

Fingrid modelling instruction for PSS/E models –

Data Centers

13.3.2026

Table of Contents

List of abbreviations.....	4
1 Introduction.....	5
1.1 Purpose and scope	5
1.2 Confidentiality.....	5
2 Modelling requirements	5
2.1 Version requirements	5
2.2 Intended use.....	6
2.3 Power flow model aggregation and structure.....	6
2.3.1 General about the power flow model	6
2.3.2 Aggregation.....	7
2.4 The model documentation.....	8
2.5 Dynamic model.....	9
2.5.1 Dynamic model requirements	9
3 References	10

13.3.2026

3 (10)

Change log

Date	Version	Changes
13.3.2026	1.0	First release

13.3.2026

4 (10)

List of abbreviations

LV	Low Voltage
MV	Medium Voltage
NDA	Non-Disclosure Agreement
OVRT	Overvoltage Ride-Through
PFAPR	Post-Fault Active Power Recovery
POC	Point of Connection – The interface between facility and the network
UVRT	Undervoltage Ride-Through

1 Introduction

1.1 Purpose and scope

This document describes the instructions for data center PSS/E simulation models to be delivered to Fingrid as a part of the grid compliance monitoring process presented in the relevant valid Finnish Grid Code, see /1/.

Delivery of a compliant model is an important precondition for demonstrating grid code compliance required to receive Final Operational Notifications for the equipment to be connected to the grid. By following this instruction, the overall quality and compatibility of the models can be ensured, which will also streamline the overall compliance monitoring process.

This document applies only for data centers as *demand facilities*. In case the data center is part of hybrid facility with production or grid energy storage systems that run parallel to the grid, the scope of modelling shall be discussed separately with Fingrid.

In this document, the term *demand unit* is used to describe any individual or aggregated load entity that is interfaced with the grid. This entity could for example consist of power supply and the load it supplies, or it could be a simple static component representing passive site support load, etc.

1.2 Confidentiality

All models and related technical information given to Fingrid will be treated as confidential. Confidentiality obligations have been specified in the Main grid contract and in relevant Finnish Grid Codes, see /1/.

Project specific NDAs (non-disclosure agreement) are not issued by Fingrid.

2 Modelling requirements

This chapter describes the general requirements for PSS/E models.

2.1 Version requirements

The PSS/E version as well as compiler used for project shall be compatible with the version used by Fingrid. The version information shall be inquired from models@fingrid.fi.

2.2 Intended use

The model shall accurately represent the steady-state and dynamic behavior of the demand facility and support the following simulation scenarios:

- Steady-state operation and control of passive components
- Setpoint changes in active and reactive power regulation if applicable
- Control mode changes for regulation of active and reactive power if applicable
- Three-phase fault in external network with an arbitrary fault impedance
- Voltage phase angle and magnitude jumps and changes to the external network impedance following events such as:
 - Disconnection of, and possible subsequent automatic reconnection of any faulty network component in the external network
 - Manual connection or disconnection (without prior fault) of any network component in the external network
- Voltage disturbances and tending voltage collapse with a duration within the required minimum simulation time
- Frequency disturbances (with duration within required minimum supported simulation time)
- Simultaneous disturbances, such as combined voltage and frequency events with active/reactive power regulation

2.3 Power flow model aggregation and structure

2.3.1 General about the power flow model

The model shall include all physical equipment that essentially affects the operation of the demand facility, such as transmission lines and cables, transformers (incl. tap changers), capacitor banks etc. The Thevenin impedance representing the background network shall be modelled as a separate branch instead of a source impedance of the infinite bus machine. Equipment and components which are connected only during island operation (e.g., backup generators) shall not be modelled.

The system base (SBASE) of the simulation model shall be 100 MVA. If the model includes machines, the machine bases (MBASE) shall not be arbitrary. The base voltage for the buses must be set as defined in Table 2. Note that the base voltages defined in

Table 2 are only for modelling purposes and the normal connection point voltages are defined by the relevant network operator.

TABLE 2. SELECTING THE BASE VOLTAGE OF THE BUSES

Normal operating voltage	Base voltage for buses
395–420 kV	400 kV
215–245 kV	220 kV
105–123 kV	110 kV
<105 kV	Normal operating voltage

Bus numbering can be selected freely, however, small bus numbers below 100 shall be avoided.

2.3.2 Aggregation

The goal of aggregation is to minimize the model size and improve the simulation performance efficiency, while maintaining a necessary level of accuracy.

Generally, the aggregation shall comply with the following points:

- The electrical network between the POC (Point of Connection) and main transformers shall be modelled in full detail.
- If demand facility has high voltage back-up supply connections, these must be included in the aggregated model.
- All main transformers shall be modelled separately, preserving winding configurations. Three-winding MV/LV transformers can be modelled as two-winding equivalents.
- All passive component types such as LV cables, MV cables MV/LV transformers, capacitors, filters etc. shall be aggregated per type behind each main transformer.
- All individual demand units 'of the same type' (incl. design and settings) shall be aggregated into as few instances as possible behind each main transformer.

One of the main difficulties in demand facility modelling is aggregation of potentially numerous different types of demand units, for example loads with varying settings, technical capabilities, characteristics, complexities or manufacturers. Simply aggregating only the loads of the same design and settings could lead to excessive number of aggregated model instances, leading to decreased model performance while providing little additional accuracy. Therefore, certain simplifications can be made in defining which loads are 'of the same type' and can be aggregated to single instance. All loads which have similar or close to similar behaviour in the following characteristics can be aggregated to same instance:

- UVRT and OVRT (or current blocking / current limiting, etc.) activation thresholds and other logic
- Load characteristics, i.e. response to smaller voltage and frequency changes (which are not activating any special operation mode, protection function, etc.)
- Protection functions, settings, reconnection logic, etc.

Considering the points above, the demand facility owner must make a proposal for the aggregation and have it approved by Fingrid in the beginning of the modelling process. The proposal should include at least the following:

- Simplified illustrations of demand facility layout (with different loads, load types, voltage levels, passive components and other equipment clearly indicated) before and after aggregation.
- Description of principles used for aggregation as well as any restrictions on its application. This includes listing the characteristics of all loads and which of these have been combined into single aggregated instances.
- The choice of models used for aggregated instances shall also be justified, i.e. why the model is accurate enough for studies. If there were multiple choices for the aggregated instance, why was the used model chosen.

2.4 The model documentation

The model documentation shall include:

- Version history of the complete model. If any changes to the model are required after the initial delivery, these changes shall be listed in the version history.
- Information on which PSS/E versions the model is compatible with.
- Requirements for the simulation environment. This includes the minimum and maximum simulation time steps and other relevant parameters.
- A description of how the aggregation has been implemented in the model.
- A functional description of how the demand facility operates within a time frame of 1 minute. The documentation shall describe at least:
 - The logics and functionalities affecting the operation during and after voltage and frequency disturbances of different magnitudes and durations in the point of connection, such as tripping, load shedding or post-fault recovery sequences.
 - The logics and functionalities affecting the operation during and after voltage and frequency variations within the normal operating voltage and frequency range.

- The logics and functionalities implemented in the simulation model, including the scope of implementation. If some logics or functionalities are omitted from the simulation model, or the scope of the implementation differs, a justification shall be provided.
- Description of protection functions and tripping signals. This includes the description of what protection signals are available to the user, and how to view these signals.
- Description of the modelled additional functionalities such as control logic of mechanically switched capacitor banks and on-load tap changers of transformers.
- Description of different load profiles, if any
- Documentation of model parameters used
- Limitations of the project specific model performance

2.5 Dynamic model

2.5.1 Dynamic model requirements

The demand facility load may be modelled using PSS/E library models (e.g., PERC1 – Power Electronic Load Component Model with Reconnect and Cease Logic), if such generic models can be parametrized to represent under-voltage ride through (UVRT) and post fault active power recovery (PFAPR) of the demand facility with sufficient accuracy. The demand facility may also be modelled with user-defined manufacturer specific models. In this case, the details shall be discussed separately with Fingrid.

For the dynamic models following general requirements must be fulfilled:

- The models shall be able to work with time steps from 1 to 5 ms.
- The initializing of the models shall not cause initial condition suspects. Model flat-run simulation shall not present any changes from the steady state.
- Models shall have stable operation for simulation times up to 5 minutes.
- Models shall have stable operation when simulating with network frequency dependence (NETFRQ) enabled
- The models shall capture the characteristics of the demand facility behavior within its full operating range of active and reactive power.
- The models shall represent the dynamic behavior of the demand facility during and after system faults, voltage disturbances and frequency disturbances.

13.3.2026

10 (10)

- The models shall represent the voltage and frequency dependency of the demand facility load seen at the POC.
- The model shall include all protection functions of the demand facility relevant from the power system perspective. Protection functions shall be modelled within the limits of simulation program capabilities.
- Tap changer dynamic models shall be parametrized with the same setpoints and delays as in the physical device.

3 References

/1/ Grid Code Specifications for Demand Facilities, KJV2018