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Specific study requirements for power park modules connected in vicinity of Fingrid's series compensated network

1 Introduction

This document defines specific study requirements for type D power park modules (converter-connected power plants) connected in vicinity of Fingrid's series compensated network. The requirements are set according to the specific study requirements defined in Grid Code Specifications for Power Generating Facilities (VJV2018, Chapter 5).

During 2020, Fingrid has studied subsynchronous interaction occurring in converter-connected power plants in vicinity of a series compensated network during 2020. In this document, subsynchronous frequency refers to the frequency range between 5 Hz and 45 Hz. According to the results of the study, converter-connected power plants connecting in vicinity of a series compensated network may become engaged in subsynchronous interaction with the series compensated network. Fingrid has published a technical white paper in English on this topic on its website [1].

When unmitigated, subsynchronous interaction between a power plant and a series compensated network may result in significant subsynchronous currents and voltages. Subsynchronous interaction must be taken into account in the design and construction of a power plant to prevent the phenomenon from causing repeated short-term unavailability, as the protection system operates, or significant unavailability, due to equipment failure. The objectives of these requirements are as follows:

- to ensure effective protection for power plants against subsynchronous currents and voltages,
- to minimise the risk of subsynchronous interaction in the various operational states of a transmission grid, including transmission outages as well as typical disturbances and faults,
- to ensure that necessary simulation modelling and measurement data of the power plant is available.

The measures mentioned above improve the availability of power plants and maintain system security and transmission reliability of the entire power system.

The study carried out by Fingrid [1] in particular focuses on wind power plants. The connected devices in other types of power park modules may also utilise similar technology, which means this requirement is set for all type D power park modules connected in vicinity of Fingrid's series compensated network.

2 Scope of application for the requirements

The requirements comprise of two levels as follows:

1. Protection requirements
   - The protection requirements against subsynchronous interaction are set for all type D power park modules connected in vicinity of Fingrid's series compensated network. The requirements are applicable if the connection point of the power plant or the connection point of the connection network of the power plant is located in the area marked with yellow in Figure 1.

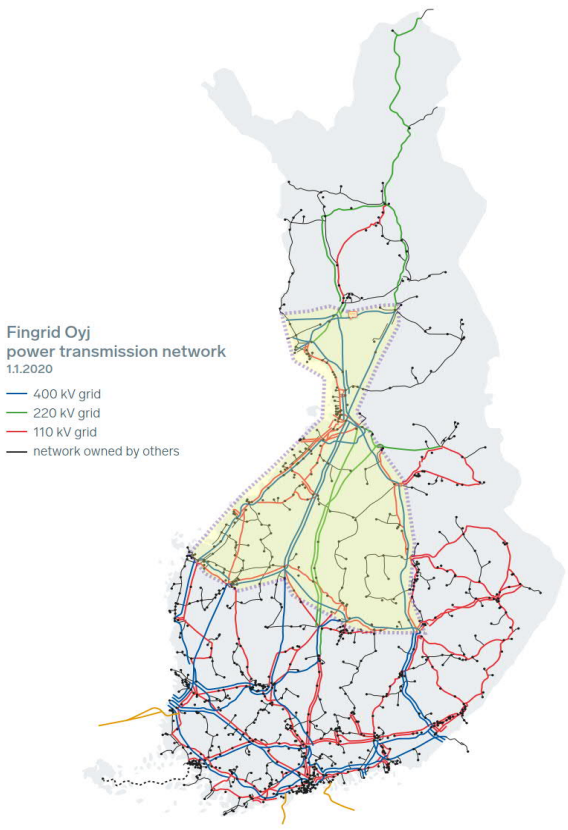

Figure 1. The requirements are applicable if the connection point of the power plant or the connection point of the connection network of the power plant is located in the area marked with yellow in Figure 1.

2. Requirements for simulation modelling, damping and instrumentation
   - The requirements for simulation modelling, damping and instrumentation are set for all type D power park modules of more than 60 MW of rated capacity and connected in vicinity of Fingrid's series compensated network. The requirements are applicable if the connection point of the power plant or the connection point of the connection network of the power plant is located in the area marked with yellow in Figure 1.

3 Requirements

3.1 Protection requirements

The power plant must be protected against any subsynchronous interaction possibly emerging between the power plant and series compensated network to avoid damage to the equipment. The protection must primarily be implemented at each converter-connected unit of the power plant (such as a wind turbine). A separate protection functionality against subsynchronous interaction is not necessary if the manufacturer of the converter-connected unit guarantees that the protection will operate (e.g., protection against over-current and over-voltage) in case of interaction. In such a case, it must be ensured that the measurement system of the protection system does not average or filter the measured signal such that a subsynchronous current or voltage component is not detected. In other words, the protection must be based on measurements of the instantaneous values of voltage and current.

Functioning of the protection must be verified by a type test report recorded at factory testing or similar test conditions.

3.2 Simulation modelling requirements

The power generating facility owner must provide Fingrid with a simulation model and calculation results as early as possible and no later than six months before the planned commissioning of the power plant.

3.2.1 Requirements for the simulation model

A PSCAD model including the project-specific plant control and protection systems must be provided for the power plant. The model must be sufficiently detailed to enable realistic replication of the power plant's operation in the subsynchronous frequency range. A scalable aggregated model is permitted.

The scope of the power plant model must be modelled as follows:

- Park controller modelling, including the park control and regulation systems.
- Turbine(module unit) model, including the turbine control and protection systems.
- The internal electrical network of the power plant, including the main transformer, turbine(module unit) transformers, and the cabling between the above-mentioned components as an aggregated component.
- The electric network between the power plant connection point and the main transformer.
- Mechanically switched capacitors (MSC) or reactors (MSR), if any, including their logic controllers.

Fingrid will provide the short-circuit currents and impedances at the connection point for modelling.

3.2.2 Required modelling analyses

A dynamic impedance scan must be produced using the power plant PSCAD model, which represents the frequency response of the power plant in the subsynchronous frequency range. When carrying out the impedance scan, the voltage control of the power plant must be operational and tuned according to the requirements. The scan must cover the five different operation points of the PQ diagram, using the maximum and minimum short-circuit current levels:

1. P = P_{max}; Q = 0.33 [Q/P_{max}]
2. P = P_{max}; Q = –0.33 [Q/P_{max}]
3. P = P_{min}; Q = Q_{max}
4. P = P_{min}; Q = Q_{min}
5. P = P_{min}; Q = 0 [*pu*]

3.3 Damping analysis and requirements

Fingrid will estimate the risk of subsynchronous interaction between the power plant and grid components using the PSCAD model and the impedance scan provided by the power generating facility owner (Chapter 3.2). In the risk assessment, the results of the impedance scan carried out by the facility owner will be compared with the results of the grid impedance scan carried out by Fingrid. The comparison will account for the present and for the future grid model in various operational situations and outage contingencies (N–0, N–1 and N–2).

If the analysis shows that the power plant may engage in subsynchronous interaction in a single frequency range or several frequency ranges, a re-tuning of the power plant control system will be required to minimise the risk of interaction. Once the re-tuning is completed, the power generating facility owner must provide Fingrid with updated impedance profiles and a new PSCAD model. Based on the delivered information, Fingrid will reassess the risk of power plant's subsynchronous interaction.

Undamped subsynchronous interaction, during normal operation and congestion conditions, will result in repeated short-term unavailability of the power plant, as the protection system operates, or in significant unavailability, due to equipment failure. If subsynchronous interaction cannot be damped by tuning the damping controller of the power plant control system, adequate damping must be achieved by modifying or upgrading the power plant engineering design.

3.4 Instrumentation requirements

The power plant must be equipped with a continuous measuring system that meets the following requirements:

- The measuring equipment must measure and record the instantaneous values of voltage and current of each phase at the connection point or at the high-voltage side of the main transformer closest to the connection point.
- The sample rate and recording rate of the measuring device must be no less than 1 kHz.
- The measurement records must be stored at least for 60 days.

Alternatively, a triggered measuring system may be used instead of continuous measuring, provided that the triggered measuring system meets the following criteria in addition to the requirements stated above:

- Pre + post fault trigger time no less than 30 + 30 seconds.
- The measuring device must be triggered when:
  - the instantaneous voltage is lower than 0.95 pu or higher than 1.05 pu,
  - the instantaneous current is higher than 1.10 pu,
  - the protective relay operates.

Furthermore, an additional measurement is recommended to trigger an alarm when the subsynchronous current level exceeds a pre-set value.

References [1] Subsynchronous Oscillation Risks of Wind Power Plants Connecting to Finnish Series Compensated Network
(URL: https://www.fingrid.fi/globalassets/dokumentit/fi/palvelut/kulutuksen-ja-tuotannon-liittaminen-kantaverkkoon/subsynchronous-oscillation-risk-of-wpps-connecting-to-finnish-series-compensated-network-white-paper.pdf)