**Network Code Compliance Testing Programme**

*/Translation from the Lithuanian language/*

**(According to connection conditions**

**LITGRID AB XX/XX/202X No 2XXX-SD-XXXX)**

*Version No 1*

*23/12/2024*

# **General Requirements**

## **Aim of the Document**

This document describes the compliance testing programme that must be successfully performed in accordance with the technical requirements for grid connection for Type D battery energy storage systems. The requirements for the control of battery energy storage systems are published on the website of Litgrid AB: [Requirements](https://www.litgrid.eu/uploads/files/dir675/dir33/dir1/4_0.php).

## **Abbreviations, Definitions and Symbols**

|  |  |
| --- | --- |
| **BESS** | Battery energy storage system |
| **PSET** | Setting of the active power setpoint to the CS. Power setpoint of unlimited park is 100%, and of fully limited is 0%. |
| **PN** | Installed power on the DC side |
| **PMAX** | Maximum capacity in consumption mode (Pmax,c), i.e. the maximum active power of the battery energy storage system at the connection point that the BESS can consume. The maximum capacity for consumption is indicated when submitting a request to issue the connection conditions for the connection of facilities to the electricity transmission network. Maximum capacity in generation mode (Pmax,g), i.e. the maximum active power of the battery energy storage system at the connection point that the BESS can generate into the network. The maximum capacity for generation is indicated when submitting a request to issue the connection conditions for the connection of facilities to the electricity transmission network. |
| **PALLOWABLE** | The maximum active power that can be supplied from electrical facilities of network users to the electrical networks of the transmission system operator or distribution system operator at the connection point and specified in the electrical facilities connection agreement concluded between the transmission system operator or distribution system operator and the network user, the statement of ownership limits, and/or other documents related to the electrical facilities of the network user. |
| **PAVL** | Power that can be generated into the network, taking into account the capacity of the BESS. |
| **P** | Generated active power |
| **FSIM** | Simulation frequency value |
| **POC** | Point Of Connection |
| **CS** | Control system |
| **SOC** | State of charge |
| **NU** | Network user |

## **General Information About the Compliance Tests**

Before initiating the compliance tests with the transmission system operator (TSO), the NU must carry out internal tests, in the course of which the operation of the BESS should be harmonised according to the requirements specified in the connection conditions of the TSO. When initiating the tests with the TSO, the NU shall declare that the BESS is functioning correctly and provide the parameters recorded during the tests.

On the day of the compliance tests, the NU must arrange for and delegate appropriate technical personnel to perform the tests. The employees represented by the NU must be able to fully understand the functions of the BESS and their connection to the grid to which the BESS is connected. Also, they must be able to set up the BESS control system so that the test programme can be carried out properly.

Before testing, the NU must submit to the TSO an operational application at least 1 business day before the desired testing date at the following e-mail address: [ltdisp@litgrid.eu](mailto:ltdisp@litgrid.eu). After assessing the availability and planned outages, the TSO representatives may approve/reject the application (compliance tests shall be carried out only after the application has been approved).

If the BESS is unable to perform any test and/or modifications in the control algorithms occur during the testing, the test must be repeated in agreement with the TSO.

If the tests fail to achieve the intended performance, the NU must provide a reasonable explanation to the TSO. In the course of BESS compliance tests, the test programme may be modified depending on the state of charge of the BESS. In this case, the TSO and the manufacturer must mutually agree on adjustments to any steps of the programme during the tests.

The final letter of approval will be sent by the TSO to the National Energy Regulatory Council after the manufacturer has performed all tests and submitted the compliance report, mathematical model, and certificates of compliance.

## **Recording of Data**

During the testing, the data shall be recorded for verification. At least the following data shall be recorded and submitted (e.g. as .csv files). In addition to the test report, the NU will be required to provide the data recorded during the tests in .csv format.

Table 1. Signals to be recorded during the test

|  |  |
| --- | --- |
| **Signal name** | **Measurement frequency** |
| P | 10 Hz |
| Q | 10 Hz |
| PAVL | 10 Hz |
| PSET | 10 Hz |
| FSIM | 10 Hz |
| VSET | 10 Hz |
| QSET | 10 Hz |
| SOC | 10 Hz |

## **BESS Data**

Table 2. Technical information about the BESS

|  |  |  |
| --- | --- | --- |
|  | BESS project location |  |
|  | PN |  |
|  | PMAX |  |
|  | PALLOWABLE |  |
|  | PCONSUMPTION |  |
|  | Nominal voltage at POC |  |
|  | Network operator: | Litgrid AB |
|  | NU contact details |  |
|  | Contact details of the testing company |  |

# **Network Code Compliance Tests**

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| **Active Power Control** | | | | | |
| *Pre-test settings:*   1. **The amount of energy (SOC) required to perform the test.** 2. **Frequency control – disabled.** 3. **Reserve function – disabled.** | | | | | |
| **Active power generation mode with 10% Pmax/min variation rate** | | | | | |
| Step | Action | Start time and initial MW value | Time when final value and MW value are reached | Comments | Verification criteria |
|  | **NU starts data recording.** |  |  |  | Accuracy of the actual control command execution must not exceed ±5% of the set value or a maximum of ±3% of PN, whichever gives the higher allowable limit. The integrated 10-minute average should not exceed 1% of PN. Readjustments must not exceed 10% of PMAX. |
|  | BESS CS sends the 100% PSET1 generation task and waits for 1 minute after the set value is reached. |  |  |  |
|  | TSO starts the generation limitation by activating the active power generation limitation function. |  |  |  |
|  | TSO sets the limit: PSET1 = XX MW [60% PALLOWABLE] and waits for 2 minutes after the set value is reached. |  |  |  |
|  | TSO sets the limit: PSET2 = XX MW [30% PALLOWABLE] and waits for 2 minutes after the set value is reached. |  |  |  |
|  | TSO sets the limit: PSET3 = XX MW [20% PALLOWABLE] and waits for 2 minutes after the set value is reached. |  |  |  |
|  | TSO sets the limit: PSET4 = XX MW [10% PALLOWABLE] and waits for 2 minutes after the set value is reached. |  |  |  |
|  | TSO sets the limit: PSET6 = XX MW [0% PALLOWABLE] and waits for 2 minutes after the set value is reached. |  |  |  |
|  | TSO deactivates the active power generation limitation function. |  |  |  |
|  | **NU stops data recording.** |  |  |  |
| **Active power consumption mode with 10% Pmax/min variation rate** | | | | | |
| Step | Action | Start time and initial MW value | Time when final value and MW value are reached | Comments | Verification criteria |
|  | **NU starts data recording.** |  |  |  | Accuracy of the actual control command execution must not exceed ±5% of the set value or a maximum of ±3% of PN, whichever gives the higher allowable limit. The integrated 10-minute average should not exceed 1% of PN. Readjustments must not exceed 10% of PMAX. |
|  | BESS CS sends the 100% PSET1 consumption task and waits for 1 minute after the set value is reached. |  |  |  |
|  | TSO starts the consumption limitation by activating the active power consumption limitation function. |  |  |  |
|  | TSO sets the limit: PSET1 = XX MW [60% PALLOWABLE] and waits for 2 minutes after the set value is reached. |  |  |  |
|  | TSO sets the limit: PSET2 = XX MW [30% PALLOWABLE] and waits for 2 minutes after the set value is reached. |  |  |  |
|  | TSO sets the limit: PSET3 = XX MW [20% PALLOWABLE] and waits for 2 minutes after the set value is reached. |  |  |  |
|  | TSO sets the limit: PSET4 = XX MW [10% PALLOWABLE] and waits for 2 minutes after the set value is reached. |  |  |  |
|  | TSO sets the limit: PSET6 = XX MW [0% PALLOWABLE] and waits for 2 minutes after the set value is reached. |  |  |  |
|  | TSO deactivates the active power consumption limitation function. |  |  |  |
|  | **NU stops data recording.** |  |  |  |

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| **Deadband Control Test** |

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| *Pre-test settings:*   1. **The amount of energy (SOC) required to perform the test.** 2. **Active power limitation and consumption function – disabled.** 3. **FSM frequency control – enabled.** 4. **Control of limited frequency sensitivity – overfrequency/underfrequency – disabled.** 5. **FSM deadband – 200 mHz.** 6. **Droop – 1%.** | | | | | |
| Step | Action | Start time and initial MW value | Time when final value and MW value are reached | Comments | Verification criteria |
|  | **NU starts data recording.** |  |  |  | Active power response must start to be generated no later than 0.5 seconds and end no later than 30 seconds after sending the frequency setpoint.  Accuracy of the actual control command execution must not exceed ±5% of the set value or a maximum of ±3% of PN, whichever gives the higher allowable limit. The integrated 10-minute average should not exceed 1% of PN. Readjustments must not exceed 10% of PMAX. |
|  | BESS CS sets simulation frequency value of 50Hz. |  |  |  |
|  | BESS CS sets simulation frequency signal FSET1 49.81Hz and waits for 1 minute after the set value is reached. |  |  | Active power response must not be generated. |
|  | BESS CS sets simulation frequency signal FSET2 50Hz and waits for 1 minute after the set value is reached. |  |  |  |
|  | BESS CS sets simulation frequency signal FSET3 49.79Hz and waits for 1 minute after the set value is reached. |  |  | Active power response +2% PMAX must occur. |
|  | BESS CS sets simulation frequency signal FSET4 50Hz and waits for 1 minute after the set value is reached. |  |  | Active power value must return to the previous value. |
|  | BESS CS sets simulation frequency signal FSET5 50.19Hz and waits for 1 minute after the set value is reached. |  |  | Active power response must not be generated. |
|  | BESS CS sets simulation frequency signal FSET6 50Hz and waits for 1 minute after the set value is reached. |  |  |  |
|  | BESS CS sets simulation frequency signal FSET7 50.21Hz and waits for 1 minute after the set value is reached. |  |  | Active power response -2% PMAX must occur. |
|  | BESS CS sets simulation frequency signal FSET8 50.00Hz and waits for 1 minute after the set value is reached. |  |  | Active power value must return to the previous value. |
|  | **NU stops data recording.** |  |  |  |  |

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| **Frequency Response Insensitivity Test** |

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| *Pre-test settings:*   1. **The amount of energy (SOC) required to perform the test.** 2. **Active power limitation and consumption function – disabled.** 3. **FSM frequency control – enabled.** 4. **Control of limited frequency sensitivity – overfrequency/underfrequency – disabled.** 5. **FSM deadband – 0 mHz.** 6. **Droop – 0.2%.** | | | | | |
| Step | Action | Start time and initial MW value | Time when final value and MW value are reached | Comments | Verification criteria |
|  | **NU starts data recording.** |  |  |  | Active power response must start to be generated no later than 0.5 seconds and end no later than 30 seconds after sending the setpoint.  Accuracy of the actual control command execution must not exceed ±5% of the set value or a maximum of ±3% of PN, whichever gives the higher allowable limit. The integrated 10-minute average should not exceed 1% of PN. Readjustments must not exceed 10% of PMAX. |
|  | BESS CS sets simulation frequency value of 50Hz. |  |  |  |
|  | BESS CS sets simulation frequency signal FSET1 49.991Hz and waits for 1 minute after the set value is reached. |  |  | Active power response may be not generated. |
|  | BESS CS sets simulation frequency signal FSET2 50Hz and waits for 1 minute after the set value is reached. |  |  | Active power value must return to the previous value. |
|  | BESS CS sets simulation frequency signal FSET3 49,989Hz and waits for 1 minute after the set value is reached. |  |  | Active power response +11% PMAX must occur. |
|  | BESS CS sets simulation frequency signal FSET4 50Hz and waits for 1 minute after the set value is reached. |  |  | Active power value must return to the previous value. |
|  | BESS CS sets simulation frequency signal FSET4 50.009Hz and waits for 1 minute after the set value is reached. |  |  | Active power response may be not generated. |
|  | BESS CS sets simulation frequency signal FSET5 50Hz and waits for 1 minute after the set value is reached. |  |  | Active power value must return to the previous value. |
|  | BESS CS sets simulation frequency signal FSET6 50.011Hz and waits for 1 minute after the set value is reached. |  |  | Active power response -11% PMAX must occur. |
|  | BESS CS sets simulation frequency signal FSET7 50Hz and waits for 1 minute after the set value is reached. |  |  | Active power value must return to the previous value. |
|  | **NU stops data recording.** |  |  |  |

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| **Frequency Sensitive Mode Test** |

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| *Pre-test settings:*   1. **The amount of energy (SOC) required to perform the test.** 2. **Active power limitation and consumption function – disabled.** 3. **FSM frequency control – enabled.** 4. **Control of limited frequency sensitivity – overfrequency/underfrequency – disabled.** 5. **FSM deadband – 0 mHz.** 6. **Droop – 4%.** | | | | | |
| Step | Action | Start time and initial MW value | Time when final value and MW value are reached | Comments | Verification criteria |
|  | **NU starts data recording.** |  |  |  | Active power response must start to be generated no later than 0.5 seconds and end no later than 30 seconds after sending the setpoint.  Accuracy of the actual control command execution must not exceed ±5% of the set value or a maximum of ±3% of PN, whichever gives the higher allowable limit. The integrated 10-minute average should not exceed 1% of PN. Readjustments must not exceed 10% of PMAX. |
|  | BESS CS sets simulation frequency value of 50Hz. |  |  |  |
|  | BESS CS sets simulation frequency signal FSET1 49.8Hz and waits for 15 minutes after the set value is reached. |  |  | Active power response +10% PMAX must occur. |
|  | BESS CS sets simulation frequency signal FSET2 50Hz and waits for 1 minute after the set value is reached. |  |  | Active power value must return to the previous value. |
|  | BESS CS sets simulation frequency signal FSET3 50.2Hz and waits for 15 minutes after the set value is reached. |  |  | Active power response -10% PMAX must occur. |
|  | BESS CS sets simulation frequency signal FSET4 50Hz and waits for 1 minute after the set value is reached. |  |  | Active power value must return to the previous value. |
|  | **NU stops data recording.** |  |  |  |

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| **Limited Frequency Sensitive Mode — Overfrequency/Underfrequency Test** |

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| *Pre-test settings:*   1. **The amount of energy (SOC) required to perform the test.** 2. **Active power limitation and consumption function – disabled.** 3. **FSM frequency control – disabled.** 4. **Control of limited frequency sensitivity – overfrequency/underfrequency – enabled.** 5. **LFSM deadband – 200 mHz.** 6. **Droop – 5%.** | | | | | |
| Step | Action | Start time and initial MW value | Time when final value and MW value are reached | Comments | Verification criteria |
|  | **NU starts data recording.** |  |  |  | Active power response must start to be generated no later than 0.5 seconds and end no later than 30 seconds after sending the setpoint.  Accuracy of the actual control command execution must not exceed ±5% of the set value or a maximum of ±3% of Pn, whichever gives the higher allowable limit. The integrated 10-minute average should not exceed 1% of Pn. Readjustments must not exceed 10% of PMAX. |
|  | BESS CS sets simulation frequency value of 50Hz. |  |  |  |
|  | BESS CS sets simulation frequency signal FSET1 50.5Hz and waits for 2 minutes after the set value is reached. |  |  | Active power response -12% PMAX must occur. |
|  | BESS CS sets simulation frequency signal FSET2 50Hz and waits for 1 minute after the set value is reached. |  |  | Active power value must return to the previous value. |
|  | BESS CS sets simulation frequency signal FSET3 49.5Hz and waits for 1 minute after the set value is reached. |  |  | Active power response +12% PMAX must occur. |
|  | BESS CS sets simulation frequency signal FSET4 50Hz and waits for 1 minute after the set value is reached. |  |  | Active power value must return to the previous value. |
|  | **NU stops data recording.** |  |  |  |  |

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| **Limited Frequency Sensitive Mode — Overfrequency/Underfrequency and Frequency Sensitive Mode Test** |
| *Pre-test settings:*   1. **The amount of energy (SOC) required to perform the test.** 2. **Active power limitation and consumption function – disabled.** 3. **FSM frequency control – enabled.** 4. **Control of limited frequency sensitivity – overfrequency/underfrequency – enabled.** 5. **FSM deadband – 10 mHz.** 6. **LFSM deadband – 200 mHz.** 7. **FSM droop – 4%.** 8. **LFSM droop – 5%.**   **Algorithm for running the FSM and LFSM together must be executed according to Fig. 1Pav. Nr. 1:** A diagram of a diagram  Description automatically generated  RJND ΔP – LFSM-U ΔP  RJND statizmas – LFSM-U droop  JD statizmas – FS droop  Išorinė RJND/RJPD nejautrumo zona – External LFSM-U/LFSM-O deadband  JD vidinė nejautrumo zona – FS internal deadband  JD ΔP – FS ΔP  RJPD statizmas – LFSM-O droop  **Fig. 1. Operation of the FSM and LFSM** |

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| --- | --- | --- | --- | --- | --- |
| Step | Action | Start time and initial MW value | Time when final value and MW value are reached | Comments | Verification criteria |
|  | **NU starts data recording.** |  |  |  | Active power response must start to be generated no later than 0.5 seconds and end no later than 30 seconds after sending the setpoint.  Accuracy of the actual control command execution must not exceed ±5% of the set value or a maximum of ±3% of Pn, whichever gives the higher allowable limit. The integrated 10-minute average should not exceed 1% of Pn. Readjustments must not exceed 10% of PMAX. |
|  | BESS CS sets simulation frequency value of 50Hz. |  |  |  |
|  | BESS CS sets simulation frequency signal FSET1 49.81Hz and waits for 2 minutes after the set value is reached. |  |  | A deviation of 180mHz from the FSM deadband must result in a +9% PMAX active power response. |
|  | BESS CS sets simulation frequency signal FSET2 50Hz and waits for 1 minute after the set value is reached. |  |  | Active power value must return to the previous value. |
|  | BESS CS sets simulation frequency signal FSET3 49.5Hz and waits for 2 minutes after the set value is reached. |  |  | A deviation of 190mHz from the FSM deadband must result in a +9.5% PMAX active power response.  In addition: A deviation of 300mHz from the LFSM deadband must result in a +12% PMAX active power response. |
|  | BESS CS sets simulation frequency signal FSET4 50Hz and waits for 1 minute after the set value is reached. |  |  | Active power value must return to the previous value. |
|  | BESS CS sets simulation frequency signal FSET5 50.19Hz and waits for 2 minutes after the set value is reached. |  |  | A deviation of 180mHz from the FSM deadband must result in a -9% PMAX active power response. |
|  | BESS CS sets simulation frequency signal FSET6 50Hz and waits for 1 minute after the set value is reached. |  |  | Active power value must return to the previous value. |
|  | BESS CS sets simulation frequency signal FSET7 50.5Hz and waits for 2 minutes after the set value is reached. |  |  | A deviation of 190mHz from the FSM deadband must result in a -9.5% PMAX active power response.  In addition: A deviation of 300mHz from the LFSM deadband must result in a -12% PMAX active power response. |
|  | BESS CS sets simulation frequency signal FSET8 50Hz and waits for 1 minute after the set value is reached. |  |  | Active power value must return to the previous value. |
|  | **NU stops data recording.** |  |  |  |

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| **aFRR Test** |
| *Pre-test settings:*   1. **The amount of energy (SOC) required to perform the test.** 2. **Active power limitation and consumption function – disabled.** 3. **FSM frequency control – disabled.** 4. **Control of limited frequency sensitivity – overfrequency/underfrequency – disabled.**   Diagram, timeline  Description automatically generated  **Fig. 2. Example of aFRR prequalification tests** |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Step | Action | Start time and initial MW value | Time when final value and MW value are reached | Comments | Verification criteria |
|  | **NU starts data recording.** |  |  |  | The aFRR providing facility must be capable of adjusting its active power to the set value with a steady-state error no greater than ±10% of the requested aFRR volume or 0.1 MW, whichever is greater.  Function performance must be in accordance with **Fig. 2**. |
|  | NU sets the aFRR function signal as ready. |  |  |  |
|  | TSO LFC controller sends the delta P signal = XX MW (10%PMAX) and waits for 5 minutes after the set value is reached. |  |  |  |
|  | TSO LFC controller sends the delta P signal = XX MW (5%PMAX) and waits for 5 minutes after the set value is reached. |  |  |  |
|  | TSO LFC controller sends the delta P signal = 0 MW and waits for 5 minutes after the set value is reached. |  |  |  |
|  | TSO LFC controller sends the minus delta P signal = - XX MW (10%PMAX) and waits for 5 minutes after the set value is reached. |  |  |  |
|  | TSO LFC controller sends the minus delta P signal = - XX MW (5%PMAX) and waits for 5 minutes after the set value is reached. |  |  |  |
|  | TSO LFC controller sends the delta P signal = 0 MW and waits for 5 minutes after the set value is reached. |  |  |  |
|  | NU sets the aFRR function signal as not ready. |  |  |  |
|  | **NU stops data recording.** |  |  |  |

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| **aFRR and FSM Priority Test** |
| *Pre-test settings:*   1. **The amount of energy (SOC) required to perform the test.** 2. **Active power limitation and consumption function – disabled.** 3. **FSM frequency control – enabled.** 4. **Control of limited frequency sensitivity – overfrequency/underfrequency – disabled.** 5. **aFRR – not ready.** 6. **FSM deadband – 200 mHz.** 7. **FSM droop – 5%.**     **Fig. 3. aFRR and FSM functionality while operating at the same time** |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Step | Action | Start time and initial MW value | Time when final value and MW value are reached | Comments | Verification criteria |
|  | **NU starts data recording.** |  |  |  | Function performance must be in accordance with **Fig. 3**. |
|  | NU sets the aFRR function signal as ready. |  |  |  |
|  | TSO LFC controller sends the delta P signal = XX MW (10%PMAX) and waits for 5 minutes after the set value is reached. |  |  |  |
|  | After 10 seconds, the BESS CS sets the simulation frequency signal FSET1  49.6Hz and waits for a reaction between the FSM and aFRR delta P. |  |  | Active power response must be the sum of aFRR and FSM delta P. |
|  | BESS CS sets simulation frequency signal FSET2 50Hz and waits for 1 minute after the set value is reached. |  |  |  |
|  | TSO LFC controller sends the delta P signal = 0 MW and waits until the set value is reached. |  |  |  |
|  | TSO LFC controller sends the delta P signal = XX MW (10%PMAX) and waits for 5 minutes after the set value is reached. |  |  |  |
|  | After 10 seconds, the BESS CS sets the simulation frequency signal FSET3  50.4Hz and waits for a reaction between the FSM and aFRR delta P. |  |  | Delta P generated by aFRR must be frozen/not executed, so only the active power response generated by the FSM must be visible. |
|  | BESS CS sets simulation frequency signal FSET2 50Hz and waits for 1 minute after the set value is reached. |  |  |  |
|  | TSO LFC controller sends the delta P signal = 0 MW and waits until the set value is reached. |  |  |  |
|  | NU sets the aFRR function signal as not ready. |  |  |  |
|  | **NU stops data recording.** |  |  |  |

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| **Reactive Power Control** |
| *Pre-test settings:*   1. **The amount of energy (SOC) required to perform the test.** 2. **FSM frequency control – disabled.** 3. **Control of limited frequency sensitivity – overfrequency/underfrequency – disabled.** 4. **aFRR – not ready.** 5. **Reactive power task to the BESS CS – 0Mvar.**     **Fig. 4. Reactive power Q/Pmax profile for the BESS** |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Reactive Power Control in 100% Consumption Mode** | | | | | |
| Step | Action | Start time and initial MW value | Time when final value and MW value are reached | Comments | Verification criteria |
|  | **NU starts data recording.** |  |  |  |  |
|  | BESS CS sends the 100% PSET1 consumption task and waits for 1 minute after the set value is reached. |  |  |  |  |
|  | TSO sends the QSET1 setpoint = XX MVar (25%QN) and waits for 2 minutes after the set value is reached. |  |  |  |  |
|  | TSO sends the QSET2 setpoint = XX MVar (50%QN) and waits for 2 minutes after the set value is reached. |  |  |  |  |
|  | TSO sends the QSET3 setpoint = XX MVar (75%QN) and waits for 2 minutes after the set value is reached. |  |  |  |  |
|  | TSO sends the QSET4 setpoint = XX MVar (100%QN) and waits for 2 minutes after the set value is reached. |  |  |  |  |
|  | TSO sends the QSET5 setpoint = XX MVar (0%QN) and waits for 2 minutes after the set value is reached. |  |  |  |  |
|  | TSO sends the QSET1 setpoint = XX MVar (-25%QN) and waits for 2 minutes after the set value is reached. |  |  |  |  |
|  | TSO sends the QSET2 setpoint = XX MVar (-50%QN) and waits for 2 minutes after the set value is reached. |  |  |  |  |
|  | TSO sends the QSET3 setpoint = XX MVar (-75%QN) and waits for 2 minutes after the set value is reached. |  |  |  |  |
|  | TSO sends the QSET4 setpoint = XX MVar (-100%QN) and waits for 2 minutes after the set value is reached. |  |  |  |  |
|  | TSO sends the QSET5 setpoint = XX MVar (0%QN) and waits for 2 minutes after the set value is reached. |  |  |  |  |
|  | **NU stops data recording.** |  |  |  |  |
| **Reactive Power Control in 100% Generation Mode** | | | | | |
| Step | Action | Start time and initial MW value | Time when final value and MW value are reached | Comments | Verification criteria |
|  | **NU starts data recording.** |  |  |  |  |
|  | BESS CS sends the 100% PSET1 generation task and waits for 1 minute after the set value is reached. |  |  |  |  |
|  | TSO sends the QSET1 setpoint = XX MVar (25%QN) and waits for 2 minutes after the set value is reached. |  |  |  |  |
|  | TSO sends the QSET2 setpoint = XX MVar (50%QN) and waits for 2 minutes after the set value is reached. |  |  |  |  |
|  | TSO sends the QSET3 setpoint = XX MVar (75%QN) and waits for 2 minutes after the set value is reached. |  |  |  |  |
|  | TSO sends the QSET4 setpoint = XX MVar (100%QN) and waits for 2 minutes after the set value is reached. |  |  |  |  |
|  | TSO sends the QSET5 setpoint = XX MVar (0%QN) and waits for 2 minutes after the set value is reached. |  |  |  |  |
|  | TSO sends the QSET1 setpoint = XX MVar (-25%QN) and waits for 2 minutes after the set value is reached. |  |  |  |  |
|  | TSO sends the QSET2 setpoint = XX MVar (-50%QN) and waits for 2 minutes after the set value is reached. |  |  |  |  |
|  | TSO sends the QSET3 setpoint = XX MVar (-75%QN) and waits for 2 minutes after the set value is reached. |  |  |  |  |
|  | TSO sends the QSET4 setpoint = XX MVar (-100%QN) and waits for 2 minutes after the set value is reached. |  |  |  |  |
|  | TSO sends the QSET5 setpoint = XX MVar (0%QN) and waits for 2 minutes after the set value is reached. |  |  |  |  |
|  | **NU stops data recording.** |  |  |  |  |
| **Reactive Power Control in 0% Generation/Consumption Mode** | | | | | |
| Step | Action | Start time and initial MW value | Time when final value and MW value are reached | Comments | Verification criteria |
|  | **NU starts data recording.** |  |  |  |  |
|  | BESS CS sends the 0% PSET1 generation task and waits for 1 minute after the set value is reached. |  |  |  |  |
|  | TSO sends the QSET1 setpoint = XX MVar (25%QN) and waits for 2 minutes after the set value is reached. |  |  |  |  |
|  | TSO sends the QSET2 setpoint = XX MVar (50%QN) and waits for 2 minutes after the set value is reached. |  |  |  |  |
|  | TSO sends the QSET3 setpoint = XX MVar (75%QN) and waits for 2 minutes after the set value is reached. |  |  |  |  |
|  | TSO sends the QSET4 setpoint = XX MVar (100%QN) and waits for 2 minutes after the set value is reached. |  |  |  |  |
|  | TSO sends the QSET5 setpoint = XX MVar (0%QN) and waits for 2 minutes after the set value is reached. |  |  |  |  |
|  | TSO sends the QSET1 setpoint = XX MVar (-25%QN) and waits for 2 minutes after the set value is reached. |  |  |  |  |
|  | TSO sends the QSET2 setpoint = XX MVar (-50%QN) and waits for 2 minutes after the set value is reached. |  |  |  |  |
|  | TSO sends the QSET3 setpoint = XX MVar (-75%QN) and waits for 2 minutes after the set value is reached. |  |  |  |  |
|  | TSO sends the QSET4 setpoint = XX MVar (-100%QN) and waits for 2 minutes after the set value is reached. |  |  |  |  |
|  | TSO sends the QSET5 setpoint = XX MVar (0%QN) and waits for 2 minutes after the set value is reached. |  |  |  |  |
|  | **NU stops data recording.** |  |  |  |  |

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| **Voltage Control** |
| *Pre-test settings:*   1. **The amount of energy (SOC) required to perform the test.** 2. **Active power limitation and consumption function – disabled.** 3. **FSM frequency control – disabled.** 4. **Control of limited frequency sensitivity – overfrequency/underfrequency – disabled.** 5. **aFRR – not ready.** 6. **Reactive power task to the BESS CS – 0Mvar.** 7. **Voltage deadband – 0kV.** 8. **Voltage droop – 4%.**     **Fig. 5. Voltage control curve**   |  |  | | --- | --- | |  |  | | Where: |  | |

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| **Voltage Control Test** | | | | | |
| Step | Action | Start time and initial MW value | Time when final value and MW value are reached | Comments | Verification criteria |
|  | **NU starts data recording.** |  |  |  | Following a step change in voltage, the BESS shall be capable of achieving 90% of the change in reactive power within 3 s and must settle at the value specified by the slope within 60 s with a steady-state reactive tolerance no greater than 5% of the maximum reactive power. |
|  | TSO sends a voltage setpoint with a value close to the current voltage level. |  |  |  |
|  | TSO activates the voltage control mode. |  |  |  |
|  | TSO sends a voltage setpoint that is 1 kV higher than the previous voltage level and waits for 1 minute after the set value is reached. |  |  |  |
|  | TSO sends a voltage setpoint that is 2 kV higher than the previous voltage level and waits for 1 minute after the set value is reached. |  |  |  |
|  | TSO sends a voltage setpoint that is 3 kV higher than the previous voltage level and waits for 1 minute after the set value is reached. |  |  |  |
|  | TSO sends a voltage setpoint that is 3 kV lower than the previous voltage level and waits for 1 minute after the set value is reached. |  |  |  |
|  | TSO sends a voltage setpoint that is 2 kV lower than the previous voltage level and waits for 1 minute after the set value is reached. |  |  |  |
|  | TSO sends a voltage setpoint that is 1 kV lower than the previous voltage level and waits for 1 minute after the set value is reached. |  |  | The initial voltage level is restored. |
|  | TSO sends a voltage setpoint that is 1 kV lower than the previous voltage level and waits for 1 minute after the set value is reached. |  |  |  |
|  | TSO sends a voltage setpoint that is 2 kV lower than the previous voltage level and waits for 1 minute after the set value is reached. |  |  |  |
|  | TSO sends a voltage setpoint that is 3 kV lower than the previous voltage level and waits for 1 minute after the set value is reached. |  |  |  |
|  | TSO sends a voltage setpoint that is 3 kV higher than the previous voltage level and waits for 1 minute after the set value is reached. |  |  |  |
|  | TSO sends a voltage setpoint that is 2 kV higher than the previous voltage level and waits for 1 minute after the set value is reached. |  |  |  |
|  | TSO sends a voltage setpoint that is 1 kV higher than the previous voltage level and waits for 1 minute after the set value is reached. |  |  | The initial voltage level is restored. |
|  | **NU stops data recording.** |  |  |  |  |
| **Voltage Droop Test** | | | | | |
| Step | Action | Start time and initial MW value | Time when final value and MW value are reached | Comments | Verification criteria |
|  | **NU starts data recording.** |  |  |  | Following a step change in voltage, the BESS shall be capable of achieving 90% of the change in reactive power within 3 s and must settle at the value specified by the slope within 60 s with a steady-state reactive tolerance no greater than 5% of the maximum reactive power. |
|  | TSO sends voltage droop coefficient value = 2%. |  |  |  |
|  | TSO sends a voltage setpoint that is 1 kV higher than the previous voltage level and waits for 1 minute after the set value is reached. |  |  |  |
|  | TSO sends a voltage setpoint that is 2 kV higher than the previous voltage level and waits for 1 minute after the set value is reached. |  |  |  |
|  | TSO sends a voltage setpoint that is 3 kV higher than the previous voltage level and waits for 1 minute after the set value is reached. |  |  |  |
|  | TSO sends a voltage setpoint that is 3 kV lower than the previous voltage level and waits for 1 minute after the set value is reached. |  |  |  |
|  | TSO sends a voltage setpoint that is 2 kV lower than the previous voltage level and waits for 1 minute after the set value is reached. |  |  |  |
|  | TSO sends a voltage setpoint that is 1 kV lower than the previous voltage level and waits for 1 minute after the set value is reached. |  |  |  |
|  | TSO sends a voltage setpoint that is 1 kV lower than the previous voltage level and waits for 1 minute after the set value is reached. |  |  |  |
|  | TSO sends a voltage setpoint that is 2 kV lower than the previous voltage level and waits for 1 minute after the set value is reached. |  |  |  |
|  | TSO sends a voltage setpoint that is 3 kV lower than the previous voltage level and waits for 1 minute after the set value is reached. |  |  |  |
|  | TSO sends a voltage setpoint that is 3 kV higher than the previous voltage level and waits for 1 minute after the set value is reached. |  |  |  |
|  | TSO sends a voltage setpoint that is 2 kV higher than the previous voltage level and waits for 1 minute after the set value is reached. |  |  |  |
|  | TSO sends a voltage setpoint that is 1 kV higher than the previous voltage level and waits for 1 minute after the set value is reached. |  |  |  |
|  | **NU stops data recording.** |  |  |  |
| **Voltage Deadband Test** | | | | | |
| Step | Action | Start time and initial MW value | Time when final value and MW value are reached | Comments | Verification criteria |
|  | **NU starts data recording.** |  |  |  | Following a step change in voltage, the BESS shall be capable of achieving 90% of the change in reactive power within 3 s and must settle at the value specified by the slope within 60 s with a steady-state reactive tolerance no greater than 5% of the maximum reactive power. |
|  | TSO sends the voltage insensitivity value = 1kV. |  |  |  |
|  | TSO sends a voltage setpoint that is 0.5 kV higher than the previous voltage level and waits for 1 minute after the set value is reached. |  |  |  |
|  | TSO sends a voltage setpoint that is 2 kV higher than the previous voltage level and waits for 1 minute after the set value is reached. |  |  |  |
|  | TSO sends a voltage setpoint that is 0.5 kV lower than the previous voltage level and waits for 1 minute after the set value is reached. |  |  |  |
|  | TSO sends a voltage setpoint that is 2 kV lower than the previous voltage level and waits for 1 minute after the set value is reached. |  |  |  |
|  | **NU stops data recording.** |  |  |  |
|  | TSO sets the initial values that were present before the test. |  |  |  |

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| **Synthetic Inertia Test** |
| *Pre-test settings:*   1. **The amount of energy (SOC) required to perform the test.** 2. **Active power limitation and consumption function – disabled.** 3. **FSM frequency control – disabled.** 4. **Control of limited frequency sensitivity – overfrequency/underfrequency – disabled.** 5. **aFRR – not ready.** 6. **FSM deadband – 10 mHz.** 7. **LFSM deadband – 200 mHz.** 8. **FSM droop – 4%.** 9. **LFSM droop – 5%.** |

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| **Synthetic Inertia Test with Disabled Function** | | | | | |
| Step | Action | Simulation frequency value [Hz] | Rate of change of frequency  [Hz/s] | Comments | Verification criteria |
|  | **NU starts data recording.** |  |  |  | FSM frequency control,  control of limited frequency sensitivity – overfrequency/underfrequency, and synthetic inertia functions are disabled, so active power response must not occur. |
|  | BESS CS sets the ROCOF deadband = ± 0 Hz/s. |  |  |  |
|  | BESS CS sets simulation frequency signal FSET1 and waits for 2 minutes after the set value is reached. | 48.5 | 1.5 | Active power response must not occur. |
|  | BESS CS sets simulation frequency signal FSET2 and waits for 2 minutes after the set value is reached. | 50 | 0.5 | Active power response must not occur. |  |
|  | BESS CS sets simulation frequency signal FSET3 and waits for 2 minutes after the set value is reached. | 51.5 | 1.5 | Active power response must not occur. |  |
|  | BESS CS sets simulation frequency signal FSET4 and waits for 2 minutes after the set value is reached. | 51.5 | 1.5 | Active power response must not occur. |  |
|  | **NU stops data recording.** |  |  |  |  |
| **Synthetic Inertia Test with Disabled Frequency Control** | | | | | |
| Step | Action | Simulation frequency value [Hz] | Rate of change of frequency  [Hz/s] | Comments | Verification criteria |
|  | **NU starts data recording.** |  |  |  | Synthetic inertia response must be proportional to the rate of change of frequency.  Synthetic inertia must be fully activated within 200 ms. |
|  | TSO activates the synthetic inertia function. |  |  |  |
|  | BESS CS sets the ROCOF deadband = ± 1 Hz/s. |  |  |  |
|  | BESS CS sets simulation frequency signal FSET1 and waits for 2 minutes after the set value is reached. | 48.5 | 0.5 | Active power response must not occur. |
|  | BESS CS sets simulation frequency signal FSET2 and waits for 2 minutes after the set value is reached. | 50 | 0.5 | Active power response must not occur. |
|  | BESS CS sets simulation frequency signal FSET3 and waits for 2 minutes after the set value is reached. | 48.5 | 1.5 | Active power response must be generated. |
|  | BESS CS sets simulation frequency signal FSET4 and waits for 2 minutes after the set value is reached. | 50 | 0.5 | Active power response must not occur. |
|  | BESS CS sets simulation frequency signal FSET5 and waits for 2 minutes after the set value is reached. | 51.5 | 0.5 | Active power response must not occur. |
|  | BESS CS sets simulation frequency signal FSET6 and waits for 2 minutes after the set value is reached. | 50 | 0.5 | Active power response must not occur. |
|  | BESS CS sets simulation frequency signal FSET7 and waits for 2 minutes after the set value is reached. | 51.5 | 1.5 | Active power response must be generated. |
|  | BESS CS sets simulation frequency signal FSET8 and waits for 2 minutes after the set value is reached. | 50 | 0.5 | Active power response must not occur. |
|  | **NU stops data recording.** |  |  |  |
| **Synthetic Inertia Test in Combination with FSM and LFSM** | | | | | |
| Step | Action | Simulation frequency value [Hz] | Rate of change of frequency  [Hz/s] | Comments | Verification criteria |
|  | **NU starts data recording.** |  |  |  | Synthetic inertia response must be proportional to the rate of change of frequency.  Synthetic inertia must be fully activated within 200 ms. |
|  | TSO activates the synthetic inertia function. |  |  |  |
|  | TSO activates the FSM frequency control and the control of limited frequency sensitivity – overfrequency/underfrequency functions. |  |  |  |
|  | BESS CS sets simulation frequency signal FSET1 and waits for 2 minutes after the set value is reached. | 48.5 | 0.5 | Active power response must not occur. |
|  | BESS CS sets simulation frequency signal FSET2 and waits for 2 minutes after the set value is reached. | 50 | 0.5 | Active power response must not occur. |
|  | BESS CS sets simulation frequency signal FSET3 and waits for 2 minutes after the set value is reached. | 48.5 | 1.5 | Active power response must be generated. |
|  | BESS CS sets simulation frequency signal FSET4 and waits for 2 minutes after the set value is reached. | 50 | 0.5 | Active power response must not occur. |
|  | BESS CS sets simulation frequency signal FSET5 and waits for 2 minutes after the set value is reached. | 51.5 | 0.5 | Active power response must not occur. |
|  | BESS CS sets simulation frequency signal FSET6 and waits for 2 minutes after the set value is reached. | 50 | 0.5 | Active power response must not occur. |
|  | BESS CS sets simulation frequency signal FSET7 and waits for 2 minutes after the set value is reached. | 51.5 | 1.5 | Active power response must be generated. |
|  | BESS CS sets simulation frequency signal FSET8 and waits for 2 minutes after the set value is reached. | 50 | 0.5 | Active power response must not occur. |
|  | **NU stops data recording.** |  |  |  |  |
|  | TSO disables the synthetic inertia, FSM frequency control and the control of limited frequency sensitivity – overfrequency/underfrequency functions. |  |  |  |

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| **Power Oscillation Damping Function** |
| *Pre-test settings:*   1. **The amount of energy (SOC) required to perform the test.** 2. **Active power limitation and consumption function – disabled.** 3. **FSM frequency control – disabled.** 4. **Control of limited frequency sensitivity – overfrequency/underfrequency – disabled.** 5. **aFRR – not ready.** 6. **POD power oscillation damping function – enabled.** 7. **Reactive power control – enabled.** |

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| **Power Oscillation Damping Function Generating Active Power Response (POD-P) When the Reactive Power Control Mode is Enabled.** | | | | | |
| Step | Action | Start time and initial MW value | Time when final value and MW value are reached | Comments | Verification criteria |
|  | **NU starts data recording.** |  |  |  | An ideal 180-degree phase shift between the active power and the simulation frequency input signal must occur. |
|  | BESS CS simulates the FSET1 0.25Hz frequency oscillations for 30 seconds. |  |  |  |
|  | BESS CS simulates the FSET2 0.275Hz frequency oscillations for 30 seconds. |  |  |  |
|  | BESS CS simulates the FSET3 0.3Hz frequency oscillations for 30 seconds. |  |  |  |
|  | BESS CS simulates the FSET4 0.325Hz frequency oscillations for 30 seconds. |  |  |  |
|  | BESS CS simulates the FSET5 0.35Hz frequency oscillations for 30 seconds. |  |  |  |
|  | BESS CS simulates the FSET6 0.375Hz frequency oscillations for 30 seconds. |  |  |  |
|  | BESS CS simulates the FSET7 0.4Hz frequency oscillations for 30 seconds. |  |  |  |
|  | BESS CS simulates the FSET8 0.425Hz frequency oscillations for 30 seconds. |  |  |  |
|  | BESS CS simulates the FSET9 0.45Hz frequency oscillations for 30 seconds. |  |  |  |
|  | BESS CS simulates the FSET10 0.475Hz frequency oscillations for 30 seconds. |  |  |  |
|  | BESS CS simulates the FSET11 0.5Hz frequency oscillations for 30 seconds. |  |  |  |
|  | **NU stops data recording.** |  |  |  |
| **Power Oscillation Damping Function Generating Active Power Response (POD-P) When the Voltage Mode is Enabled.** | | | | | |
|  | **NU starts data recording.** |  |  |  | An ideal 180-degree phase shift between the active power and the simulation frequency input signal must occur. | |
|  | TSO switches the voltage control mode. |  |  |  |
|  | BESS CS simulates the FSET1 0.25Hz frequency oscillations for 30 seconds. |  |  |  |
|  | BESS CS simulates the FSET2 0.275Hz frequency oscillations for 30 seconds. |  |  |  |
|  | BESS CS simulates the FSET3 0.3Hz frequency oscillations for 30 seconds. |  |  |  |
|  | BESS CS simulates the FSET4 0.325Hz frequency oscillations for 30 seconds. |  |  |  |
|  | BESS CS simulates the FSET5 0.35Hz frequency oscillations for 30 seconds. |  |  |  |
|  | BESS CS simulates the FSET6 0.375Hz frequency oscillations for 30 seconds. |  |  |  |
|  | BESS CS simulates the FSET7 0.4Hz frequency oscillations for 30 seconds. |  |  |  |
|  | BESS CS simulates the FSET8 0.425Hz frequency oscillations for 30 seconds. |  |  |  |
|  | BESS CS simulates the FSET9 0.45Hz frequency oscillations for 30 seconds. |  |  |  |
|  | BESS CS simulates the FSET10 0.475Hz frequency oscillations for 30 seconds. |  |  |  |
|  | BESS CS simulates the FSET11 0.5Hz frequency oscillations for 30 seconds. |  |  |  |
|  | **NU stops data recording.** |  |  |  |
| **Power Oscillation Damping Function Generating Active Power Response (POD-Q) When the Reactive Power Control Mode is Enabled.** | | | | | | |
| Step | Action | Start time and initial MW value | Time when final value and MW value are reached | Comments | Verification criteria | |
|  | **NU starts data recording.** |  |  |  | An ideal 180-degree phase shift between the reactive power and the simulation frequency input signal must occur. | |
|  | TSO switches the reactive power control mode. |  |  |  |
|  | BESS CS simulates the FSET1 0.25Hz frequency oscillations for 30 seconds. |  |  |  |
|  | BESS CS simulates the FSET2 0.275Hz frequency oscillations for 30 seconds. |  |  |  |
|  | BESS CS simulates the FSET3 0.3Hz frequency oscillations for 30 seconds. |  |  |  |
|  | BESS CS simulates the FSET4 0.325Hz frequency oscillations for 30 seconds. |  |  |  |
|  | BESS CS simulates the FSET5 0.35Hz frequency oscillations for 30 seconds. |  |  |  |
|  | BESS CS simulates the FSET6 0.375Hz frequency oscillations for 30 seconds. |  |  |  |
|  | BESS CS simulates the FSET7 0.4Hz frequency oscillations for 30 seconds. |  |  |  |
|  | BESS CS simulates the FSET8 0.425Hz frequency oscillations for 30 seconds. |  |  |  |
|  | BESS CS simulates the FSET9 0.45Hz frequency oscillations for 30 seconds. |  |  |  |
|  | BESS CS simulates the FSET10 0.475Hz frequency oscillations for 30 seconds. |  |  |  |
|  | BESS CS simulates the FSET11 0.5Hz frequency oscillations for 30 seconds. |  |  |  |
|  | **NU stops data recording.** |  |  |  |
| **Power Oscillation Damping Function Generating Active Power Response (POD-Q) When the Reactive Power Control Mode is Enabled.** | | | | | | |
| Step | Action | Start time and initial MW value | Time when final value and MW value are reached | Comments | Verification criteria | |
|  | **NU starts data recording.** |  |  |  | An ideal 180-degree phase shift between the reactive power and the simulation frequency input signal must occur. | |
|  | TSO switches the voltage control mode. |  |  |  |
|  | BESS CS simulates the FSET1 0.25Hz frequency oscillations for 30 seconds. |  |  |  |
|  | BESS CS simulates the FSET2 0.275Hz frequency oscillations for 30 seconds. |  |  |  |
|  | BESS CS simulates the FSET3 0.3Hz frequency oscillations for 30 seconds. |  |  |  |
|  | BESS CS simulates the FSET4 0.325Hz frequency oscillations for 30 seconds. |  |  |  |
|  | BESS CS simulates the FSET5 0.35Hz frequency oscillations for 30 seconds. |  |  |  |
|  | BESS CS simulates the FSET6 0.375Hz frequency oscillations for 30 seconds. |  |  |  |
|  | BESS CS simulates the FSET7 0.4Hz frequency oscillations for 30 seconds. |  |  |  |
|  | BESS CS simulates the FSET8 0.425Hz frequency oscillations for 30 seconds. |  |  |  |
|  | BESS CS simulates the FSET9 0.45Hz frequency oscillations for 30 seconds. |  |  |  |
|  | BESS CS simulates the FSET10 0.475Hz frequency oscillations for 30 seconds. |  |  |  |
|  | BESS CS simulates the FSET11 0.5Hz frequency oscillations for 30 seconds. |  |  |  |
|  | **NU stops data recording.** |  |  |  |

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| **Emergency Power Control** |
| Emergency power control is performed for each BESS individually; therefore, the NU shall coordinate the test programme with the Operator before signing the test programme. The requirements for emergency power control are provided below:   1. A logic input connection with at least 4 binary inputs must be provided for the emergency power control, and it must be used to receive an external control command from the TSO’s facilities. The adjustment condition for each connection must be defined separately. 2. Upon receipt of the external control command, the BESS must start executing it within a time period not exceeding 100 ms. 3. The change of active power in the BESS control system is configured according to:    1. the operation mode (consumption / generation);;    2. the set active power value to which the power change must be performed P, MW;    3. the adjustment speed at which the power action (dP/dt) is performed, MW/s;    4. the delay of the received emergency control command for power change after accepting the command (Td), ms.. 4. Provision must be made for the possibility of changing the BESS control mode upon receipt of an external control command. Such mode can be the activation of frequency control or synthetic inertia functions. 5. The BESS shall have the possibility to change the emergency power control parameters at the request of the TSO. 6. It must be possible to activate the emergency power control functions remotely from the TSO control system. |