The prequalification process and technical requirements of Frequency Containment Reserve (FCR) Service

Version 22.07.2022

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1 Introduction

This document describes:

- Prequalification process of Reserve Units that will be used to provide Frequency Containment Reserve (hereinafter referred to as FCR))
- Verification of compliance with the technical requirements concerning Reserve Units in accordance with articles 154 and 155 of the Guideline on System Operation, Commission Regulation (EU) 2017/1485.

2 Reserve Unit Prequalification

2.1 Prequalification process

Balancing Service Provider is responsible for carrying out the prequalification tests in accordance with paragraph 4 of this document and for delivering the required information in accordance with paragraph 2.2.

The process illustrated in Figure 1 is followed in the prequalification of a Reserve Unit.

1. The Balancing Service Provider will notify Transmission System Operator about the wish to prequalify a Reserve Unit at least 2 weeks before prequalification testing by providing one or more alternative testing times.
2. After notification, Transmission System Operator will review the testing plan and will assess the testing plan within the 2 weeks.
3. If testing plan is approved, the Balancing Service Provider can proceed with the Reserve Unit prequalification test. Transmission System Operator has the right to send its representative to the prequalification tests. Balancing Service Provider is responsible for the costs caused by the carrying out of the tests and Transmission System Operator only for its own personnel costs. Balancing Service Provider can cancel the pre-qualification test up to 1 hour before the test. If Balancing Service Provider has cancelled all agreed testing times, then the Balancing Service provider has to start the process again from step 1. If not agreed differently.
4. After prequalification test, Balancing Service Provider will share the test results with Transmission System Operator
5. Transmission System Operator will verify that all necessary documentation are provided within 8 weeks. However, both parties work as expedient as possible in good faith.
6. If additional data is needed Balancing Service Provider will be notified and will have 4 weeks to provide missing information.
7. Transmission System Operator will analyze the prequalification test data no later than 3 months. If all necessary documentation is provided and results fulfill the requirements, set in this document, the Reserve Unit is accepted and Transmission System Operator will inform Balancing Service Provider of the result of the prequalification process. If the requirements are not fulfilled, a correction request is sent to the Balancing Service Provider, who has to carry out the necessary corrections or the Reserve Unit is not accepted.

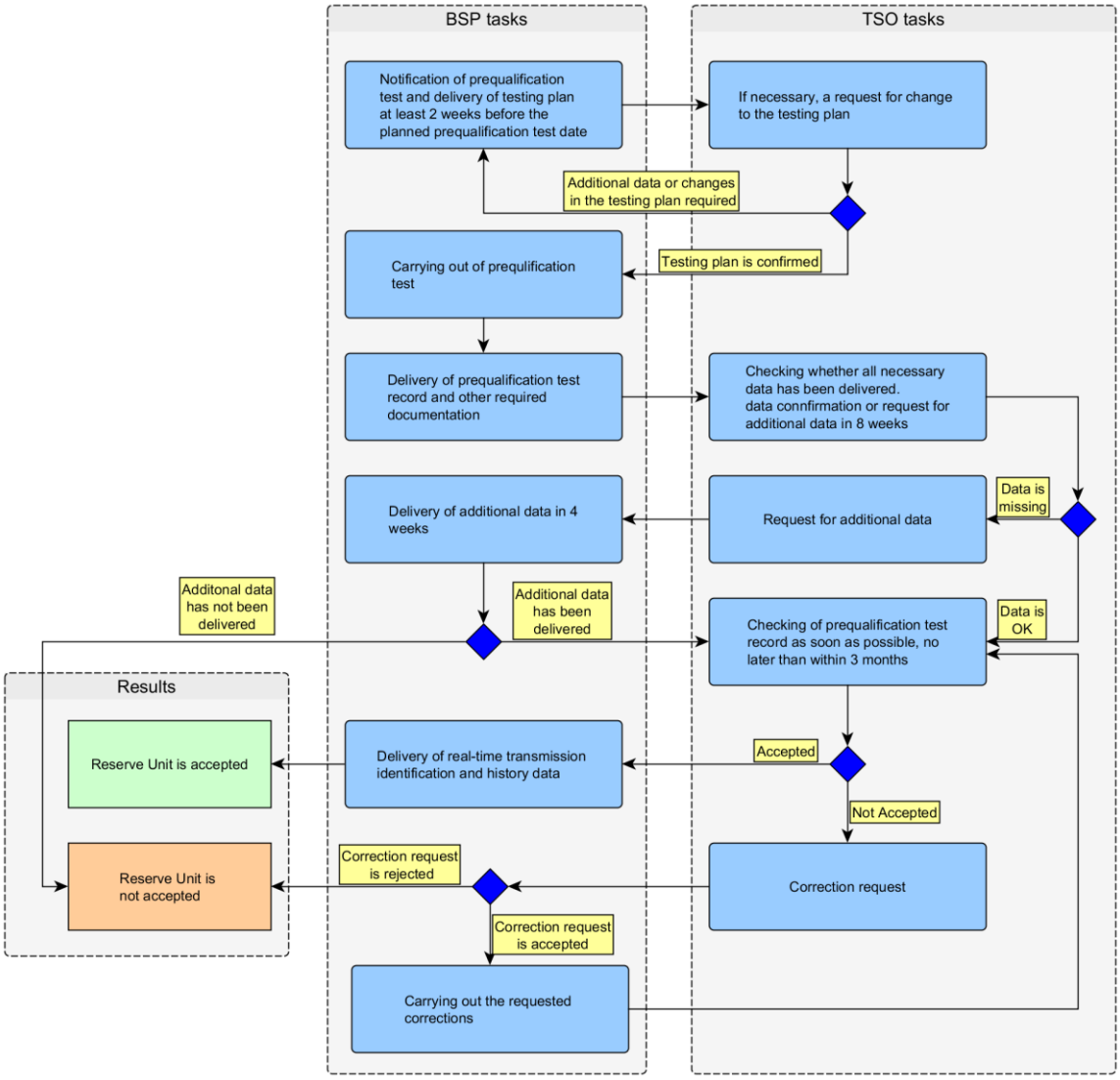

Figure 1. Prequalification process

2.2 Necessary documentation

In the notification to Transmission System Operator the Balancing Service Provider will provide:

1. Symmetric maximum FCR capacity ΔP value to be tested ;
2. initial testing plan for the Reserve Unit or Resource;
3. information about control systems connection standard;
4. if applicable, additional clarifications and description of the working states in which Reserve Unit can provide the specified FCR values;
5. EIC of the Reserve Unit;
6. If applicable, the list of EIC of Reserve Providing Units or technical entities within Reserve Providing Group;
7. EIC of the Balancing Service Provider;
8. Contact details of test responsible;
9. Applicable only for Limited Energy Reservoir (hereinafter referred to as LER) FCR units, comprehensive description of energy reservoir management (hereinafter referred to as ERM) of LER FCR unit and technical details of the energy reservoir.

The Balancing Service Provider will document and deliver the results of the prequalification test to Transmission System Operator electronically according to the Transmission System Operator document “Technical principles and solutions for TSO electrical installations”[1].

Balancing Service Provider is responsible for providing following test records for Reserve Unit:

1. Time-stamped scheduled active power output of all services for Reserve Unit;
2. Time-stamped instantaneous FCR active power for:
    a. Each FCR providing unit,
    b. Each FCR providing group, and
    c. each power generating module or demand unit of a FCR providing group with a maximum active power output larger than or equal to 1,5 MW.
3. Time-stamped instantaneous total active power output:
    a. Each FCR providing unit,
    b. Each FCR providing group, and
    c. each power generating module or demand unit of a FCR providing group with a maximum active power output larger than or equal to 1,5 MW.
4. FCR droop value (or equivalent parameter);
5. FCR deadband;
6. State of charge level for LER FCR providers;
7. Reserve mode status for LER FCR providers.

The data resolution must be equal or lower than 10s.

The requirements concerning the reporting and follow-up of the maintaining of the reserves have been described in Transmission System Operator document “Agreement for Frequency Containment Reserves Service”.

In case of a Reserve Unit prequalification renewal, only the prequalification test record and any changed information needs to be delivered.

[1] Kliendi tootmismooduli katsetamiste ja katsekava koostamise nõuded

2.3 Validity period of prequalification test

The validity period of prequalification test is 5 years. A prequalification test shall be renewed before the ending of the validity period. A prequalification test shall also be renewed whenever changes influencing control capability are carried out on the Reserve Unit.

New prequalification is necessary to increase the maximum FCR capacity of a Reserve Unit. Changes in composition of units participating in a Reserve Unit do not automatically trigger new prequalification if the previous technical capability is maintained.

3 Technical requirements for the service provider

3.1 FCR activation process

Frequency Containment Reserves are activated in decentralized manner based on the measured frequency deviation from nominal frequency of 50 Hz. FCR providers delivers their FCR by means of a proportional control reacting to frequency deviations.

1. For generation units the proportional activation is negative - in case of positive frequency deviation, the power output of the FCR provider shall decrease and vice versa.
2. For demand units the proportional activation is positive - in case of positive frequency deviation, the power output of the FCR provider shall increase and vice versa.
3. The generic activation scheme of a FCR provider is shown in Figure 2. The graph represents on the y-axis the FCR activation (in p.u. of the dimensioned value) and on the x-axis the frequency deviation (mHz) that causes this activation.
4. The curve is intended to be static, it refers to the condition reached once the transient of FCR deployment is completed.

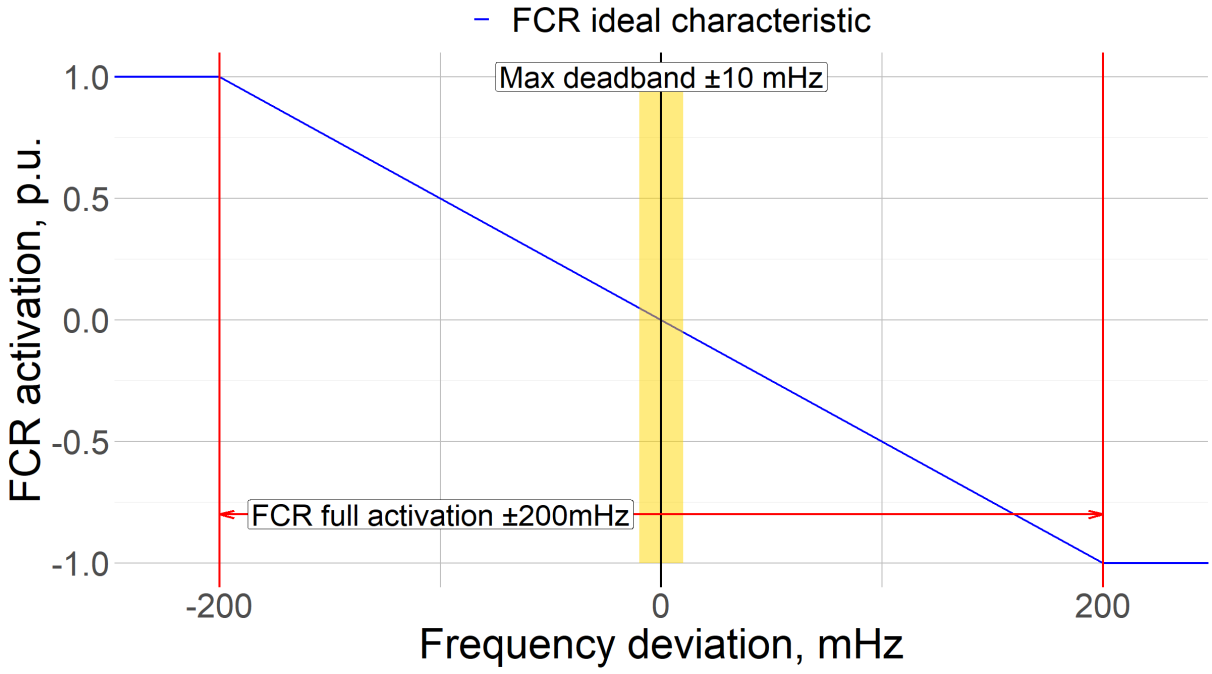

Figure 2. FCR activation curve characteristics

Balancing Service Provider provides real-time measurement of measured frequency and provided FCR amount to connecting TSOs' operation control system.

3.1.1 Centralised activation of FCR providing groups

In presence of technical entities within FCR providing groups activated via centralized system, it shall be guaranteed that a local activation of each technical entity is still possible even in presence of system split or communication issues. All the units shall implement a decentralized frequency measurement per connection point and the measures shall be made on local frequency that always ensure an autonomous FCR activation capability.

Furthermore, technical entities within FCR providing groups activated via centralized system shall be equipped with a functionality aiming at detecting any error in the decentralized system (e.g. loss of communication with decentralized units, failure of the units, etc.). If an error is detected, the provider shall provide the countermeasures needed to ensure the FCR capability.

For each FCR providing group using a centralized system for frequency assessment a separate frequency measurement is required to be established to prevent FCR activation malfunction with frequency measurement failure.

In accordance with SO GL Article 154.9, the usage of centralized frequency measurement is allowed for FCR groups with a prequalified FCR capacity <= 1.5 MW. If a BSP decides to prequalify several FCR groups <= 1.5 MW using centralized frequency measurement, a different frequency meter must be used for each concerned FCR group for redundancy reasons. For any other FCR group, it is required as per product definition local frequency measurement on each delivery point within that FCR group.

3.2 Activation speed

A Reserve Unit contributing to the maintaining of the Frequency Containment Reserves shall follow the following principles:

1. The activation of the FCR by each provider shall begin as soon as possible but no later than 2 s after a frequency deviation. No intentional delay for the activation is allowed. If a provider has need for a delay in the initial activation of active power frequency response greater than 2 s, it is requested to demonstrate the technical reason for the need.
2. in case of a frequency deviation equal to or larger than 200 mHz, at least 50 % of the full FCR capacity shall be delivered at the latest after 15 seconds;
3. in case of a frequency deviation equal to or larger than 200 mHz, 100 % of the full FCR capacity shall be delivered at the latest after 30 seconds;
4. in case of a frequency deviation equal to or larger than 200 mHz, the activation of the full FCR capacity shall rise at least linearly from 15 to 30 seconds; and
5. in case of a frequency deviation smaller than 200 mHz the related activated FCR capacity shall be at least proportional with the same time behaviour referred to in points (1) to (4) and illustrated on Figure 2.

3.3 FCR service accuracy

A potential FCR providing unit or group of units shall be capable of controlling its active power to a set-point value with a steady-state error not greater than ±10% of the FCR capacity or 0,1 MW, whichever is larger.

The frequency measurement used for the frequency control and the determination of the FCR to be provided shall have an accuracy at least 10mHz.

3.4 Technical requirements for LER FCR providers

3.4.1 LER FCR minimum full activation period in alert state

As of triggering the alert state[2] and during the alert state, each LER FCR provider shall ensure a continuous FCR full activation for a time period no less than 30 minutes, defined as TminLER of LER FCR providers. The TminLER requirement is fulfilled by dimensioning the energy reservoir to meet the minimum requirement.

LER FCR providers shall have an active ERM that allows them to ensure a continuous physical activation of FCR in normal state.

The ERM management is an active operation condition in which the state of charge (hereinafter referred to as SOC) is kept within a level that ensure the full activation for a time period no less than 30 minutes whenever an alert state is triggered. This condition is achieved by the FCR provider operating on the energy market or directly exchanging energy with other plants. The ERM management shall not rely on over fulfilment of activation. The activated FCR shall depend only on frequency deviation.

3.4.2 LER FCR provider energy reservoir management requirements

Each LER FCR provider shall provide a comprehensive description of the active ERM of the LER FCR provision by providing information on the following points:

1. Full capacity of energy reservoir;
2. Operational limits that affect usage of reservoir;
3. Operable capacity of reservoir;
4. Permissible charge/discharge power;
5. Description of planned ERM strategy (energy source used for management);
6. Information on the rate of use of ERM (continuous, each 5 min, etc.);
7. Simulation of ERM operation for 24 hours frequency data (TSO shall provide test data);
8. Strategy for operation in alert state and "Reserve Mode";
9. Expected bid regularity and size.

3.4.3 LER FCR Reserve Mode operation

FCR providers with LER shall implement a specific operational status called “Reserve Mode”. This operation consists in limiting the FCR contribution from LER only to short-term frequency deviations, and not to the mean value.

During a long-lasting frequency deviation, as a LER is approaching the exhaustion condition (reservoir completely full or empty), the “Reserve Mode” shall be triggered. The consequence is that the provided FCR is not proportional to frequency deviation anymore. With “Reserve Mode” the FCR is proportional only to the short-term frequency deviations, the mean value is not provided anymore.

The LER shall provide only the FCR proportional to the following signal:

[2] The alert state is a condition in which the system is within operational security limits, but a contingency from a contingency list has been detected and in case of its occurrence the available remedial actions are not sufficient to keep the normal state.
Alert state is triggered by one the two following conditions:

- The absolute frequency deviation has continuously exceeded 50 mHz for 15 minutes.
- The absolute frequency deviation has continuously exceeded 100 mHz for 5 minutes.

$$\Delta f_{RM}(t) = \Delta f(t) - \frac{1}{n(t - t_{aFRR\ FAT})}\left(\sum_{i=o}^{n(t-t_{aFRR\ FAT})} \Delta f(t - t_i)\right)$$

Where:

$\Delta f(t)$ is the frequency deviation at the time t;

$t_{aFRR\ FAT}$ is the Full Activation Time of aFRR of 5 minutes;

$n(t - t_{aFRR\ FAT})$ is the number of frequency deviation samples within$t_{aFRR\ FAT}$

The FCR contribution associated to the mean value ($\Delta f(t) - \Delta f_{RM}(t)$) shall be taken over by aFRR. The Figure helps to explain the work of the “Reserve Mode”.

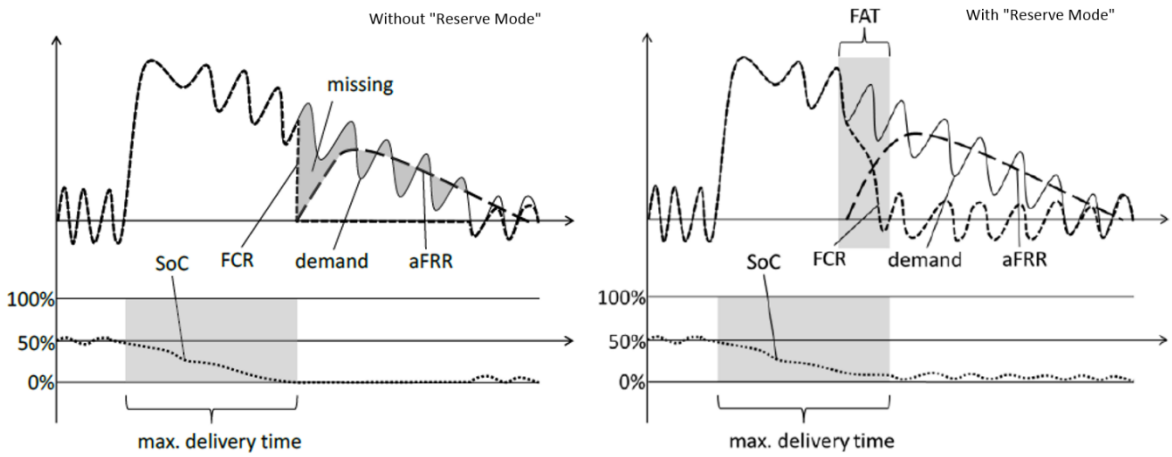

Figure 8. LER "Reserve Model"

The fulfilment of this requirement shall be verified during the prequalification process specified in chapter 4.1.3.

3.4.4 LER FCR providing unit prequalification scaling

LER FCR providing units shall have a ratio of rated power to prequalified FCR of 1.25:1 to ensure system security while operating FCR.

3.5 Real-time data exchange

Balancing Service Provider shall deliver unit-specific data to Transmission System Operator control system (hereinafter referred to as SCADA):

1. FCR status (on/off)
2. FCR capacity (MW), that was sold to the FCR capacity market for current MTU
3. Reserve Unit total scheduled active power output (MW)
4. Reserve Unit total actual active power output (MW)
5. Reserve Unit FCR active power output (MW)
6. FCR droop value (% or equivalent parameter)
7. FCR deadband (mHz)

The sending cycle of the information shall be at least 10 seconds. TSO monitors the activation of the reserve on the basis of the real-time information. The activated FCR volume shall be at least with accuracy 0,01 MW.

3.5.1 Additional real-time data requirement for LER FCR providers

In addition to the previously listed real-time data requirement, LER FCR providers shall provide connecting TSO following data points in real-time with time resolution of at least 10s:

1. State of charge (SOC) level (%)
2. Reserve Mode status (on/off)

4 Prequalification test

Balancing Service Provider shall make sure that a Reserve Unit that provides Frequency Containment Reserve fulfils the requirements laid down in this document. The fulfilment of the requirements shall be verified by means of prequalification tests that shall be carried out in a normal operating situation of the Reserve Unit. The requirements and guidelines given in this document shall be followed in the execution of the prequalification tests.

Balancing Service Provider determines the maximum symmetric FCR capacity to be tested for upward and downward activation. The Reserve Unit providing FCR are tested for dynamic and static characteristics. Both tests are carried out by simulating frequency deviations for the Reserve Unit and initiating the FCR activation. LER FCR units are also tested to verify the LER FCR provider Reserve Mode activation and operation.

4.1.1 FCR static parameter test

4.1.1.1 Purpose of the test

The aim of this test is to characterize the steady state parameters of the frequency control, especially the frequency dead band and the frequency droop. A fictitious frequency disturbance is simulated in the control system of the potential FCR providing unit or group of units to produce active power variations.

4.1.1.2 Initial conditions

The potential FCR providing unit or group of units be connected to the grid and in normal operating conditions.

Initial settings of control:

1. Status of FCR: ON
2. Active power setpoint: Any value permitting full range of activation for FCR (the selected value shall not be modified during the test)
3. Voltage/Reactive power setpoint: Any value
4. Droop setting According to the maximum FCR provision

4.1.1.3 Testing method

The test is carried out simulating fictitious frequency ramps within the control system of the potential FCR providing unit or group of units and recording the corresponding active power variations. The simulation shall be done possibly blocking the disturbances due to the real frequency variations of the grid. The simulating of the frequencies shall be performed by the FCR provider. The simulation of the frequencies shall be recorded during the test and provided for TSO in xls, csv or txt formats. It is required to measure active power response and simulating frequencies with at least 100 ms sample rate.

For the verification of the BSP capability to comply with the requirements for FCR provision in case of large frequency transients and emergency state set in the chapter 4.2.4, the testing

with -/+400 mHz frequency variations shall be performed. The frequency response of FCR providing units is verified during large frequency deviation cases. Frequency response of FCR providing unit has to fulfil minimum FCR provision requirements. FCR providing unit can provide additional FCR in case the frequency deviation exceeds bonds of +/- 200 mHz.

Starting from the initial conditions indicated above, the test shall be done as follows:

1. Define a certain setpoint (base line) around which the following steps will take place.
2. Maintain this setpoint for 30 seconds before the next step, the baseline for the prequalification test is defined by taking the average active power value over the 30 seconds.
3. Simulate a frequency variation *dfsim* from 0 mHz up to 200 mHz with a ramp of 0.4 mHz/s (or similar),
4. Wait for at least 5 minutes (or more if necessary) to reach steady-state conditions,
5. Start a new variation of *dfsim* up to 400 mHz with a ramp of 0.4 mHz/s (or similar),
6. Wait for at least 5 minutes (or more if necessary) to reach steady-state conditions,
7. Start a new variation of *dfsim* from 400 mHz to 200 mHz with a ramp of -0.4 mHz/s (or similar),
8. Wait for at least 5 minutes (or more if necessary) to reach steady-state conditions,
9. Start a new variation of *dfsim* from 200 mHz to -200 mHz with a ramp of -0.4 mHz/s (or similar),
10. Wait for at least 5 minutes (or more if necessary) to reach steady-state conditions,
11. Start a new variation of *dfsim* from -200 mHz to -400 mHz with a ramp of -0.4 mHz/s (or similar),
12. Wait for at least 5 minutes (or more if necessary) to reach steady-state conditions,
13. Start a new variation of *dfsim* from -400 mHz to -200 mHz with a ramp of 0.4 mHz/s (or similar),
14. Wait for at least 5 minutes (or more if necessary) to reach steady-state conditions,
15. Start a new variation of *dfsim* from -200 mHz to 0 mHz with a ramp of 0.4 mHz/s (or similar).

The frequency profile which shall be simulated within the control system of the potential FCR providing unit or group of units is reported in Figure 3.

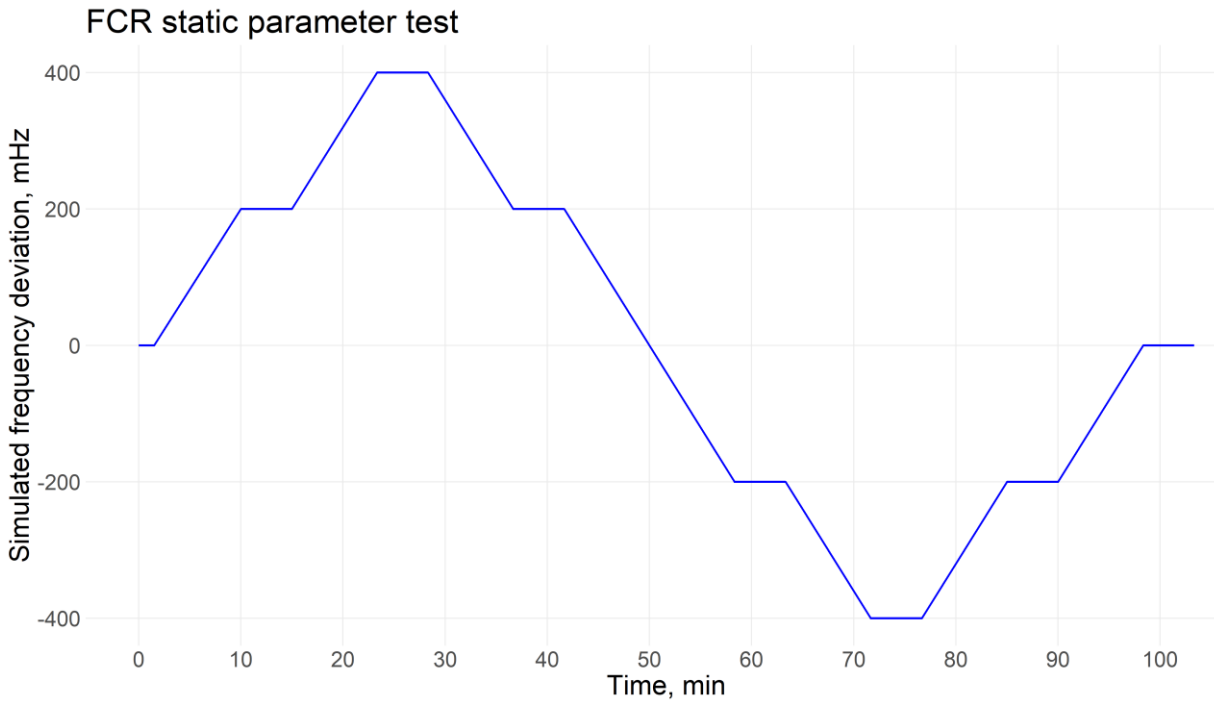

Figure 3. Simulated frequency profile for the static characterization of the frequency control

4.1.1.4 Data analysis

The recordings shall be analysed to derive the static parameters of the frequency control performed by the unit and compare them with the service requirements; especially the following parameters shall be assessed:

1. frequency dead band settings,
2. frequency droop,
3. accuracy of frequency control.

The frequency dead band is identified as the frequency band in which the potential FCR providing unit does not provide an appreciable power contribution.

The frequency droop value is calculated considering the electric power *P*, its reference *Pref* and the value of *dfsim*. Data collected during the test shall be filtered to remove the dynamics of the control.

4.1.2 FCR dynamic parameter test

4.1.2.1 Purpose of the Test

The aim of this test is to characterize the dynamics of the frequency control. A fictitious frequency disturbance is simulated in the speed governor to produce active power variations.

4.1.2.2 Initial conditions

The potential FCR providing unit or group of units shall be connected to the grid and in normal operating conditions.

Initial settings of control:

1. Status of FCR: ON
2. Active power setpoint: Any value between (min+20%) and (max-20%) (the selected value shall not be modified during the test)
3. Voltage/Reactive power setpoint: Any value

The test shall be performed at least at two different active power set-point close to the minimum and maximum values of the operating range of the potential FCR providing unit or group of units

4.1.2.3 Testing method

The test is carried out simulating fictitious frequency steps within the control system of the potential FCR providing unit or group of units and recording the corresponding active power variations. The simulation shall be done possibly blocking the disturbances due to the real frequency variations of the grid.

For the verification of the BSP capability to comply with the requirements for FCR provision in case of large frequency transients and emergency state set in the paragraph 4.2.4 of entire document, the testing with -/+400 mHz frequency variations shall be performed. The frequency response of FCR providing units is verified during large frequency deviation cases. Frequency response of FCR providing unit has to fulfil minimum FCR provision requirements. FCR providing unit can provide additional FCR in case the frequency deviation exceeds bonds of +/- 200 mHz.

Starting from the initial conditions indicated above, the test shall be done as follows:

1. Simulate a frequency step *dfsim* of 200 mHz,
2. Wait for 30 minutes,
3. Simulate a new step of frequency *dfsim* from 200 mHz to 400 mHz,
4. Wait for at least 5 minutes (or more if necessary) to reach steady-state conditions,
5. Simulate a new step of frequency *dfsim* from 400 mHz to 0 mHz,
6. Wait for at least 5 minutes (or more if necessary) to reach steady-state conditions,
7. Simulate a new step of frequency *dfsim* from 0 mHz to -200 mHz,
8. Wait for at least 5 minutes (or more if necessary) to reach steady-state conditions,
9. Simulate a new step of frequency *dfsim* from -200 mHz to -400 mHz,
10. Wait for at least 5 minutes (or more if necessary) to reach steady-state conditions,
11. Start a step variation of *dfsim* from -400 mHz to 0 mHz,
12. Wait for at least 5 minutes (or more if necessary) to reach steady-state conditions,

The resulting simulated frequency profile is reported in Figure 4.

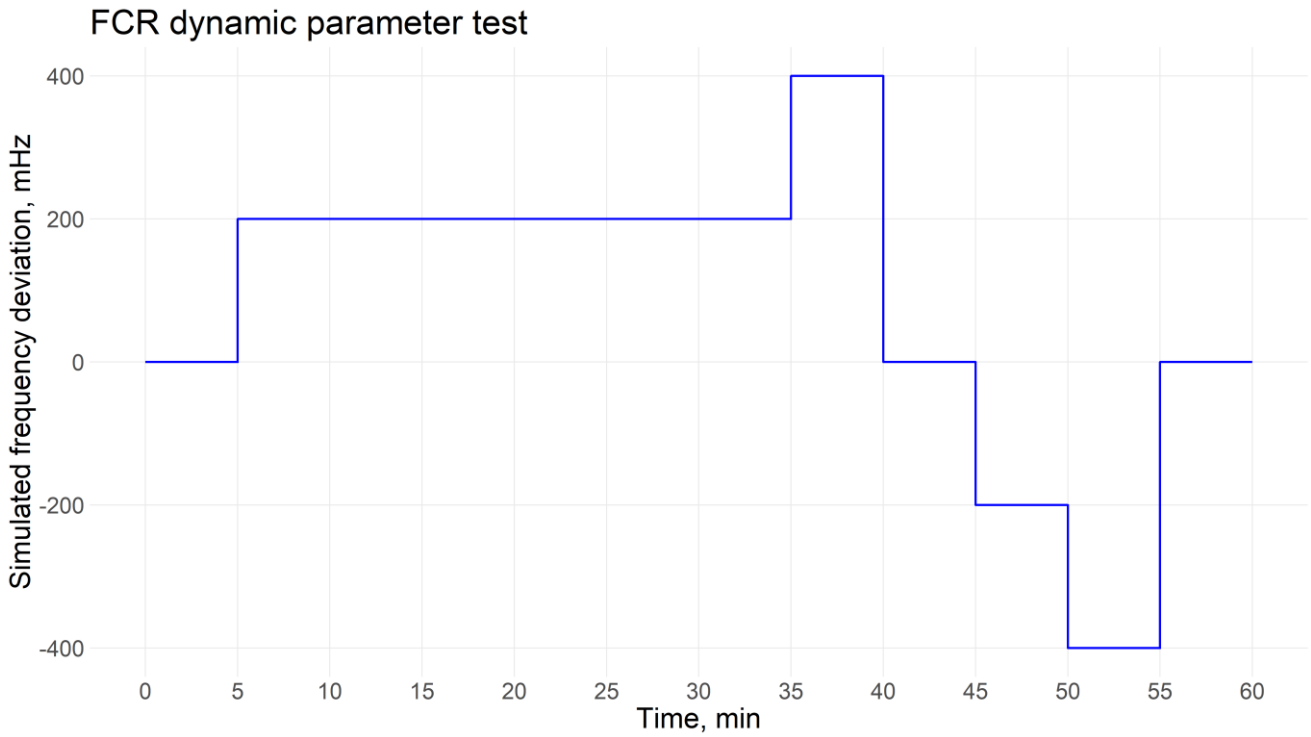

Figure 4. Simulated frequency profile for the dynamic characterization of frequency control deployment

4.1.2.4 Data analysis

The recordings shall be analysed to derive the dynamic parameters of the frequency control performed by the unit and compare them with the service requirements; the following parameters of the control shall be assessed:

1. Activation and full activation times. The FCR providing BSP shall be capable of activating full active power response at or above the line shown in Figure 2.
2. Temporary over-fulfilment (overshoot) and stability of the control.

The stability of the frequency control is assessed considering the overall behaviour of the electric power *P* and the value of *dfsim*. For steady frequency value, the generated power shall also be steady at its steady state value. The overshoots shall be less than 10 percent of maximum FCR service amount. If overshoot exceeds 10% of maximum FCR service amount, technical explanation shall be provided.

4.1.3 LER FCR Reserve Mode test

4.1.3.1 Purpose of the test

The aim of the test is to confirm the Reserve Mode capability of LER FCR providers as described in chapter 3.4.3

4.1.3.2 Initial conditions

The potential LER FCR providing unit or group of units be connected to the grid and in normal operating conditions.

1. Status of FCR: ON
2. Status of energy reservoir within range of 40-60% SOC
3. Active power setpoint: Any value which allows to keep the energy reservoir stable at its initial value
4. Voltage/Reactive power setpoint: Any value

4.1.3.3 Testing method

The test is carried out by simulating fictious frequency steps within the control system of the potential LER FCR providing unit or LER FCR providing group. The simulation shall be done possibly blocking the disturbances due to the real frequency variations of the grid.

Starting from the initial conditions indicated above, the test shall consist in:

1. Start of the test with frequency deviation of 0 mHz;
2. At 5 minutes, step from *dfsim* 0 mHz to *dfsim* +150 mHz and wait for 5 minutes;
3. At 10 minutes, Reserve Mode status shall be activated and oscillation of simulated frequency between range of +/- 50 mHz shall be simulated to reflect the short-term frequency deviations for 15 minutes;
4. At 25 minutes, frequency deviation set-point is changed to *dfsim* 0 mHz and Reserve Mode is deactivated wait for 5 minute;
5. Step from *dfsim* 0 mHz to *dfsim* -150mHz and wait for 5 minutes;
6. Reserve Mode status shall be activated and oscillation of simulated frequency between range of +/- 50 mHz shall be simulated to reflect the short-term frequency deviations for 15 minutes;
7. Frequency deviations is returned to *dfsim* 0 mHz and Reserve Mode is deactivated.

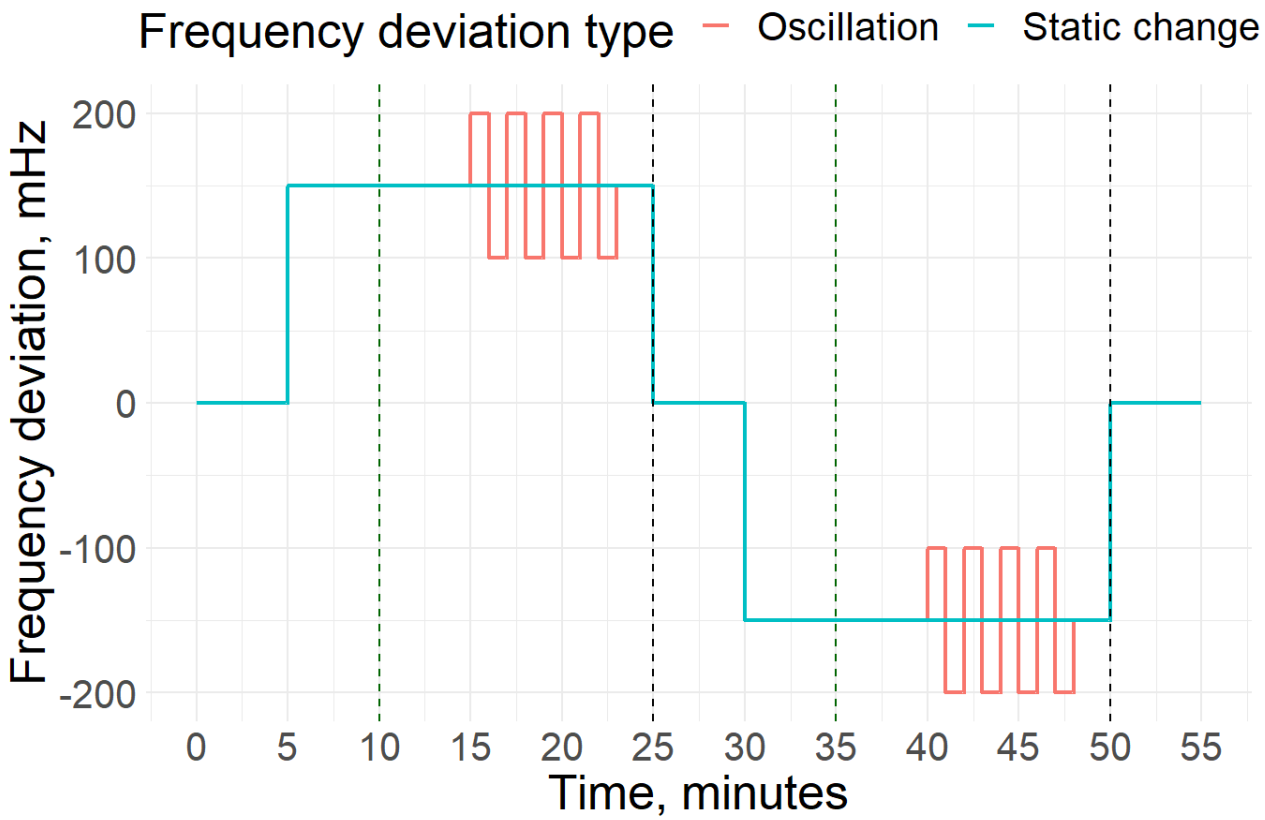

Figure 5. Example LER FCR Reserve Mode test with frequency deviation oscillation

4.1.3.4 Data analysis

The recordings shall be analysed to derive the frequency oscillation response in Reserve Mode. The actual response of the unit shall be compared with the service requirements, where

the LER FCR provider with Reserve Mode activated must be able to follow the frequency oscillation activations.