TRANSPOWER

# EMT Case User Guide

**Date: 15/09/2026**

| Version | Date | Change |
|---|---|---|
| 1.0 | 15/09/2026 | Initial Release |

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## IMPORTANT

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# Contents

# 1. Glossary

| Abbreviation | Full Form/Explanation |
|---|---|
| **ANI** | Transpower site code for Aniwhenua |
| **AVR** | Automatic Voltage Regulator |
| **CSV** | Comma-Separated Values |
| **DYR** | PSSE dynamics data file |
| **EMI** | Electricity Market Information; the Electricity Authority platform where the public PowerFactory case files are published |
| **EMT** | Electromagnetic Transient; time-domain simulation that represents the instantaneous voltage and current waveforms of the power system |
| **HVDC** | The inter-island High Voltage Direct Current link |
| **IBR** | Inverter-Based Resource; a generating or storage plant connected to the network through a power electronic converter |
| **IEEE** | Institute of Electrical and Electronics Engineers |
| **NIPS** | North Island Power System |
| **PRSIM** | Power System Importer; Manitoba Hydro software used to convert network and power flow data into a PSCAD case |
| **PSCAD** | Power System Computer Aided Design; Manitoba Hydro electromagnetic transient (EMT) simulation software |
| **PSS** | Power System Stabilizer |
| **PSS/E (PSSE)** | Power System Simulator for Engineering; Siemens software whose data formats are used to transfer the case between PowerFactory and PRSIM |
| **RAW** | PSS/E raw data file, containing the network topology and solved power flow data |
| **SEQ** | PSS/E sequence data file, containing the negative and zero sequence impedance data |
| **SIPS** | South Island Power System |
| **SLD** | Single-Line Diagram |
| **WAI** | Transpower site code for Waiotahe |

# 2. Introduction

This guide is intended for asset owners performing electromagnetic transient (EMT) studies, such as connection studies, which require a Power System Computer Aided Design (PSCAD) model of the New Zealand power system.

The guide documents the process for using Power System Importer (PRSIM) to convert network and power flow data from PowerFactory into an EMT case for use with PSCAD. It covers the steps for exporting a power flow from PowerFactory into PRSIM and PSCAD. It also describes the process of reducing the full North Island Power System (NIPS) or South Island Power System (SIPS) PRSIM case into a smaller study region, with the rest of the network represented by a multiport equivalence.

This workflow creates one PRSIM case which can be used to produce several PSCAD cases (one for each power flow condition). For users familiar with PowerFactory, the one PRSIM case serves as the equivalent of a PowerFactory project, while the different PSCAD cases are equivalent to different study cases within a PowerFactory project.

Sections 3 to 5 cover background information, section 6 contains the main process for creating a PSCAD case, and section 7 contains the process for final configuration of the case within PSCAD.

# 3. Files Provided by System Operator

The **.zip** package provided on Transpower's website contains the NIPS files shown below (with an equivalent structure available for SIPS); each is described in detail in Table 1:

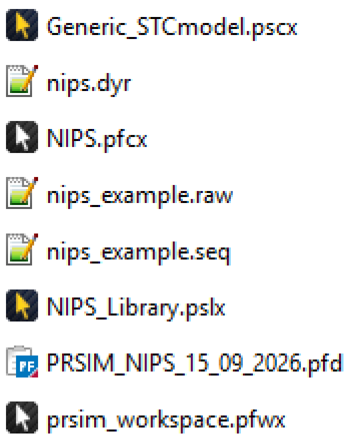



Figure 1: NIPS File Structure

Table 1: Descriptions of Files Provided by the System Operator

| Filename | Description |
|---|---|
| **prsim_workspace.pfwx** | This is the workspace file which should be opened in PRSIM. Opening this workspace will automatically load **NIPS.pfcx**. |
| **NIPS.pfcx** | This is the PRSIM case file for the North Island. It contains the entire island and will usually need to be reduced for regional studies such as connection studies. |
| **NIPS_Library.pslx** | This file contains generic models for assets that are not handled automatically by PRSIM. Set this as the User library in PRSIM. Optionally, the user may automate the import of detailed generator PSCAD models by including them to this file. |
| **nips_example.raw**, **nips_example.seq**, **nips.dyr** | These example PSSE files are provided as a known working example when setting up or debugging PRSIM. When performing a study, **.raw** and **.seq** PSSE files will be exported from the NIPS PowerFactory case instead. **nips.dyr** will always be used as the **.dyr** file. |
| **Generic_STCmodel.pscx** | This file contains generic model that a user can utilize to represent STATCOM. |
| **PRSIM_NIPS*.pfd** | This is the NIPS PowerFactory case. It is a modified version of the EMI case with serial numbers assigned to allow reliable conversion between PowerFactory and PRSIM. |

# 4. Required Software Versions

To ensure the process in this guide can be carried out as intended, use the following software:

- DIgSilent's PowerFactory 2024
- Export performed with PSSE V33 format
- Manitoba Hydro's Power System Computer Aided Design (PSCAD) V5.02
    - Using Intel Fortran Classic 2021.12.0 32bit and 64bit compiler
- Manitoba Hydro's Power System Importer (PRSIM) V1.1.0

# 5. Process Overview

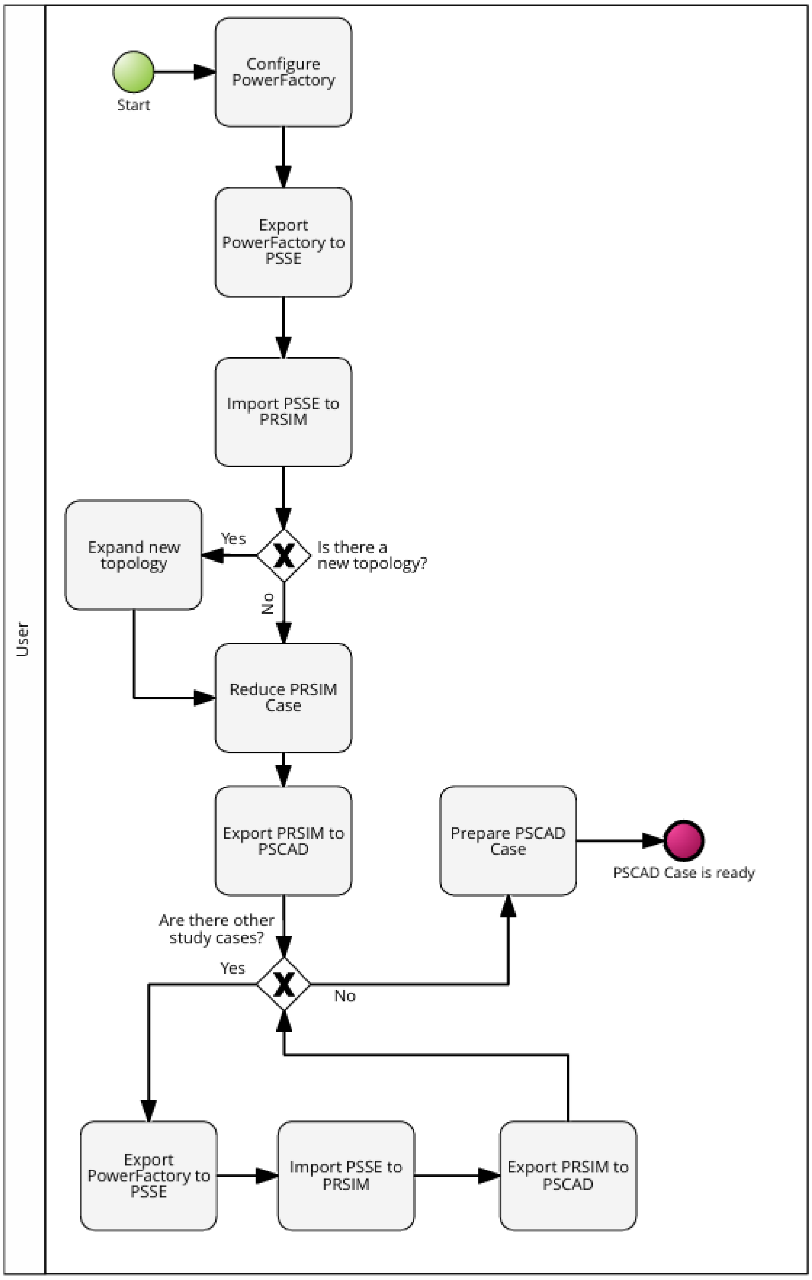



Figure 2: Case Creation Process Diagram

# 6. Case Creation Process

## 6.1 Configure the PowerFactory Case

1. Open the **PRSIM_NIPS*.pfd**(or **PRSIM_SIPS*.pfd**) case in PowerFactory and add the asset under study (including any connection assets) to the PowerFactory case.

2. Assign serial numbers to any new buses created.

***Note:*** *Serial Numbers*

*All terminals in the PowerFactory case must have a unique Serial Number in the Description tab, which will become the PSSE Bus number for that terminal when exported in PSSE format (**.raw**, **.seq**). Assign any new assets with serial numbers starting at 9001 (9001, 9002, 9003, etc.) to avoid overlap with serial numbers already used by Transpower. Before exporting, sort terminals by Serial Number in the Network Model Manager to check that there are no terminals with blank serial numbers.*

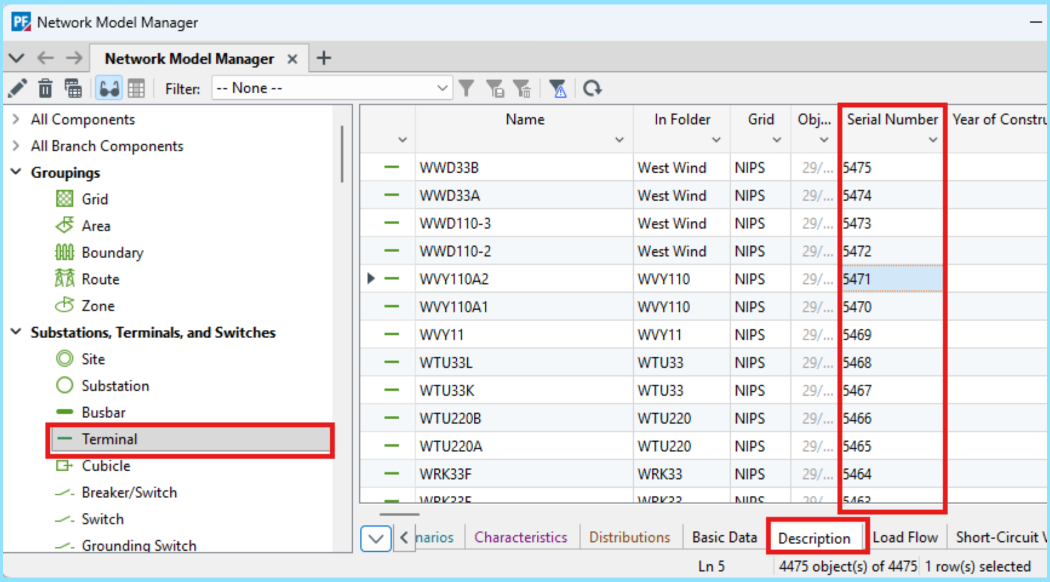



Figure 3: Serial Numbers

3. Configure the desired power flow conditions and solve the power flow. Note that the power flow must be correct even outside of the study area as it will affect the parameters of the multiport equivalence.
4. Power flow and topology should be double-checked at this point, as any later changes will require restarting the process.

## 6.2 Export from PowerFactory to PSSE Files

1. Ensure that the power flow has been solved before attempting to export.
2. Select the PSSE export option shown in Figure 4 below and choose PSSE Version **V33**.

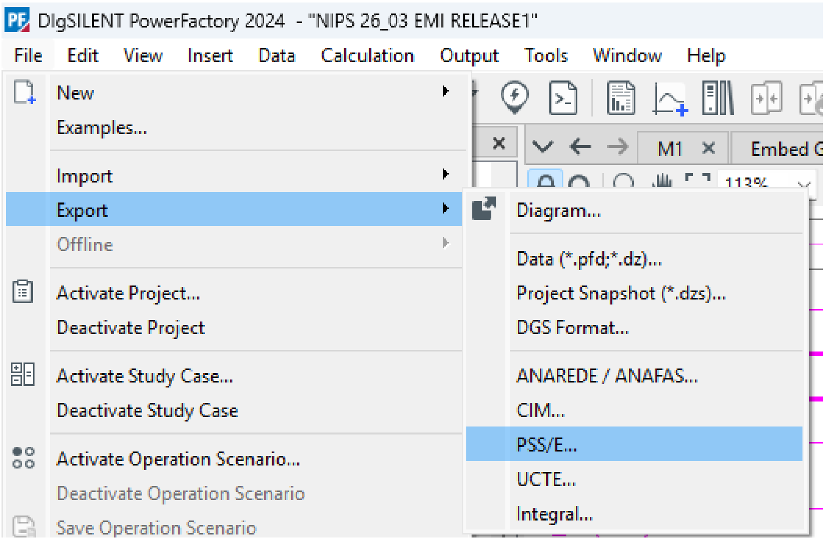



Figure 4: PSSE Export

3. In the **Advanced Options**, set **PSS/E Bus Number** to **Use Serial Number**.
4. Export the files. The **.raw** and **.seq** files should be given a consistent naming scheme that identifies which study scenario they belong to and should be stored in the same folder as the PRSIM case. The **.dyr** file can be discarded.
5. Repeat steps 1-3 for each study scenario.
6. Open the **.raw** file in a text editor and double-check the PSSE bus numbers. These numbers should match the Serial Numbers in PowerFactory, and no bus should be assigned a number less than 1000.

## 6.3 Import PSSE Files to PRSIM

1. Navigate to **File** > **Default Models** > **Startup libraries** > **User library** and set the user library to **NIPS_Library.pslx**. The application must then be restarted for the change to take effect.

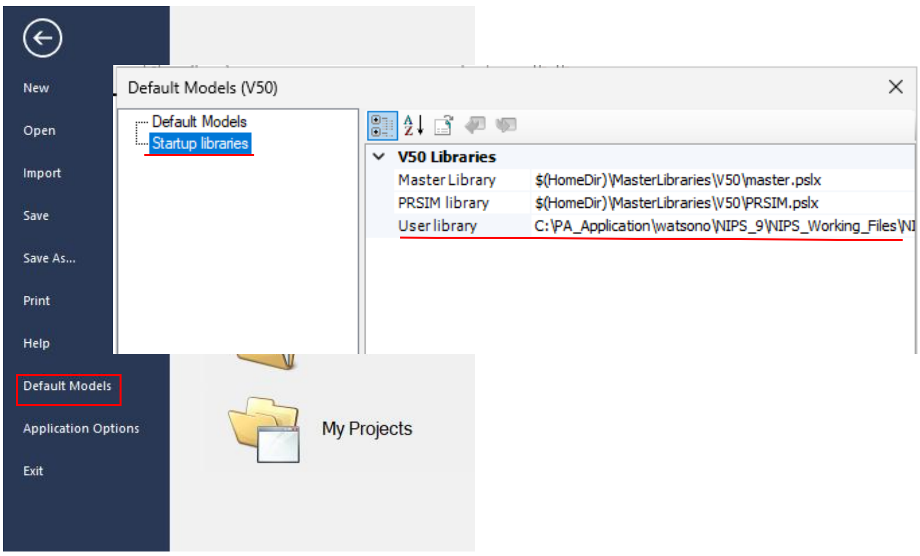



Figure 5: Setting the User Library

2. Load the PRSIM workspace (**prsim_workspace.pfwx**) in PRSIM. Once loaded, the PRSIM workspace tree should appear as follows:

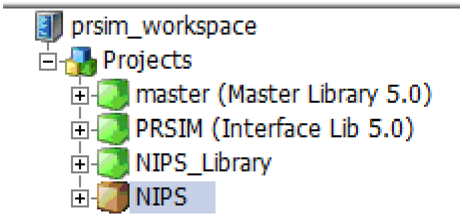



Figure 6: PRSIM Workspace Tree

3. Right-click on **NIPS.pfcx** and use the **Import RAW Data** option to import the **.raw** file exported from PowerFactory above – see Figure 7 below.
4. Use the **Import SEQ Data** option to import the **.seq** file exported from PowerFactory
5. Use **Import DYR Data** option to import **nips.dyr**. Do <u>not</u> use the **.dyr** file export from PowerFactory.

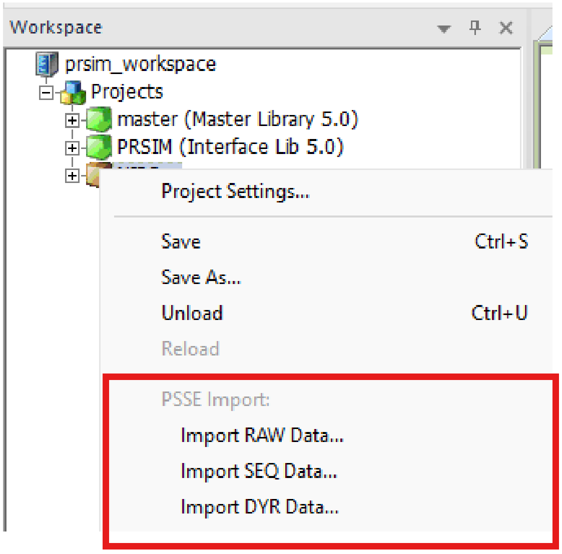



Figure 7: Importing RAW, SEQ and DYR

## 6.4 Expand New Topology (if applicable)

1. After importing the **.raw** file, a "+" sign should appear at any location where new buses have been added* (if topology has not changed, skip to the next section).

** during export to PSSE, note that PowerFactory combines buses with zero impedance connections. Because of this, opening a bus-tie circuit breaker or switch may cause a "new" bus to be created when the previously combined bus is split into two.*

2. Select **Expand Bus** from the menu.
3. Select the bus to expand and place it on the SLD. Repeat for each new bus.

***Tips:*** *Expanding Topology*

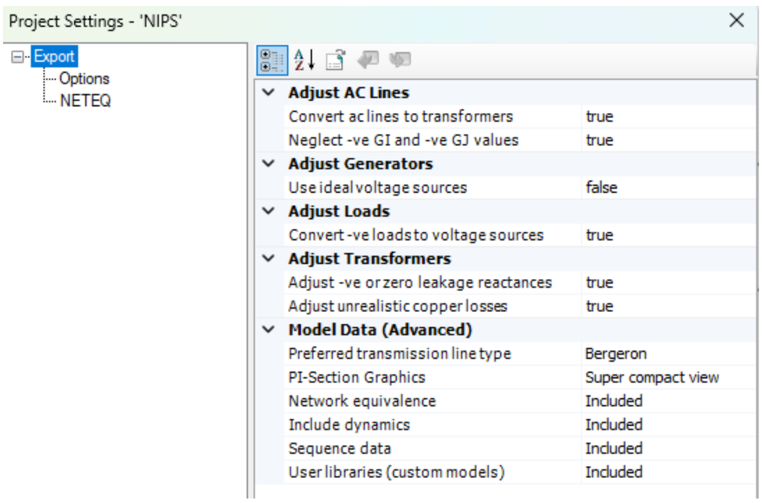
- Avoid overlapping lines on the SLD. PSCAD may treat overlapping lines as electrically connected regardless of the topology contained in the **.raw** file.
- If any items expand outside of a subpage when they should be inside the subpage (or vice versa), they can be copy-and-pasted into the correct location and manually reconnected on the SLD.
- See PRSIM V1.0.0 User Manual for more information on the PRSIM interface.

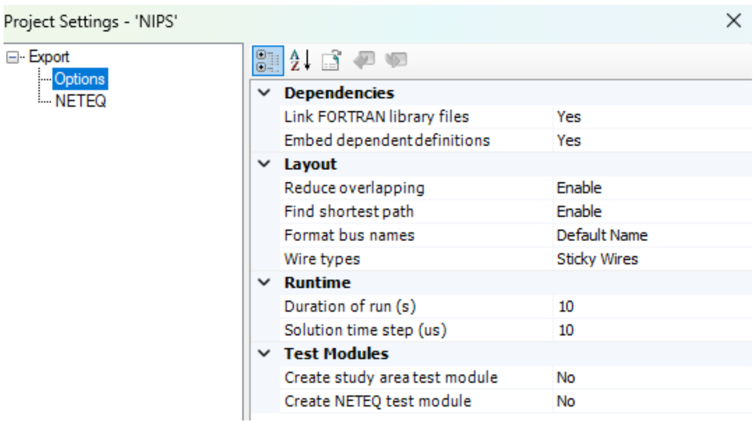
## 6.5 Reduce PRSIM Case to Study Area

1. Ensure that the study area is known. For connection studies, the study area will be specified by System Operator.
2. Delete all buses outside of the study area from the SLD. PRSIM will automatically produce a multi-port equivalence for any buses which are not included in the SLD when exporting to PSCAD.
3. Check that any Inverter Based Resources which will not have a detailed model are assigned a generic model from **NIPS_Library.pslx.** Detailed models can be copied into the PSCAD case later.

## 6.6 Export from PRSIM to PSCAD

1. Navigate to the main schematic (not inside a module/substation) before exporting.
2. Select **Home>Export Settings** in PRSIM and ensure the export settings match the screenshots in Figure 8 below.





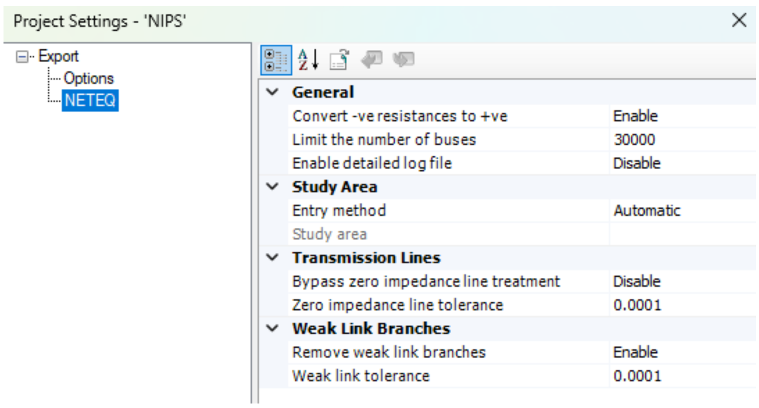




Figure 8: Required Export Settings

3. Click **Ok** to generate the **.psmx** file.
4. Use **Right click > Save As** in the workspace tree to rename the case. Give the case a descriptive name which matches the **.raw** and **.seq** files used to create the case. Do not rename **.psmx** files in the file explorer.
5. The case is now ready for use in PSCAD. Click on **Launch PSCAD** to open the **.psmx** file and all required libraries in PSCAD.

## 6.7 Other Study Cases

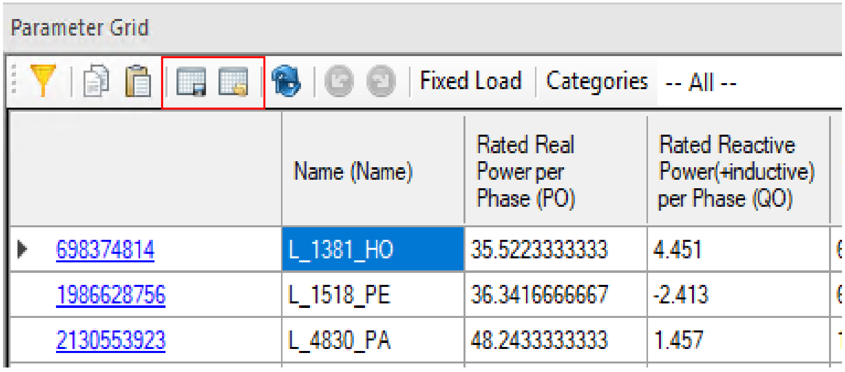
1. If there are other study cases (such as different power flow conditions and outages) follow the workflow at the bottom of Figure 2 in Section 5. In short:
2. Export PowerFactory to PSSE (see section 6.2)
3. Import PSSE to PRSIM (see section 6.3)
4. Export PRSIM to PSCAD (see section 6.6)
5. Repeat for any other study cases.

# 7. Prepare the PSCAD Case

Any PSCAD EMT models being used, both for the connecting asset and any nearby assets, will need to be copied into the case. The generic IBR models included in **NIPS_Library.pslx** and **SIPS_Library.pslx** are not representative of the actual behaviour of the assets.

## 7.1 Load Model

The load models can be edited individually from the parameter grid or in bulk via **.csv** export/import:




| | Name (Name) | Rated Real Power per Phase (PO) | Rated Reactive Power(+inductive) per Phase (QO) |
|---|---|---|---|
| 698374814 | L_1381_HO | 35.5223333333 | 4.451 |
| 1986628756 | L_1518_PE | 36.3416666667 | -2.413 |
| 2130553923 | L_4830_PA | 48.2433333333 | 1.457 |

Figure 9: Import/Export Load Parameters to CSV

Where more specific load behaviour is not required, use a composite load representation consisting of 60% constant current and 40% constant impedance characteristics.

## 7.2 Simulation

Machine dynamics are released at 1 second; a further ~3 seconds should be allowed for the case to reach steady state before studies are performed.

The model has been designed and tested with a time step of 10µs. Users intending to use a different time step should verify the model performance and numerical stability for their specific application.

## 7.3 Network element representation

The following subsections describe how the principal network elements are represented in the PSCAD case exported from PRSIM.

Users should review the representation of each network element and make any study-specific changes required before undertaking EMT studies.

### 7.3.1 Transmission Line

Transmission lines are represented using the positive-, negative-, and zero-sequence resistance, reactance, and susceptance values imported from the PowerFactory case.

Where the electrical length of a transmission line is too short to support a distributed transmission-line model at the specified simulation time step, PRSIM may represent the line using an equivalent PI section. Users may manually replace the equivalent PI section with a frequency-dependent or distributed-parameter transmission-line model where this is necessary for the study.

Replacing a PI section with a distributed transmission-line model may require the simulation time step to be reduced below 10µs. This will increase the overall simulation time.

### 7.3.2 Synchronous Generator

The synchronous generator models included in the PSCAD network case are based on the corresponding machine data in the EMI PowerFactory case. Machine type, operating status, active and reactive power dispatch, and relevant electrical parameters are imported or configured to establish representative operating conditions for EMT studies.

Some generators have transient open-circuit time constants that exceed the default parameter limits applied by PSCAD. This may result in warnings during compilation or case initialisation. These warnings do not normally prevent the case from compiling or running.

Users should review any warnings and confirm that the generator parameters are appropriate for the intended study.

### 7.3.3 AVR and PSS

All synchronous generator excitation systems are represented using the IEEE Type AC1A excitation system model with generic parameters. These generic models support case initialisation and provide a representative voltage-control response but are not intended to reproduce the detailed dynamic performance of individual generating units.

Where plant-specific excitation-system behaviour is important to the study, users should replace the generic AC1A model with an appropriate plant-specific AVR model. The replacement model should be validated against the corresponding source model or available plant response data.

Power System Stabiliser (PSS) models are not included in the PSCAD network case.

### 7.3.4 Governors

Governor models are not included in the PSCAD network case.

### 7.3.5 Transformer and Tap changer

Transformer impedances, operating status, and tap positions are based on the corresponding PowerFactory case. Transformer winding connections and phase-angle displacement are represented using the information available in the PSS/E RAW data exported from PowerFactory.

Automatic tap-changing controls are not included unless specifically configured in the PSCAD case. Tap positions therefore remain fixed during the simulation by default.

Neutral grounding resistors and earthing transformers are not represented automatically. Users should add these components where their representation is relevant to the study, particularly for unbalanced faults, zero-sequence studies, or temporary overvoltage assessments.

### 7.3.6 Loads

Loads imported from PowerFactory are initially represented as constant active and reactive power loads. However, it is generally advised to model the active and reactive power components using a composite load representation consisting of 60% constant current and 40% constant impedance characteristics. This approach has been adopted to provide a realistic approximation of aggregate load behaviour and to align with widely accepted power system load modelling practices.

Follow the process described in Section 7.1 to update the load-model characteristics

### 7.3.7 Shunt elements

Shunt capacitors are represented using the reactive power rating, operating status, and bus voltage from the corresponding PowerFactory case.

Shunt reactors may be imported using an equivalent shunt-capacitor representation with a negative (or zero) reactive power value. Users should review these components and replace them with an appropriate PSCAD reactor model where the reactor’s detailed switching, saturation, energisation, or transient behaviour is relevant to the study.

### 7.3.8 IBRs

Inverter-based resources included in the exported network case are represented using generic models from the NIPS or SIPS PSCAD library. These generic models are intended to support network-case initialisation and are not representative of the detailed control or protection behaviour of the corresponding plant.

## 7.4 Case Validation

Following conversion to PSCAD, users should confirm that the steady-state operating condition remains consistent with the source PowerFactory case. Bus voltages, generator dispatch levels, transformer power flows, and major network transfers should be checked prior to undertaking EMT studies.

# 8. Known Limitations

- This EMT case is intended for connection studies. It is not suitable for other types of studies, such as protection studies.
- WAI three-winding transformer winding angle is unsupported in PSCAD. Winding angle has been hardcoded to a different value to avoid errors.
- ANI three-winding transformer parameters cause numerical instability and must be kept out of service or re-modelled manually in PSCAD.
- Neutral Grounding Resistors (NGRs) are not included in the PSCAD case and should be added by the user where required for the study.
- Shunt reactors are not represented in detail within the PSCAD case. Users should add or replace reactor models where reactor behaviour is relevant to the study objectives.
- Where the conversion of negative loads to voltage-source equivalents may materially affect the study results, the "-ve Load as VS" option shown in Figure 8 should be set to False.
- The HVDC is not modelled; the HVDC bus is left unexpanded in PRSIM so that power flow from HVDC will be included in the multiport equivalence.
- Governors and Power System Stabilisers are not modelled on synchronous machines.
- Synchronous machines all use a generic IEEE AC1A excitation model.
- All IBRs are represented by generic models, which should be replaced with site-specific models as needed.
- Generic Type 1 Wind Turbine Generator model takes several seconds to stabilise.