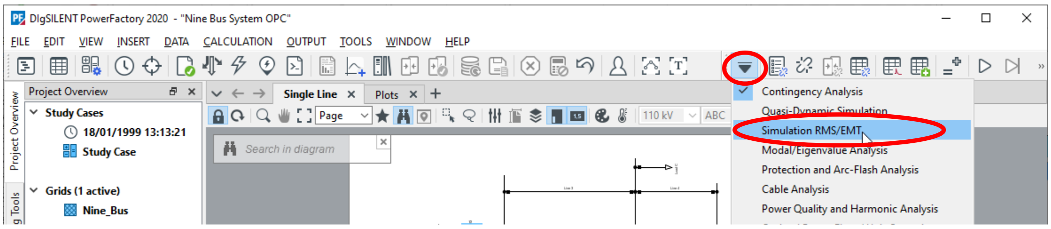
Prog ID: Matrikon.OPC.Simulation.1

DB Synchronisation

● OFF

○ ON

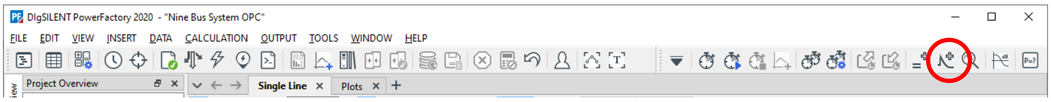
2. Select the down arrow in the toolbar and select the “RMS/EMT Simulation” in the appearing context menu to change the toolbar:



DIgSILENT PowerFactory 2020 - "Nine Bus System OPC"
FILE EDIT VIEW INSERT DATA CALCULATION OUTPUT TOOLS WINDOW HELP
Project Overview
Study Cases
18/01/1999 13:13:21
Study Case
Grids (1 active)
Nine_Bus
Single Line
Plots
Page
Search in diagram
110 kV
Contingency Analysis
Quasi-Dynamic Simulation
Simulation RMS/EMT
Modal/Eigenvalue Analysis
Protection and Arc-Flash Analysis
Cable Analysis
Power Quality and Harmonic Analysis

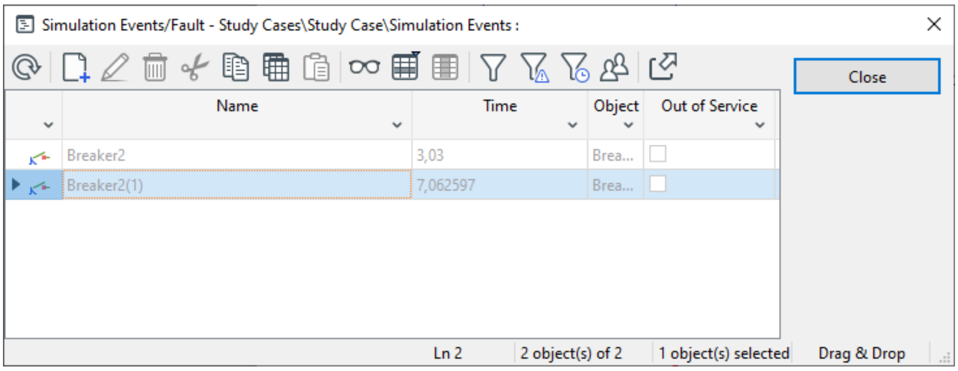
3. Always delete previous simulation events:

   Display the simulation event queue by pressing the corresponding button on ***PowerFactory*** ’s toolbar as depicted below:



DIgSILENT PowerFactory 2020 - "Nine Bus System OPC"
FILE EDIT VIEW INSERT DATA CALCULATION OUTPUT TOOLS WINDOW HELP
Project Overview
Single Line
Plots

   A list of all simulation events of the last run will appear. Delete these events by pressing the delete button 🗑 for each element.

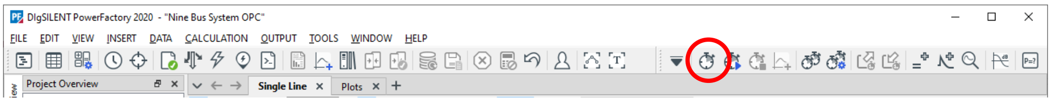


Simulation Events/Fault - Study Cases\Study Case\Simulation Events :

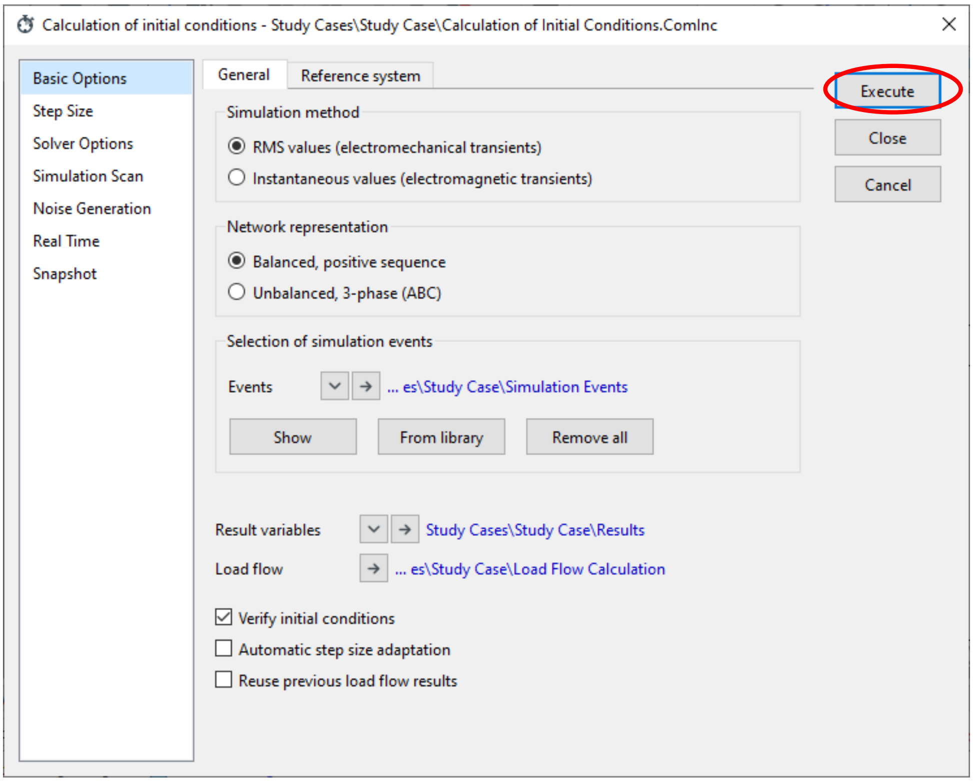
Name	Time	Object	Out of Service
Breaker2	3,03	Brea...	□
Breaker2(1)	7,062597	Brea...	□

Ln 2 | 2 object(s) of 2 | 1 object(s) selected | Drag & Drop

4. Calculate initial conditions for simulation by pressing the *Calculate Initial Conditions* button:


DIgSILENT PowerFactory 2020 - "Nine Bus System OPC"
FILE EDIT VIEW INSERT DATA CALCULATION OUTPUT TOOLS WINDOW HELP
Project Overview
Single Line
Plots

A calculation dialog will appear. Just press *Execute* to start the calculation:



Calculation of initial conditions - Study Cases\Study Case\Calculation of Initial Conditions.ComInc

Basic Options
Step Size
Solver Options
Simulation Scan
Noise Generation
Real Time
Snapshot

General | Reference system

Simulation method

● RMS values (electromechanical transients)

○ Instantaneous values (electromagnetic transients)

Network representation

● Balanced, positive sequence

○ Unbalanced, 3-phase (ABC)

Selection of simulation events

Events ... es\Study Case\Simulation Events

Result variables Study Cases\Study Case\Results

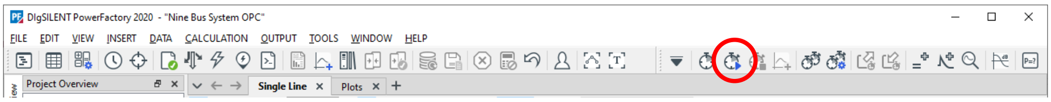
Load flow ... es\Study Case\Load Flow Calculation

☑ Verify initial conditions

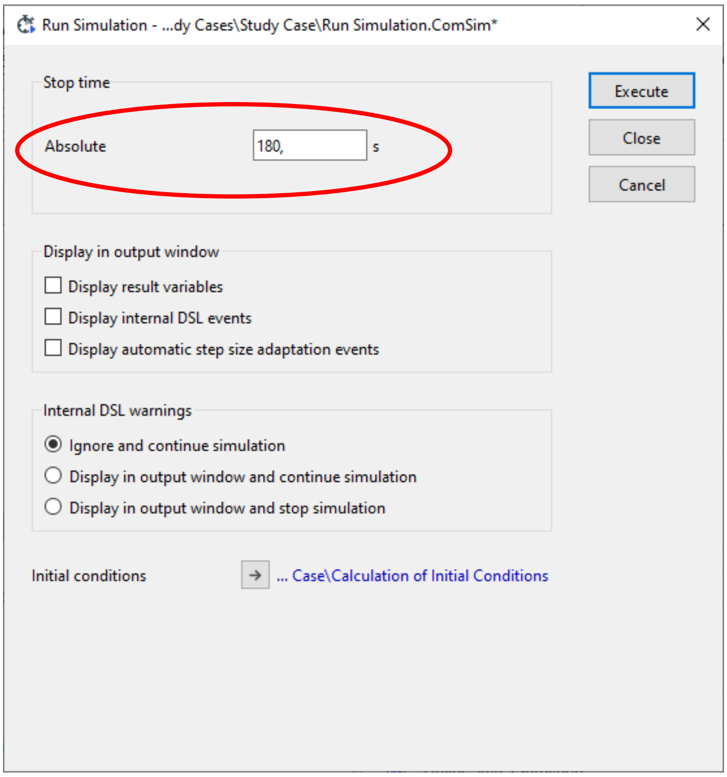
□ Automatic step size adaptation

□ Reuse previous load flow results

5. Run the simulation by pressing the button next to the initial condition button in main toolbar


DIgSILENT PowerFactory 2020 - "Nine Bus System OPC"
FILE EDIT VIEW INSERT DATA CALCULATION OUTPUT TOOLS WINDOW HELP
Project Overview
Single Line
Plots

Enter a duration in the appearing simulation dialog and press *Execute*.



Run Simulation - ...dy Cases\Study Case\Run Simulation.ComSim*

Stop time

Absolute 180, s

Display in output window

□ Display result variables

□ Display internal DSL events

□ Display automatic step size adaptation events

Internal DSL warnings

● Ignore and continue simulation

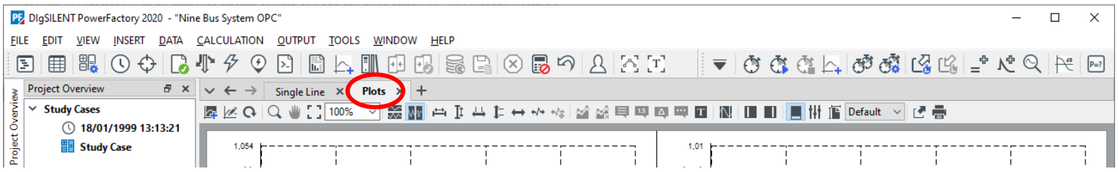
○ Display in output window and continue simulation

○ Display in output window and stop simulation

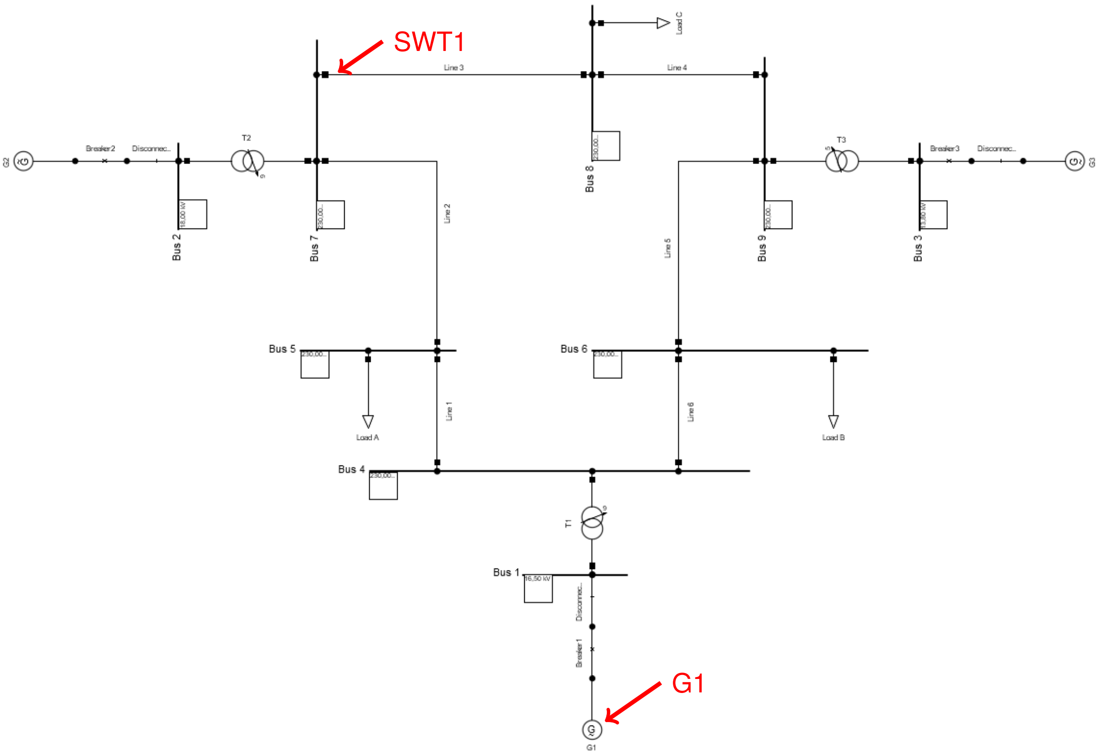
Initial conditions → ... Case\Calculation of Initial Conditions

The simulation is now running. Result values will be written to OPC server and changed values are read into ***PowerFactory*** effecting the running simulation.

For the following examples, please change to the preconfigured plot page by clicking on the tab below the single line graphics in ***PowerFactory*** .

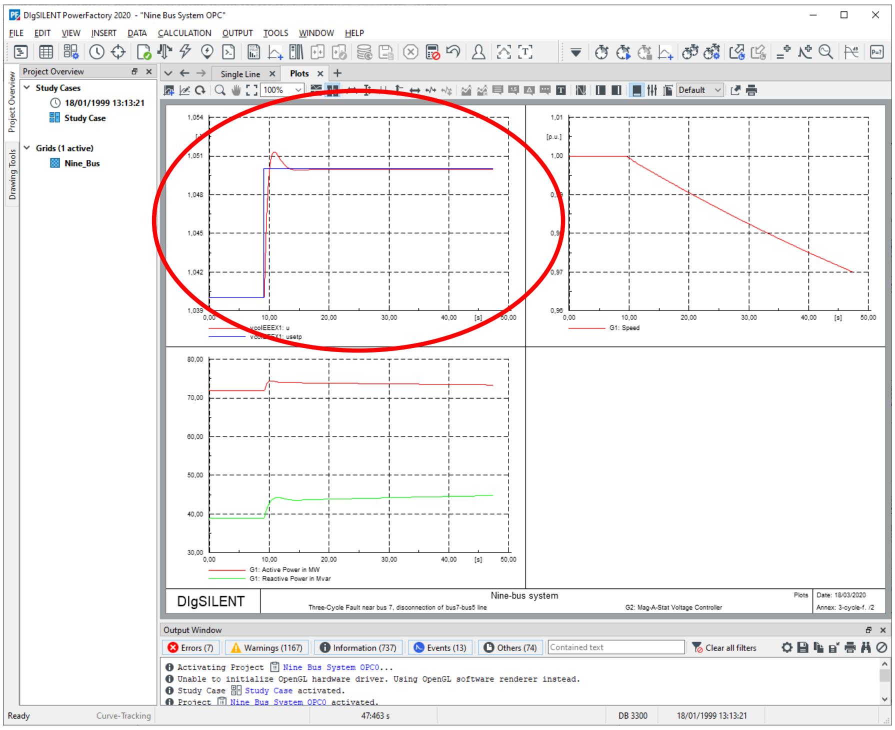


DIgSILENT PowerFactory 2020 - "Nine Bus System OPC"



Example 1: Increasing AVR setpoint of G1.

1. While running a simulation, increase the voltage setpoint of generator G1 by 1%. This is done by changing the OPC item PF.BUS_1_GEN_17KV_G1_V_CTRL to “1”.
2. The effect can be seen in the plot:



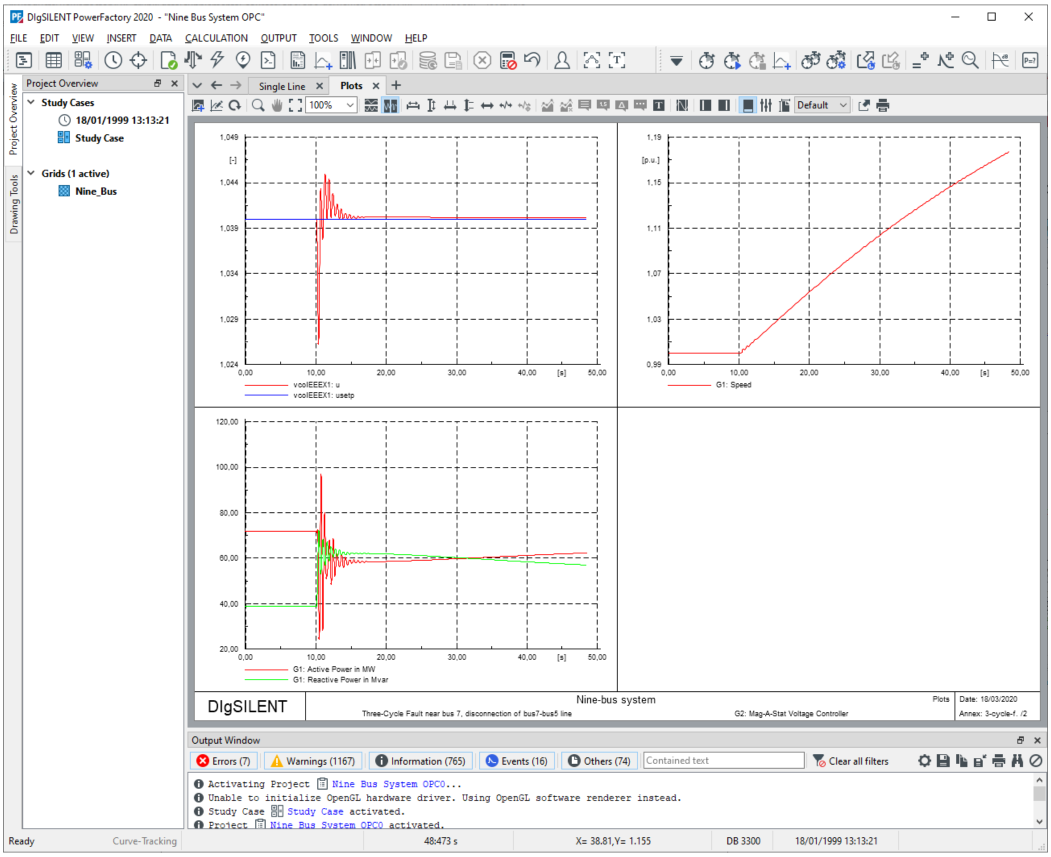
```
Activating Project Nine Bus System OPC0...
Unable to initialize OpenGL hardware driver. Using OpenGL software renderer instead.
Study Case Study Case activated.
Project Nine Bus System OPC0 activated.
```

Example 2: Opening a breaker.

1. Before simulation, initialize the value of OPC item PF.BUS_7_SWITCH_230KV_BUS_7_CUB_3 to “1”.

2. While running a simulation, open the breaker SWT1. The state of this breaker is represented by value of item PF.BUS_7_SWITCH_230KV_BUS_7_CUB_3_RES. Change the value of corresponding write item PF.BUS_7_SWITCH_230KV_BUS_7_CUB_3 to “0” (=“opened”).

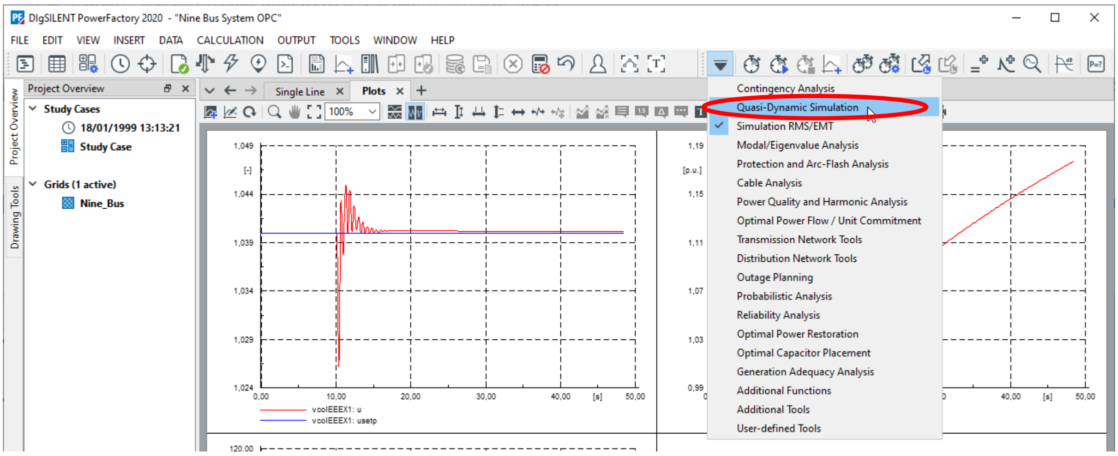
3. The effects can be seen in the plots:



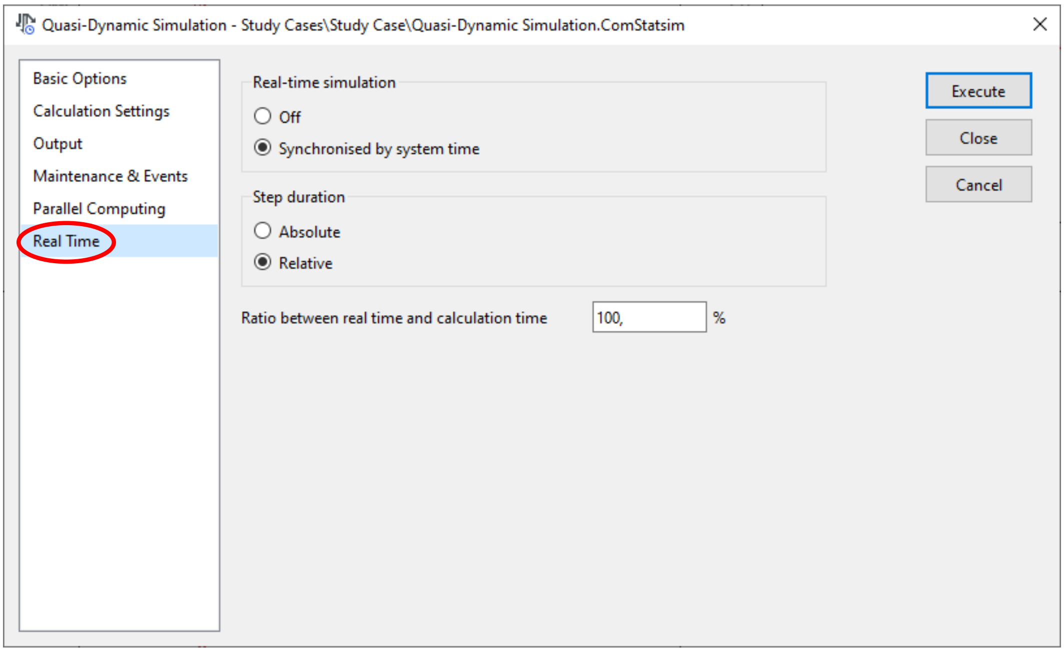
```
Activating Project Nine Bus System OPC0...
Unable to initialize OpenGL hardware driver. Using OpenGL software renderer instead.
Study Case Study Case activated.
Project Nine Bus System OPC0 activated.
```

2.7 Quasi Dynamic Simulation (QDS)

It is also possible to use the OPC-interface in a Quasi Dynamic Simulation. The configuration is equal to the TDS case described above. First an OPC-link must be started in mode *OPC TDS*. Afterwards the QDS command can be configured and started.



It is very important to specify a real time factor in the QDS settings. Otherwise the simulation will run extremely fast and the OPC server has no chance to react on changes.


Quasi-Dynamic Simulation - Study Cases\Study Case\Quasi-Dynamic Simulation.ComStatsim

Real-time simulation

○ Off

● Synchronised by system time

Step duration

○ Absolute

● Relative

Ratio between real time and calculation time 100, %

3 Details on *PowerFactory* 's OPC Link

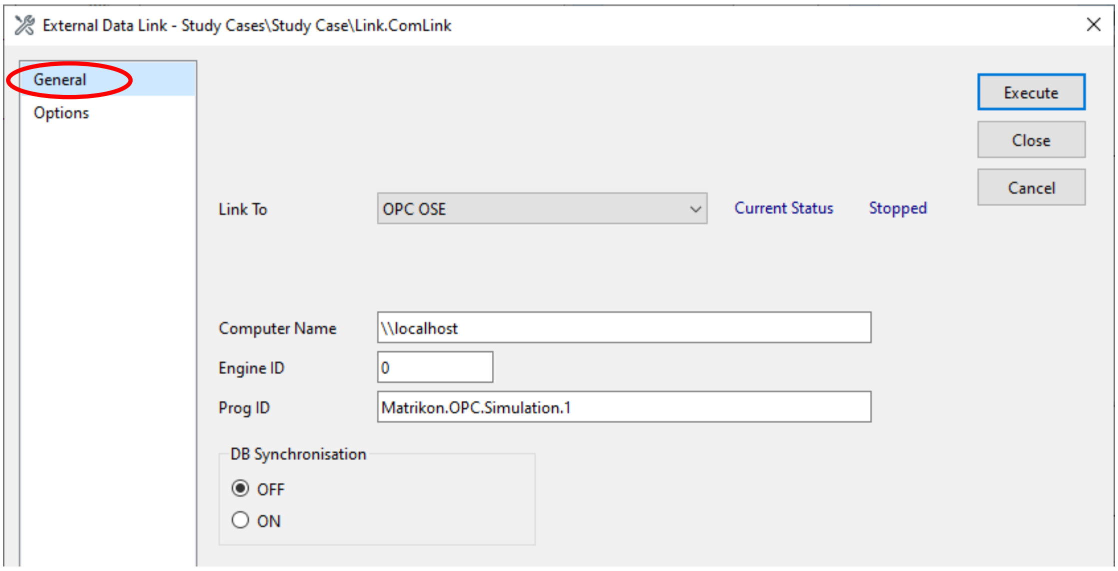
This chapter gives some information on the OPC link and how data is exchanged with an OPC server.

3.1 External Data Link

The connection to an OPC server is established by an instance of class ComLink. This link object holds the OPC client configuration and is responsible for sending and receiving data.

3.1.1 Options

Following configuration options are available:



External Data Link - Study Cases\Study Case\Link.ComLink

Link To: OPC OSE

Current Status: Stopped

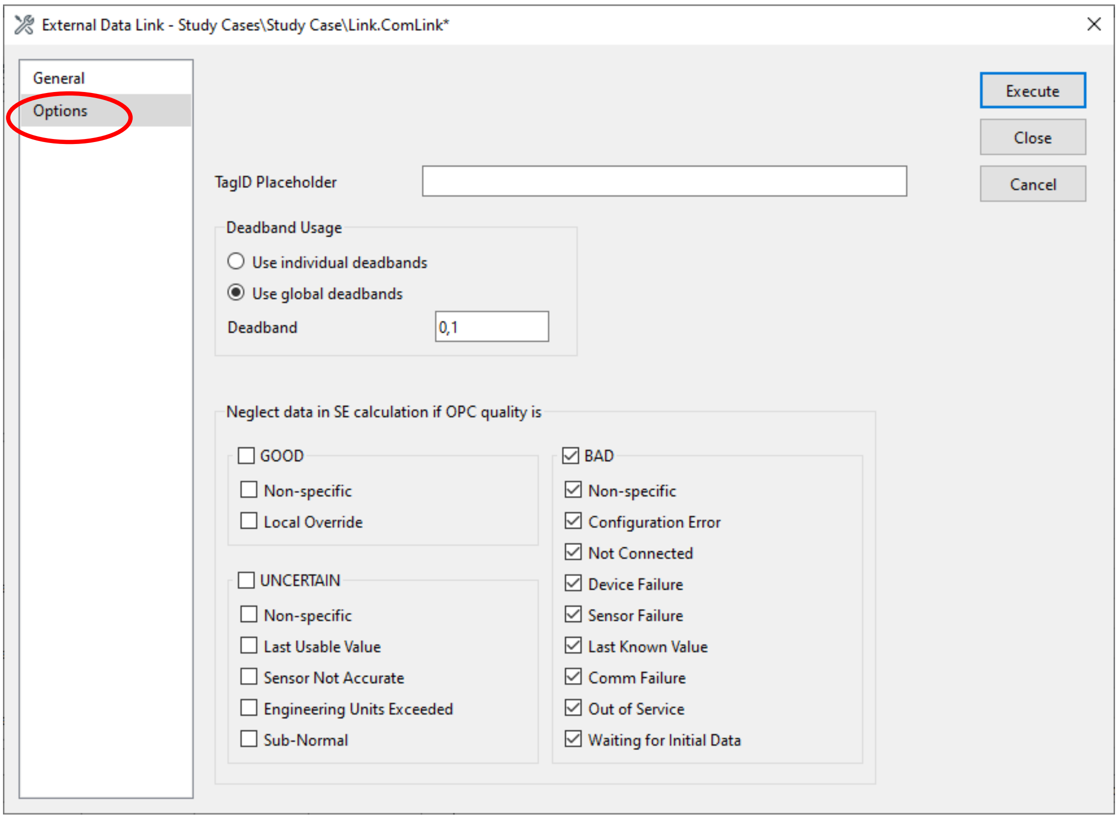
Computer Name: \\localhost

Engine ID: 0

Prog ID: Matrikon.OPC.Simulation.1

DB Synchronisation: ● OFF ○ ON

Link to	Selection of connection type. This affects the way how input data is set to the ***PowerFactory*** objects. For OPC there are two possible modes available: • OPC OSE: Received values are directly used in LDF / SE calculation. • OPC TDS: Received values are transformed into simulation events. These events are processed by a running simulation.
Computer Name	Name of the OPC server
Engine ID	Identifies current running instance of ***PowerFactory*** . Only necessary if there is more than one ***PowerFactory*** connecting to same OPC server. Just use different values in this case.
Prog ID	OPC Service Name



TagID Placeholder

Deadband Usage

○ Use individual deadbands

● Use global deadbands

Deadband 0,1

Neglect data in SE calculation if OPC quality is

☐ GOOD
- ☐ Non-specific
- ☐ Local Override

☐ UNCERTAIN
- ☐ Non-specific
- ☐ Last Usable Value
- ☐ Sensor Not Accurate
- ☐ Engineering Units Exceeded
- ☐ Sub-Normal

☑ BAD
- ☑ Non-specific
- ☑ Configuration Error
- ☑ Not Connected
- ☑ Device Failure
- ☑ Sensor Failure
- ☑ Last Known Value
- ☑ Comm Failure
- ☑ Out of Service
- ☑ Waiting for Initial Data

TagID Placeholder	This is a kind of keyword replacement list that offers the possibility to adapt OPC tag names to different environments / OPC servers. The replacement will be applied to all OPC tags for all configured measurement objects. The list must be of form *key=value[;key2=value2]**. Example: TagID = *%group%.G1_V_CTRL* using a replacement list of *%group%=PF1* would result in a tag PF1.G1_V_CTRL. Simply adjusting the replacement would also allow to connect to a different group, e.g. *%group%=PF2* leads to PF2.G1_V_CTRL
Deadband Usage	Value changes are only processed if the difference between the last value that was transferred and the actual values is greater than this deadband (only used for floating point numbers). Since ***PowerFactory*** 2017 SP1 the deadband value is used for sent and received values to minimize the network traffic and the number of generated events. • Use individual deadbands: deadband value (absolute value) is specified in each external measurement object (see 2.2 External Measurement Objects) • Use global deadbands: one deadband (absolute value) is specified for all external measurement objects (individual deadband is ignored)
Neglect data in SE calculation (only visible for type OPC OSE)	Selection of OPC qualities that have to be neglect in state estimation. If a value is received its quality is checked. If the quality is selected as to be neglected, the value is marked to be ignored by SE.

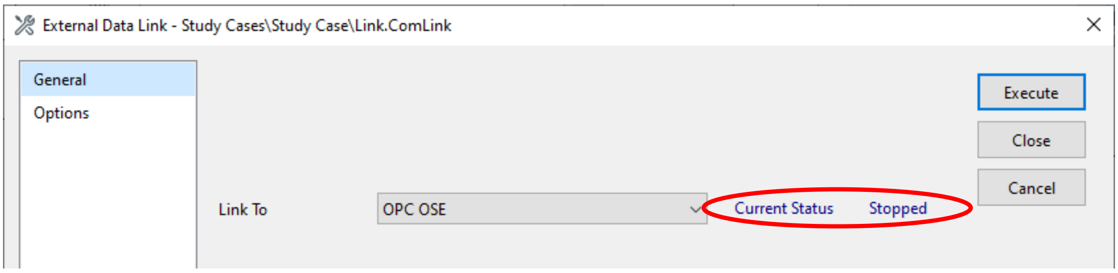
3.1.2 Connecting / Disconnecting

Connecting or disconnecting is done by pressing the button *Execute*:

If there is currently no active connection, a new one will be established. After the connection was successfully initiated, the external data link object searches for all external measurement objects that are calculation relevant (in an active grid) and not out of service. For each of these objects, a subscription to the corresponding OPC item is established. This is only done on creating the connection. Changing an external measurement object while the connection is established has no effect.

Pressing *Execute* while the connection is active will terminate this connection.

The connection status is always displayed on the dialog of the data link object:



External Data Link - Study Cases\Study Case\Link.ComLink

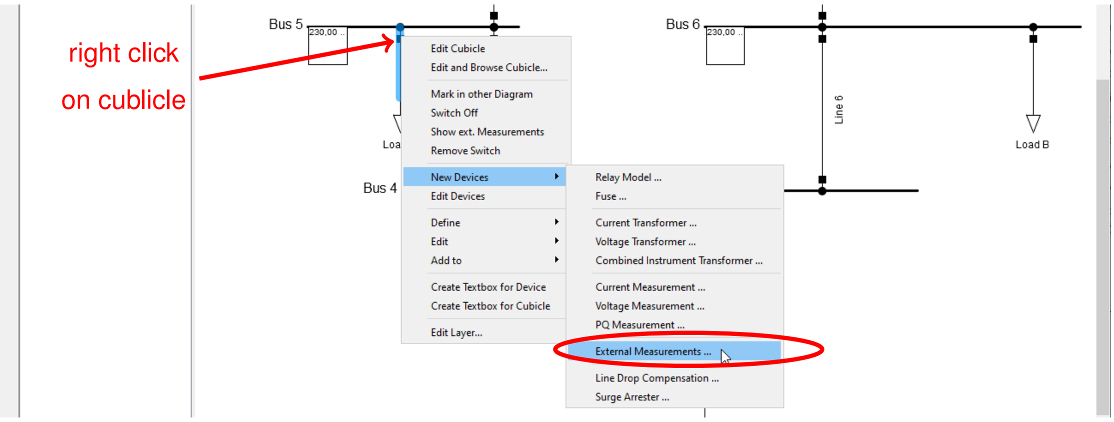
Link To: OPC OSE

Current Status: Stopped

3.2 External Measurement Objects

The mapping of OPC items to ***PowerFactory*** objects and variables is done by "External Measurement Objects" (classes StaExt*). For each OPC item that should be processed by ***PowerFactory*** , such an object must be created and configured in ***PowerFactory*** .

A new external measurement object can be created by right clicking on a cubicle in the single line graphics and selecting *New Devices* → *External Measurement...* from the context menu.

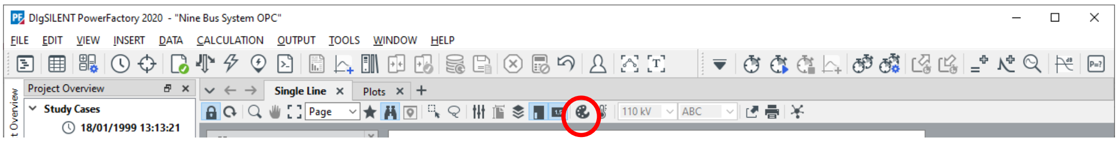


right click on cubicle

Also, from this context menu, a list of all existing external measurement objects can be displayed by selecting *Show ext. Measurements* from context menu.

Normally, a measurement object is located in one of the cubicles of the measuring object.

Existing measurement objects can be visualized in single line graphics by a colouring mode. This mode can be enabled in the colour representation settings:


DIgSILENT PowerFactory 2020 - "Nine Bus System OPC"
FILE EDIT VIEW INSERT DATA CALCULATION OUTPUT TOOLS WINDOW HELP
Project Overview
Study Cases
18/01/1999 13:13:21
Single Line
Plots
Page
110 kV
ABC

Enable "3. Other", select the Secondary Equipment in the first combo box and the "Measurement Locations" in the second one:

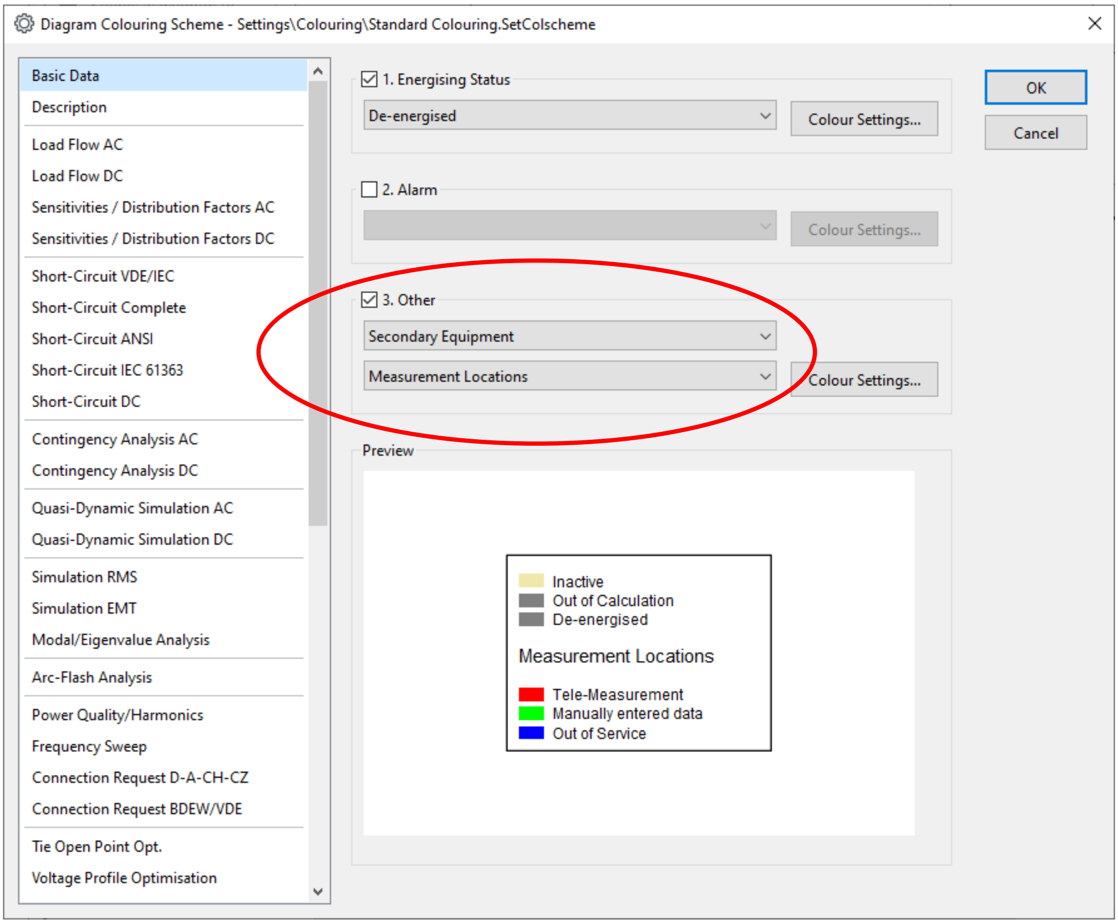


Diagram Colouring Scheme - Settings\Colouring\Standard Colouring.SetColscheme

☑ 1. Energising Status
De-energised

□ 2. Alarm

☑ 3. Other
Secondary Equipment
Measurement Locations

Preview

🟨 Inactive
⬛ Out of Calculation
⬛ De-energised

Measurement Locations

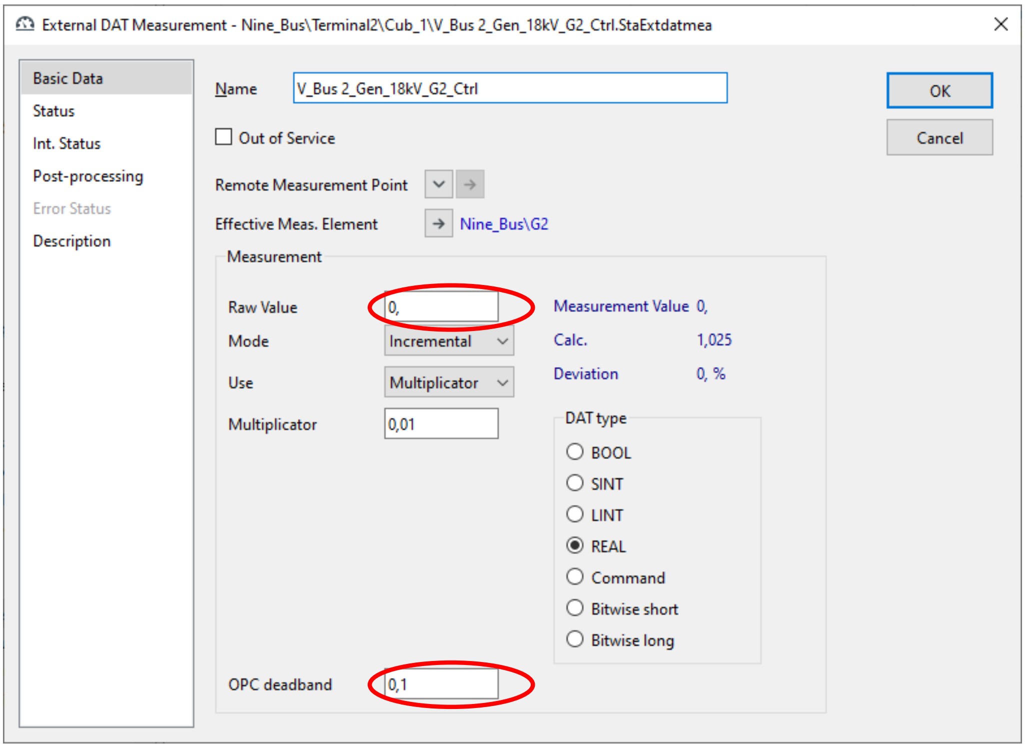
🟥 Tele-Measurement
🟩 Manually entered data
🟦 Out of Service

3.2.1 Common settings for all measurement objects

Tab "Basic Data" For all external measurement objects, the raw measurement value is displayed on this page in a frame called Measurement. If the individual deadband settings are enabled (see External Data Link) then the OPC deadband value is relevant for all external measurement objects with data type "REAL" and status "Write"[8]: Changing values are only processed if the difference between old and new values is greater than this deadband value.

The OPC deadband field is only available for external measurement objects, which data type is declared as "REAL" and their status is "Write".

[8] These external measurement objects write their "REAL" values to the OPC server.



External DAT Measurement - Nine_Bus\Terminal2\Cub_1\V_Bus 2_Gen_18kV_G2_Ctrl.StaExtdatmea

Name: V_Bus 2_Gen_18kV_G2_Ctrl

□ Out of Service

Remote Measurement Point

Effective Meas. Element: Nine_Bus\G2

Measurement

Raw Value: 0,

Mode: Incremental

Use: Multiplicator

Multiplicator: 0,01

Measurement Value 0,

Calc. 1,025

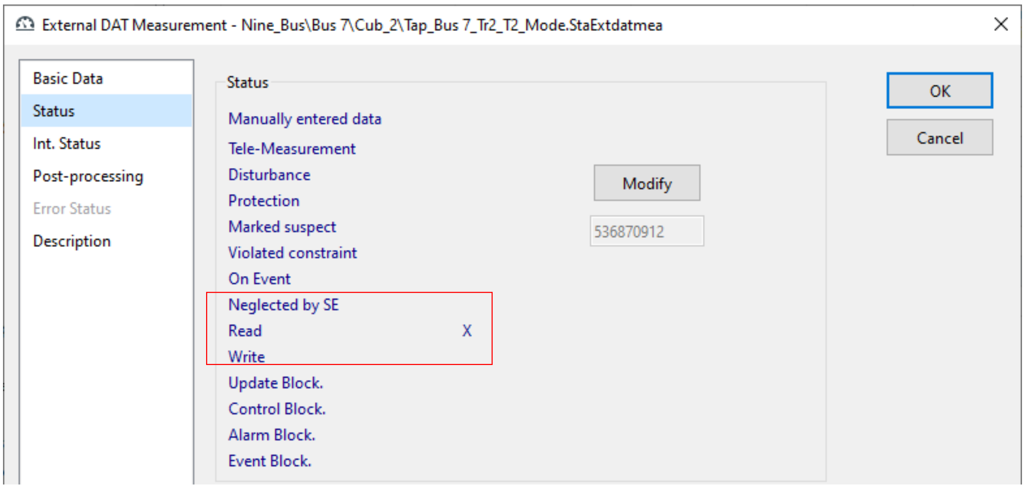
Deviation 0, %

DAT type

○ BOOL
○ SINT
○ LINT
● REAL
○ Command
○ Bitwise short
○ Bitwise long

OPC deadband: 0,1

Tab "Status" On the tab page "Status" of a measurement object, the status can be set: There are 3 statuses that are of interest.



External DAT Measurement - Nine_Bus\Bus 7\Cub_2\Tap_Bus 7_Tr2_T2_Mode.StaExtdatmea

Status

Manually entered data
Tele-Measurement
Disturbance
Protection
Marked suspect
Violated constraint
On Event
Neglected by SE
Read X
Write
Update Block.
Control Block.
Alarm Block.
Event Block.

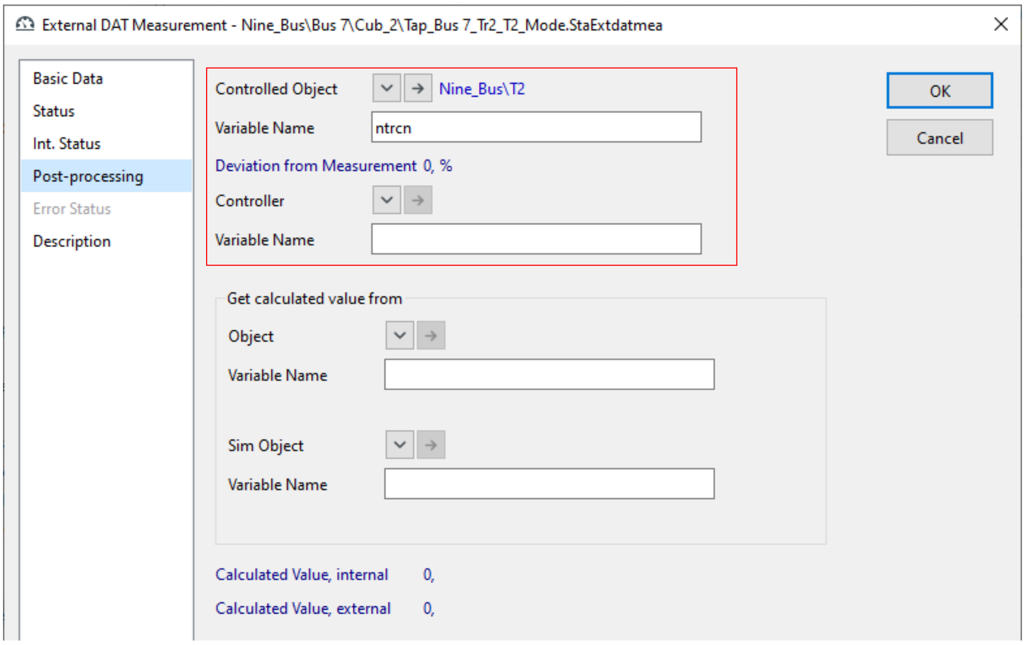
536870912

Read	If set, the OPC item's value is read by ***PowerFactory*** (considered as input for ***PowerFactory***).
Write	If set, ***PowerFactory*** writes values into this OPC item (Output).
Neglected by SE	Determines whether the value should by neglected in state estimation.

Tab "Post-processing" The "Post-processing" tab, allows to configure from which object the value is taken and on which object received data is written to.

The attributes framed by a red box in the screenshot below determine where to put received data. It can be configured to put received data directly into a ***PowerFactory*** object or, optionally, into a controller for an object.

Depending on the concrete measurement type, there are only some of these options visible.



External DAT Measurement - Nine_Bus\Bus 7\Cub_2\Tap_Bus 7_Tr2_T2_Mode.StaExtdatmea

Controlled Object: Nine_Bus\T2

Variable Name: ntrcn

Deviation from Measurement 0, %

Controller:

Variable Name:

Get calculated value from

Object:

Variable Name:

Sim Object:

Variable Name:

Calculated Value, internal 0,

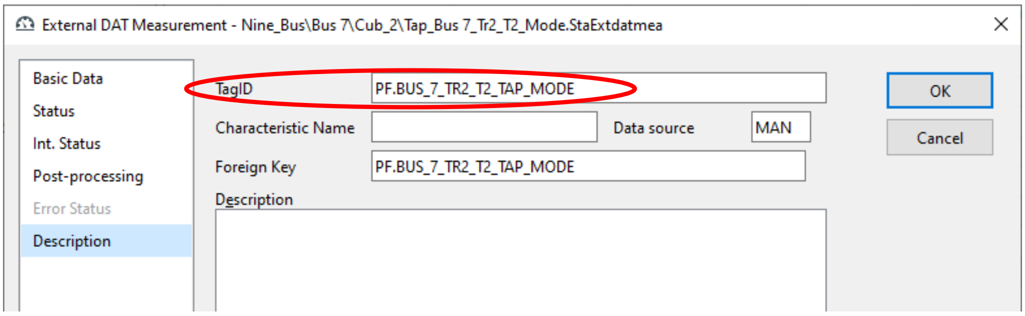
Calculated Value, external 0,

Some measurement objects also provide a frame Get calculated value from. This allows configuring from which ***PowerFactory*** object the value should be taken (that is written to OPC server). If there is no simulation running, the value is taken from the object and variable that is referenced by the upper attributes. While running a simulation, the value is taken from the referenced Sim Object.

If this lower frame is not available, the attribute Effective Meas. Element on "Basic Data" tab indicates where the value is taken from. This can be configured by setting the attribute Remote Measurement Point.

Tab "Description" On description page, it is necessary to set the tag name of the corresponding OPC item. This is where the data is read and / or written to.

For each OPC tag name can be only one measurement object configured in ***PowerFactory*** . Note: The tag name is case sensitive!



External DAT Measurement - Nine_Bus\Bus 7\Cub_2\Tap_Bus 7_Tr2_T2_Mode.StaExtdatmea

TagID: PF.BUS_7_TR2_T2_TAP_MODE

Characteristic Name:

Data source: MAN

Foreign Key: PF.BUS_7_TR2_T2_TAP_MODE

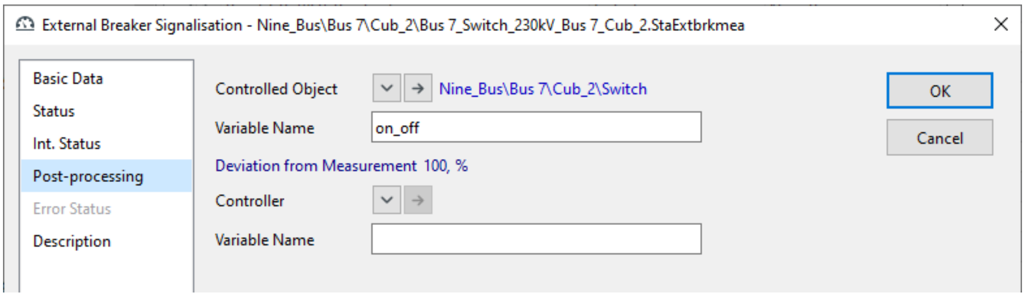
Description

3.2.2 Breaker Measurements

The breaker measurement object (class StaExtBrkmea) simplifies access to switch statuses (open / closed). It must be placed either in a switch-able cubicle or in a cubicle on one side of a breaker.

Reading the switch status is configured automatically (no object where to get the value from must be configured). This can be changed by setting the Remote Measurement Point on tab "Basic Data" manually.

For setting the switch status, the post-processing must be configured like this:



External Breaker Signalisation - Nine_Bus\Bus 7\Cub_2\Bus 7_Switch_230kV_Bus 7_Cub_2.StaExtbrkmea

Controlled Object: Nine_Bus\Bus 7\Cub_2\Switch

Variable Name: on_off

Deviation from Measurement 100, %

Controller:

Variable Name:

3.2.3 External P, Q, V Measurements

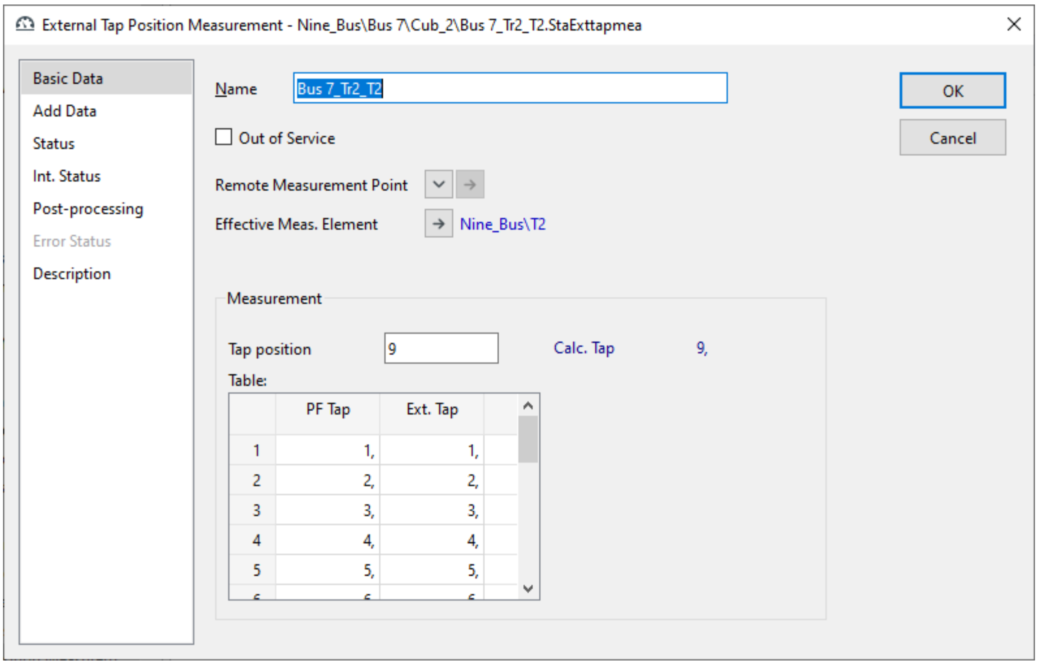
For accessing the active (P), reactive (Q) power or voltage (V), there are also specialized measurement objects (classes StaExtpmea, StaExtqmea, StaExtvmea) available. These objects must be placed in the cubicle where the values should be taken from.

Normally, these objects are only used as input values for the State Estimation calculation. Therefore, no post-processing must be configured (measured values are not set to any object).

3.2.4 External Tap Measurements

For accessing the tap setting of a transformer, a specialized tap measurement object (class StaExttapmea) can be used. It is always necessary to set the tap settings mapping table.

Example configuration:



External Tap Position Measurement - Nine_Bus\Bus 7\Cub_2\Bus 7_Tr2_T2.StaExttapmea

Name: Bus 7_Tr2_T2

□ Out of Service

Remote Measurement Point

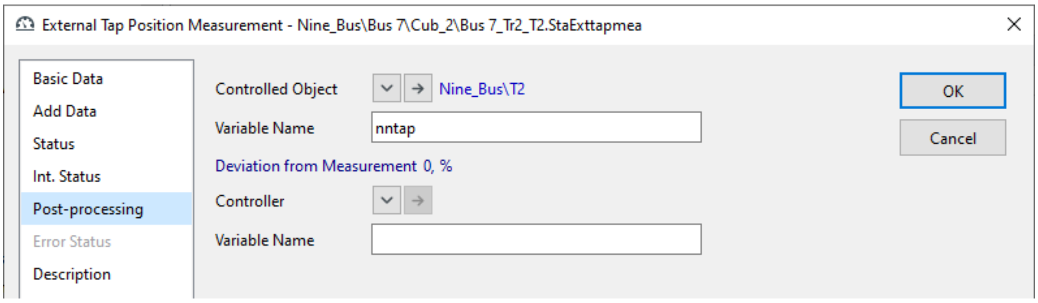
Effective Meas. Element: Nine_Bus\T2

Measurement

Tap position: 9   Calc. Tap: 9,

Table:

	PF Tap	Ext. Tap
1	1,	1,
2	2,	2,
3	3,	3,
4	4,	4,
5	5,	5,



External Tap Position Measurement - Nine_Bus\Bus 7\Cub_2\Bus 7_Tr2_T2.StaExttapmea

Controlled Object: Nine_Bus\T2

Variable Name: nntap

Deviation from Measurement 0, %

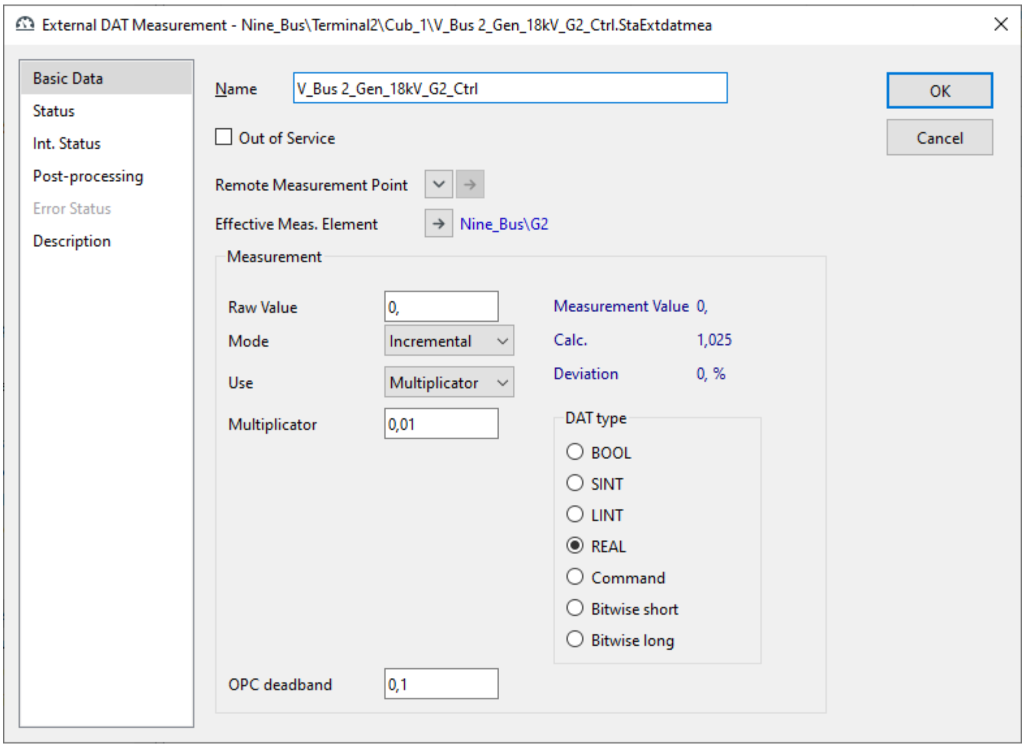
Controller

Variable Name

3.2.5 External DAT Measurement

The external DAT measurement (class StaExtdatmea) is the most generalized form of a measurement object. This object can be configured to access any ***PowerFactory*** object.

On tab “Basic Data”, the data type must be set according to the OPC item’s data type. In addition, a processing of the value (scaling, absolute or incremental) can be configured.



External DAT Measurement - Nine_Bus\Terminal2\Cub_1\V_Bus 2_Gen_18kV_G2_Ctrl.StaExtdatmea

Name: V_Bus 2_Gen_18kV_G2_Ctrl

□ Out of Service

Remote Measurement Point

Effective Meas. Element: Nine_Bus\G2

Measurement

Raw Value: 0,

Mode: Incremental

Use: Multiplicator

Multiplicator: 0,01

Measurement Value: 0,

Calc.: 1,025

Deviation: 0, %

DAT type

○ BOOL

○ SINT

○ LINT

● REAL

○ Command

○ Bitwise short

○ Bitwise long

OPC deadband: 0,1

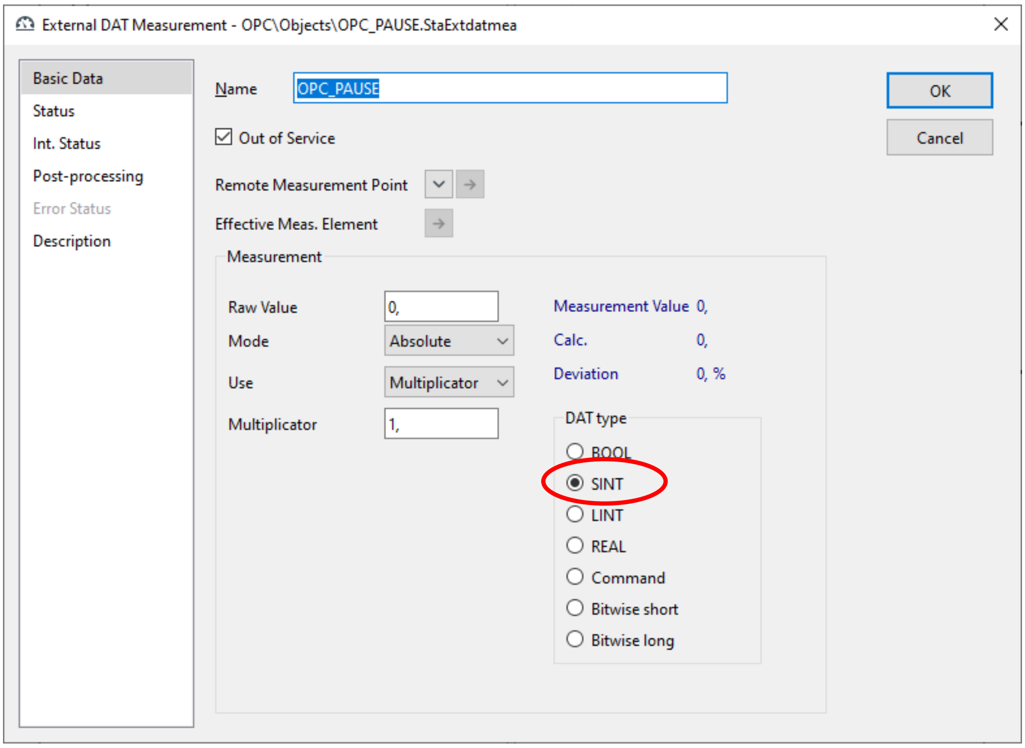
3.3 Advanced Topics

3.3.1 Pausing Simulation in TDS mode

It is possible to pause and resume a simulation in ***PowerFactory*** via OPC. For this purpose a specially configured external measurement object is used. That measurement object must be of type StaExtdatmea and should be created somewhere in an active grid or study case.

The measurement object must be configured as follows:

- DAT Type must be set to "SINT".



External DAT Measurement - OPC\Objects\OPC_PAUSE.StaExtdatmea

Basic Data
Status
Int. Status
Post-processing
Error Status
Description

Name: OPC_PAUSE

☑ Out of Service

Remote Measurement Point

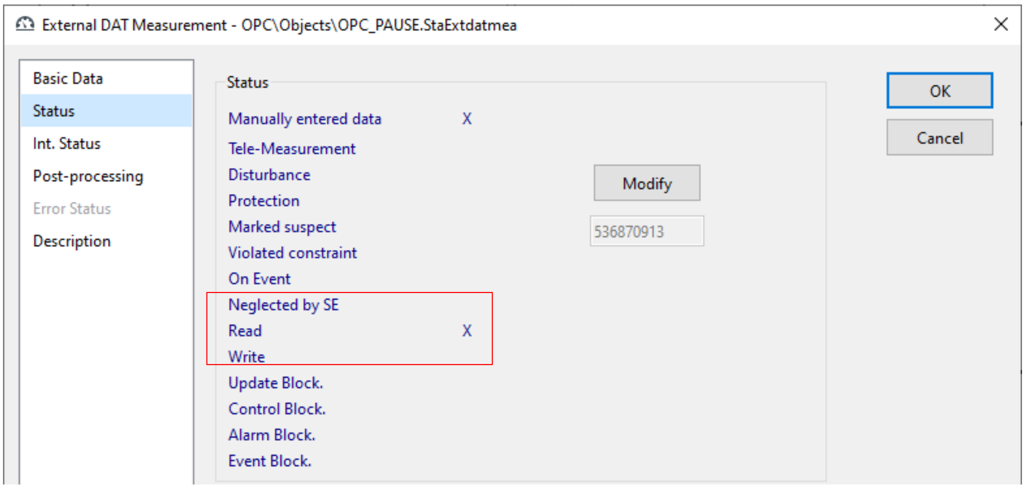
Effective Meas. Element

Measurement

Raw Value	0,	Measurement Value	0,
Mode	Absolute	Calc.	0,
Use	Multiplicator	Deviation	0, %
Multiplicator	1,		

DAT type
○ BOOL
● SINT
○ LINT
○ REAL
○ Command
○ Bitwise short
○ Bitwise long

- Status must be configured for reading.



External DAT Measurement - OPC\Objects\OPC_PAUSE.StaExtdatmea

Basic Data
Status
Int. Status
Post-processing
Error Status
Description

Status

Manually entered data	X
Tele-Measurement	
Disturbance	
Protection	
Marked suspect	
Violated constraint	
On Event	
Neglected by SE	
Read	X
Write	
Update Block.	
Control Block.	
Alarm Block.	
Event Block.	

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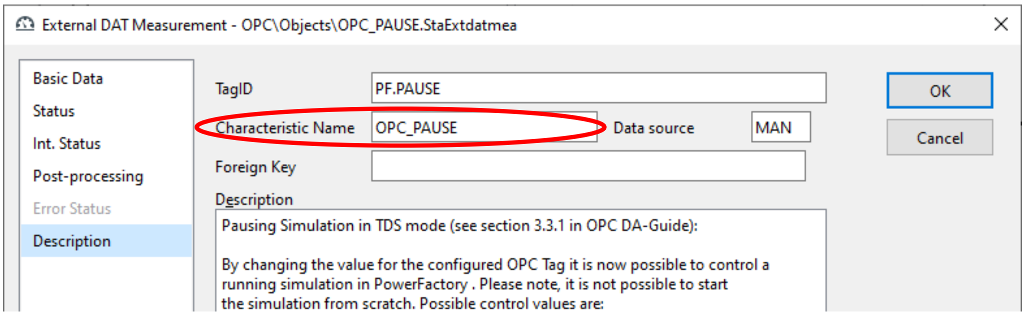
- Characteristic Name must be set to “OPC_PAUSE” (case sensitive)
  The desired OPC Tag is freely configurable.



External DAT Measurement - OPC\Objects\OPC_PAUSE.StaExtdatmea

TagID: PF.PAUSE

Characteristic Name: OPC_PAUSE

Data source: MAN

Foreign Key:

Description:

Pausing Simulation in TDS mode (see section 3.3.1 in OPC DA-Guide):

By changing the value for the configured OPC Tag it is now possible to control a running simulation in PowerFactory . Please note, it is not possible to start the simulation from scratch. Possible control values are:

By changing the value for the configured OPC Tag (here: ANY.OPC_TAG.NAME) it is now possible to control a running simulation in ***PowerFactory*** . Please note, it is not possible to start the simulation from scratch.

Possible control values are:

0:	simulation is running normally
1:	simulation is halted

3.3.2 Saving Simulation in TDS mode

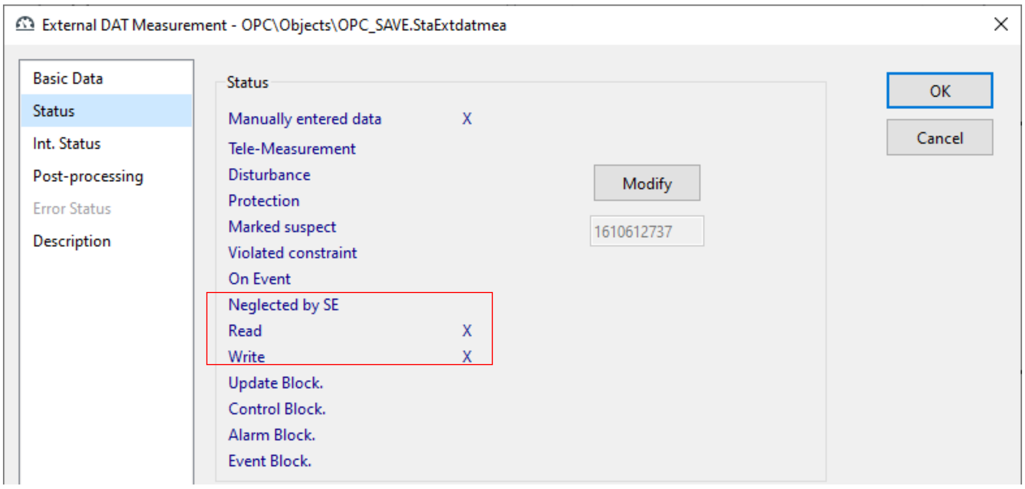
Saving the state of a simulation is a new feature introduced in ***PowerFactory*** 18. The save process can be started via OPC, by using a special external measurement object. This object must have the type StaExtdatmea and should be created somewhere in an active grid or study case. The object behaviour is a little bit special, because it is not only read but also written by ***PowerFactory***.
When the associated OPC-Value is changed to 1 on OPC-server side, the save process is started. After completion of the save process, ***PowerFactory*** will overwrite the value with the return code.

The following return values are possible:

- **0:** No error.
- **-1:** The save process has failed.
- **-2:** The information were stored in memory, but not written to a snapshot file.

In order to use the feature, the StaExtdatmea should be configured as follows:

- The DAT Type must be set to "SINT" as shown in section 3.3.1.
- The Status must be configured for reading and writing


External DAT Measurement - OPC\Objects\OPC_SAVE.StaExtdatmea

Status

Manually entered data X
Tele-Measurement
Disturbance
Protection
Marked suspect
Violated constraint
On Event
Neglected by SE
Read X
Write X
Update Block.
Control Block.
Alarm Block.
Event Block.

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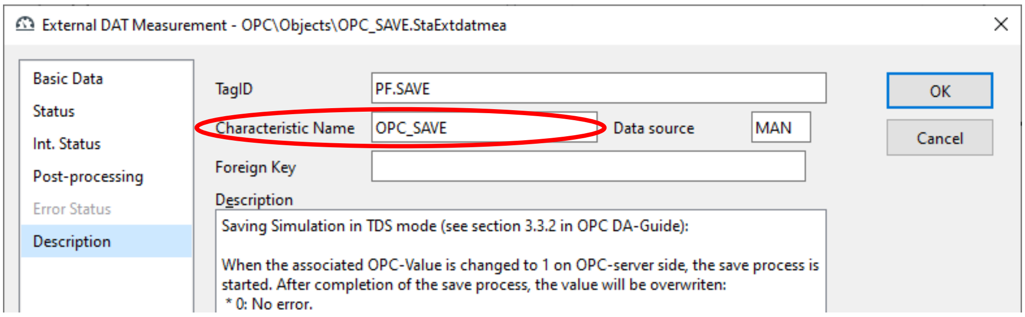
- The Characteristic Name must be set to "OPC_SAVE" (case sensitive)
The desired OPC Tag is freely configurable.


External DAT Measurement - OPC\Objects\OPC_SAVE.StaExtdatmea

TagID PF.SAVE
Characteristic Name OPC_SAVE Data source MAN
Foreign Key
Description
Saving Simulation in TDS mode (see section 3.3.2 in OPC DA-Guide):

When the associated OPC-Value is changed to 1 on OPC-server side, the save process is started. After completion of the save process, the value will be overwriten:
* 0: No error.

4 Troubleshooting

This section does explain the solution for some issues identified with the OPC communication.

4.1 Unable to establish link to OPC server

PowerFactory will write the error message *Create Instance Error* to the output window if no connection to the OPC server could be established. Mostly this is related to the COM/DCOM settings of the machine. Please perform the following checks to isolate the issue:

1. Install an OPC client like ”Matrikon Explorer” on the machine running PowerFactory. Try to connect to the OPC server using this extra client. If the connection could not be created, check your COM/DCOM settings. It is also possible that the *”OPC Core Components Redistributable”* package is not installed on the machine.
2. Check if the server is registered in the Windows Component Services. Even if the server is running on a different machine, the OPC-server must be registered as Component. Otherwise PowerFactory is not able to resolve the GUID of the server instance.

4.2 PowerFactory freezes in RMS/EMT simulation

Depending on the machine it can happen that PowerFactory freezes in multi threading mode when a RMS/EMT simulation is started. This is mostly related to the OpenGL acceleration mode defined in the advanced settings of PowerFactory. Try to change the mode to ”Software” in order to fix the problem.

4.3 OPC-Tag with Read/Write mode is not updated correctly

In principle a tag should not be defined for read and write mode at once in PowerFactory, especially if DSL models are associated with the tag. However, in some cases it might by necessary to use this feature (for instance for status tags in Online OPC mode). Such tags must be defined as StaExtdatmea with type ”Real”. Furthermore it is important that the deadband is set to ”0”. Otherwise the refresh does not work correctly.