

Fingrid Oyj

Test program for prequalification of Fast Frequency Reserve provision

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Introduction

This document describes the tests that shall be performed for prequalifying FFR providing entities in the Nordic power system. The document contains a step-by-step instruction on how to perform the testing.

- Section 1 contains a summary of the process to plan for prequalification. This process is recommended to initiate well in advance of the prequalification testing.
- Section 2 describes preparations to perform just prior to performing the tests.
- Section 3 describes the tests to perform.
- Section 4 indicates tasks to perform after the testing, to handle the test results and to prepare for the formal application.

For a full description of the technical requirements please refer to "The technical requirements and the prequalification process of Fast Frequency Reserve".

1. Planning for prequalification

Prior to performing the prequalification tests, the applying reserve provider should ensure compliance with the following items. When necessary, contact with Fingrid should be established well in advance.

- Take note of the current regulations and technical requirements.
- Ensure that all documents used for reference are the most recent provided by Fingrid.
- Ensure that Fingrid is informed about the testing according to established processes for prequalification.
- Perform analysis of the ability of the entity to be prequalified to comply with the technical requirements and aim to find suitable controller parameters.
- Ensure that uncertainties and/or possible derogations/exceptions are approved by Fingrid before proceeding with tests.
- Decide upon activation frequency and support duration of the providing entity.
- Decide upon the test method depending on if an external or internal signal generator is used. If an internal signal generator is used a complementary test shall be performed.
- Decide maximum and minimum capacity for which the entity should be prequalified. The tests need to be performed for these capacities. If it is clear that the amount of capacity has no impact on fulfilling the technical requirements, testing at minimum capacity can be omitted if agreed with Fingrid before testing.
- Ensure that the measurement system complies with the requirements summarized in Table 1.

Table 1: Minimum requirements for measurements

Measured quantity	Category	Rated power ¹	Accuracy ²	Resolution	Sampling rate
Active power	1	< 2 MW	± 5 %	0.01 MW	10 Hz
	2	2–10 MW	± 1 %		
	3	< 10 MW	± 0.5 %		
Grid frequency	N/A	N/A	± 10 mHz	10 mHz	10 Hz
Applied frequency	N/A	N/A	± 10 mHz	10 mHz	10 Hz

- Ensure that the logged data and real-time telemetry can be provided during FFR provision.
- Become familiar with the tasks to perform after testing, see Section 4.

¹ Rated power of the resource being measured.

² The value shall include the total inaccuracy of instrument (measurement) transformer, measurement transducer and any other equipment in the measurement system.

2. Preparations for testing

Prior to performing the tests, the following points should be checked.

- The providing entity should be set up such that normal frequency measurement input is replaced by an artificial frequency source.
- Ensure that the data outlined below is logged.
- Ensure that logging equipment is correctly time synchronized (if applicable).
- Ensure that logged data can be formatted and reported after the test as required in Section 4.2.

The testing shall preferably be performed by using external equipment as the artificial frequency source, connected to the frequency measurement equipment. If not feasible, an internal signal may be generated in software, but then additional testing shall be performed using natural variations of the system frequency. See Section 3.1 for descriptions of the test methods.

See Table 1 for requirements on accuracy, resolution and sampling rate of the measurements.

Signals to be continuously logged during the tests:

- Instantaneous active power [MW]
- Measured grid frequency [Hz]
- Applied frequency [Hz]
- Status ID indicating which controller parameter set is active, if it can be automatically changed during the test.

In addition, it is recommended that possible other important states that may be affecting the FFR response are logged as well.

3. Prequalification test

This section contains a specification of the tests to be performed. The tests shall be performed for minimum and maximum FFR capacity, or only for maximum capacity if agreed with Fingrid. Results from tests must be reported in test protocols and attached to the application together with logged test data.

3.1. Test methods

There are two possible test methods to use in performing the FFR prequalification. The recommended test method is method 1 which uses an external synthetic test signal. If test method 2 is selected, two tests according to methods 2a and 2b must be performed. For reassessment of an already prequalified entity, the system natural frequency variation test is enough, if the response is satisfactory.

3.1.1. Test method 1 – External synthetic frequency signal

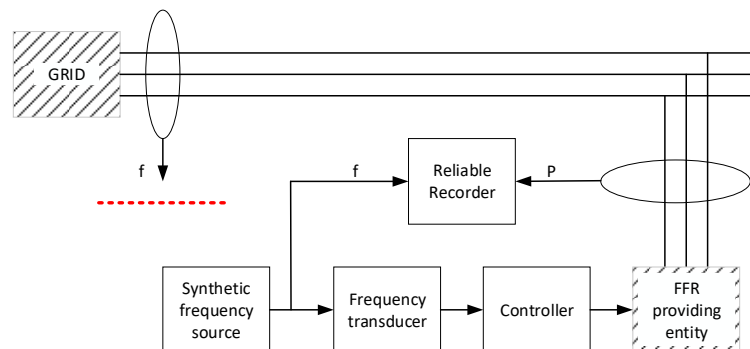


Figure 1. Test with external synthetic frequency signal.

3.1.2. Test method 2a – Internal synthetic frequency signal

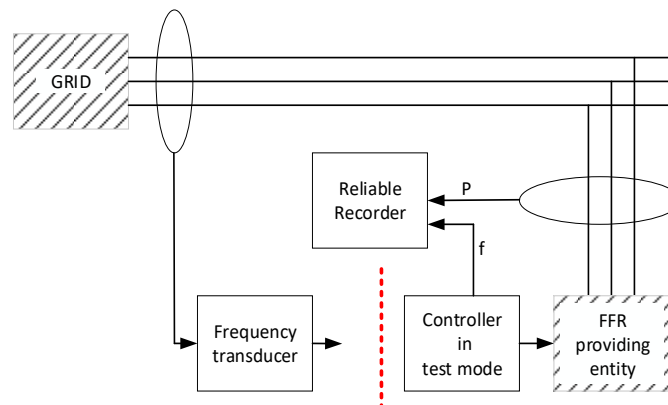


Figure 2. Test with internal synthetic frequency signal.

3.1.3. Test method 2b – Natural system frequency test signal

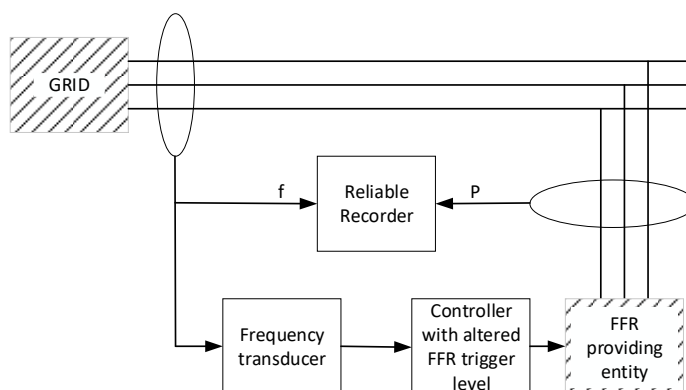


Figure 3. Test with actual system frequency measurement with adjusted frequency activation level

Test method 2b is intended as a complement to test method 2a. The test method 2b means that the trigger level for activating FFR is adjusted close to the current system frequency so that the resource will be activated by normal frequency variations. Thus, all parts of the activation process are tested except the activation level itself, which is tested in test method 2a.

3.2. Test program

The prequalification test shall be performed for all providing entities to determine their capacity.

Perform either a ramp or step response sequence for frequency according to Figure 4 or Figure 5 with selected frequency threshold for activating FFR according to the alternatives found in the technical requirements for FFR. The ramp or step response must be performed from a starting frequency in the range of 49.9–50.1 Hz. The measurement data must be logged for at least 2 minutes prior to applying the test signal. The logging must continue until the providing entity has deactivated and is ready for a new activation.

3.2.1. Step response test

For step response tests according to Figure 4, two steps must be used. FFR must be activated within a frequency band of ± 0.05 Hz around the selected frequency threshold for activation. This means that after the first step, FFR should not be activated, and after the second step, FFR should be activated.

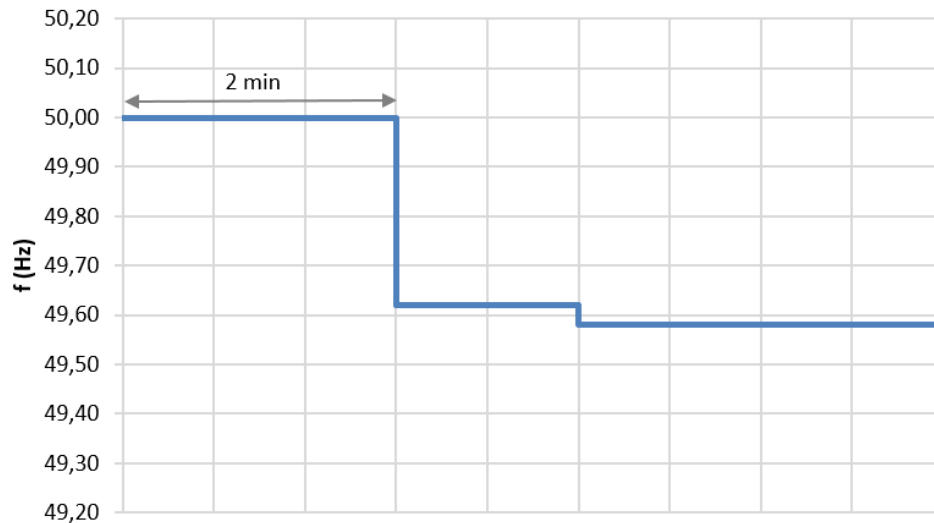


Figure 4. FFR step response sequence, example for activation level 49.6 Hz. First step is performed to a level just above the resource is activated, then another step just below the activation threshold.

3.2.2. Ramp response test

If a ramp response test is performed according to Figure 5, the ramp speed is not critical but must not be faster than -0.2 Hz/s in order for it to be possible to obtain the frequency level at the time of activation. As with the step response test, FFR must be activated within ± 0.05 Hz around the frequency threshold for activation.

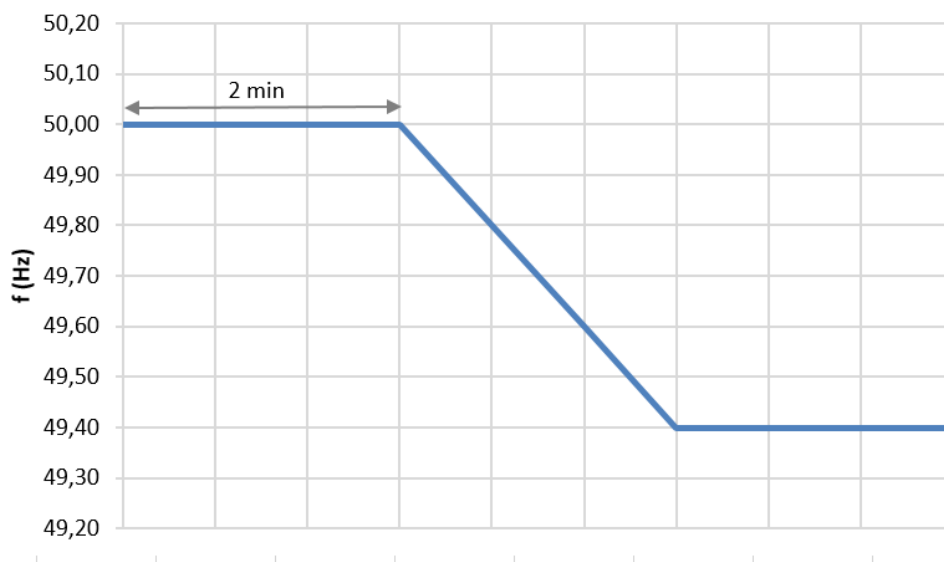


Figure 5. FFR ramp response test.

3.3. Complementary test using natural system frequency

For entities using an internal signal generator as the applied synthetic frequency signal, i.e. test method 2a, an additional test needs to be performed using test method 2b. For this test the natural system frequency shall be used as the input, instead of the synthetic frequency, see section 3.1.3 and Figure 3. The activation threshold frequency for FFR activation shall for the test be adjusted close to the current frequency so that an activation can be expected to occur.

This test will show that the entity will activate its FFR provision correctly when measuring the actual frequency.

4. Tasks to perform after testing

This section contains a description of tasks to be performed after the testing has been concluded, and prior to sending in the prequalification application.

4.1. Data logging

Data shall be prepared in the format for history data specified in Fingrid's "Reserve trading and information exchange guidelines", with the exception that time-stamps do not have to be synchronized to UTC and that a running number of seconds may be used instead of a full time-stamp.

4.2. Reporting

The test results shall be documented in a free-form test report. The data shall be provided to Fingrid in a set of files for the various tests and named on the format [DateTime]_[Resource]_[Test].csv

where:

- [DateTime] = The day and time of the day the test is performed in format YYYYMMDDThhmm e.g. 20190310T1210
- [Resource] = Identifier for the resource agreed with Fingrid, e.g. "FFRG1"
- [Test] = The test performed, e.g. "FFR_step"

For each test the following information shall be provided:

- P_{max} in [MW]
- P_{min} in [MW]
- Active power setpoint of FFR providing entity [MW]
- Expected FFR capacity in [MW] (see **Error! Reference source not found.**)
- Graph showing the applied frequency and the measured power over time

4.3. Calculation of capacity and compliance

This section describes the necessary calculations to determine the expected prequalified capacity and the overdelivery.

4.3.1. Calculation of prequalified capacity

Prequalified FFR capacity is the smallest volume of FFR from the tested unit within the time interval Δt_a , see Figure 6 and mathematically expressed according to Equation 1.

$$C_{pre-qual} = \min(abs(P(t) - P(0))) \text{ [MW]} \quad \text{[Equation 1]}$$

Where,

$C_{pre-qual}$	prequalified FFR capacity [MW]
$P(t)$	active power exchange between the grid and the providing entity [MW]
$P(0)$	baseline for active power
t	time where $t \in \{[t_{FullAct}, t_{FullAct} + t_{MinDur}]\}$
$t_{FullAct}$	maximum activation time (specified for the providing entity according to technical requirements 0.70, 1.00, or 1.30 s)
t_{MinDur}	minimum duration time (specified for the providing entity according to technical requirements 5.0 or 30 s)

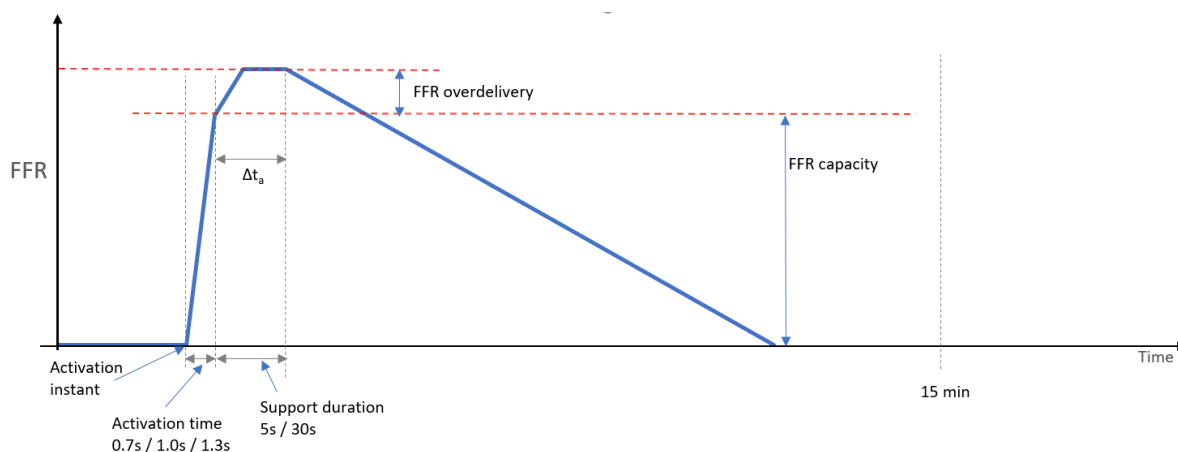


Figure 6: Definition of prequalified FFR capacity, over-delivery, activation time and support duration.

4.3.2. Calculation of overdelivery of prequalified FFR

The maximum permitted overdelivery of FFR capacity is 20% of prequalified FFR capacity, see Figure 6. The overdelivery of FFR is the difference between the maximum delivered FFR capacity in the time interval Δt_a and the prequalified FFR capacity expressed as a percentage of prequalified FFR capacity. Mathematically expressed according to Equation 2.

$$FFR_{OD} = \max(\text{abs}(P(t) - P(0) - C_{pre-qual}))/C_{pre-qual} * 100 [\%] \quad [\text{Equation 2}]$$

Where,

FFR_{OD}	overdelivery of FFR [%]
$C_{pre-qual}$	prequalified FFR capacity [MW]
$P(t)$	active power exchange between the grid and the providing entity [MW]
$P(0)$	baseline for active power
t	time where $t \in \{[t_{FullAct}, t_{cycle}]\}$

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- $t_{FullAct}$ maximum activation time (specified for the providing entity according to technical requirements 0.70, 1.00, or 1.30 s)
- t_{cycle} Time to complete an entire FFR activation cycle, including activation, deactivation, and recovery.