SONI Battery ESPS Compliance Test Procedures

(Transmission Connected Battery ESPS)

1. ENERGISATION AND DISPATCH TESTING

Energisation and First Export:

The Battery ESPS shall complete all pre-energisation requirements and will be issued:

- An Energisation Operational Notification (EON) prior to energisation.
- An Interim Operational Notification (ION) prior to first export.

On energisation, the following limits / requirements apply:

- A capacity limit of 10 MW (MEC and MIC) is applied by the Battery ESPS independent of Active Power Control System used by SONI.

- Frequency Response will remain OFF except as required during commissioning activities, or as instructed by SONI. Such commissioning activities will be agreed with SONI through load profiles, as noted below. The ESPS shall submit load profiles to SONI for approval of commissioning and internal testing activities.

First Active Power Dispatch Test (+/- 10MW)

- The ESPS shall inform SONI when the Battery ESPS is available for an Active Power Dispatch Test (also providing information on the available reactive power).

- SONI will carry out a Dispatch Test, not exceeding the +/-10 MW limit applied within the ESPS controller (this may include a combination of EDIL dispatch and Emergency Action controls)

- Providing there is reactive power capability available, SONI will also carry out a brief Reactive Power control test, which may include issuing MVAr set points. (Note this will apply for transmission connected units where SONI has control over reactive power output)

- SONI will review the results from the first Active Power Dispatch Test and will advise whether the ESPS has passed or failed

- If the test is passed – SONI will advise that the cap can be lifted **to full MEC and MIC**

- If the test is failed – the 10MW cap on import and export will remain in place. ESPS to resolve any issues identified and notify SONI when a repeat 10MW dispatch test can be carried out.

Completing Commissioning

- The ESPS will continue to progress the project through the commissioning programme, submitting load profiles to SONI for approval as necessary.

- The ESPS shall also submit internal test results to demonstrate that commissioning of frequency response and reactive power control and capability is completed.

- Following review of commissioning results, SONI may turn on frequency response and use reactive power control if required.

Operational Readiness Confirmation (ORC) Dispatch Test

- The ESPS informs SONI that commissioning is complete and requests the final dispatch test (for ORC).
- This test will consist of active power dispatch instructions across the full operating range of the Battery ESPS. This may include a combination of EDIL dispatch instructions and direct Emergency Action SCADA set points.
- For transmission connected units where SONI has control of reactive power output, this test will also include reactive power set points.
- SONI will review the results from the ORC Dispatch Test and will advise whether the ESPS has passed or failed
- If the test is passed, SONI will issue an ORC. On issuing the ORC, SONI will advise its Real-Time Operations department that the unit is now considered controllable and available for dispatch
- If the test is failed – the ESPS must resolve any issues identified and notify SONI when a repeat ORC dispatch test can be carried out

Grid Code Compliance Testing and System Services Testing

Following receipt of Operational Readiness Confirmation, the ESPS can progress to scheduling dates for Grid Code Compliance testing, and System Services testing.

Dispatch Test Procedure

The ESPS should, where possible, ensure the unit has sufficient state of charge in advance of commencing testing each day. Before each test section, the state of charge of the ESPS should be checked and adjusted if required, following approval by SONI.

Throughout the test procedure, for instances where Emergency Action is OFF it is noted that the expected MW output is 0MW. It is understood that there may be small MW imports at the connection point to account for house load, unless otherwise instructed by SONI.

It should be noted that the terms permissible import and permissible export in this procedure are defined as:

- A maximum of 10MW in the case of the first Active Power Dispatch Test
- MIC and MEC in the case of the ORC Dispatch Test

Step No.	Action	Comments
1	If SONI has control of the ESPS Reactive Power, ensure the ESPS is close to 0 MVAr at the connection point.	
2	Confirm market PNs have been submitted and notify ESPS EDIL operator (if required)	
3	Ensure frequency response is **OFF**	
4	In EMS, turn Emergency Action **ON**	
5	Send Active Power Set-point of **50% permissible export** (allow the ESPS to achieve this Set-point and wait **1 minute**).	
6	Send Active Power Set-point of **20% permissible export** (allow the ESPS to achieve this Set-point and wait **1 minute**).	
7	Send Active Power Set-point of **30% permissible import** (allow the ESPS to achieve this Set-point and wait **1 minute**).	
8	Send Active Power Set-point of **70% permissible import** (allow the ESPS to achieve this Set-point and wait **1 minute**).	
9	Send Active Power Set-point of **40% permissible import** (allow the ESPS to achieve this Set-point and wait **1 minute**).	
10	In EMS, turn Emergency Action **OFF** (allow ESPS to return to 0MW and wait **1 minute**).	
11	Send Active Power Set-point of **20% permissible export** and wait **1 minute**. (ESPS should not respond with Emergency Action **OFF**)	
12	Turn Emergency Action **ON** (allow the ESPS to achieve the current Set-point and wait **1 minute**).	
13	Send Active Power Set-point of **0 MW** (allow the ESPS to achieve this Set-point and wait **1 minute**).	
14	Send Active Power Set-point of **20% permissible export** (allow the ESPS to achieve this Set-point and wait **1 minute**).	
15	Turn Emergency Action **OFF** (allow ESPS to return to 0MW and wait **1 minute).**	
16	Send **MVAr** Set-point no.1 (allow the ESPS to achieve this Set-point and wait **1 minute**). *Timing and magnitude of change in MVAr dependent on system conditions on day of test*	
17	Send **MVAr** Set-point no.2 (allow the ESPS to achieve this Set-point and wait **1 minute**). *Timing and magnitude*	

	of change in MVAr dependent on system conditions on day of test	
18	Send **MVAr** Set-point no.3 (allow the ESPS to achieve this Set-point and wait **1 minute**). *Timing and magnitude of change in MVAr dependent on system conditions on day of test*	
19	Send **MVAr** Set-point no.4 (allow the ESPS to achieve this Set-point and wait **1 minute**). *Timing and magnitude of change in MVAr dependent on system conditions on day of test*	
20	Send **MVAr** Set-point of **0 MVAr** (allow the ESPS to achieve this Set-point and wait **1 minute**).	
21	Ensure Frequency Response status is returned to pre-test condition	
22	Ensure Emergency Action is **OFF** and MW set-point is **0MW**	
THE FOLLOWING TEST STEPS WILL ONLY BE PERFORMED IF EDIL DISPATCH IS OPERATIONAL		
23	In EDIL, SONI/CHCC to issue DI for **40% permissible export** (allow the ESPS to achieve this Set-point and wait **1 minute**).	
24	In EDIL, SONI/CHCC to issue DI for **10% permissible export** (allow the ESPS to achieve this Set-point and wait **1 minute**).	
25	In EDIL, SONI/CHCC to issue DI for **40% permissible import** (allow the ESPS to achieve this Set-point and wait **1 minute**).	
26	In EDIL, SONI/CHCC to issue DI for **20% permissible import** (allow the ESPS to achieve this Set-point and wait **1 minute**).	
27	In EDIL, SONI/CHCC to issue DI for **0MW** (allow the ESPS to achieve this Set-point and wait **1 minute**).	
28	Ensure frequency status is returned to pre-test positon as noted in step 3	
29	In EMS, ensure EMERGENCY ACTION is **OFF** and MW set-point is 0MW	
30	Notify ESPS EDIL operator that the dispatch test has been completed and unit is returned to normal operation	

2. ACTIVE POWER CONTROL TESTS

Purpose of tests:

To establish that the active power control capability of the Battery ESPS is in compliance with the requirements detailed in Section B.1 of the Battery ESPS Grid Code Implementation Note.

The purpose of this test is to demonstrate the Active Power Control functions of the ESPS, including ramp rates applied. This test procedure also includes verification of house load and battery capacity. Availability signals are recorded during this test and should be assessed in the test report.

Results Required:

The following data must be captured by the ESPS at the time of testing and submitted to SONI in the format of a time series record and Microsoft Excel Plot:

- ESPS Available Active Power Export (MW)
- ESPS Available Active Power Import (MW)
- ESPS Useable Energy Remaining (MWhr)
- ESPS Total Useable Storage Capacity (MWhr)
- Actual active power to/from the ESPS (MW)
- Emergency Action ON/OFF
- Emergency Action set-point from SONI
- Frequency Response ON/OFF
- Number of modules online

Pass Criteria:

Active Power Control

- Active Power export and import is limited to the MEC and MIC of the ESPS respectively
- ESPS Control System receives all online Emergency Action set-points, commences implementation of all set-points within 10 seconds of receipt and provides the correct set-point feedback
- When Emergency Action is ON, ESPS regulates its active power output to within the greater of (±0.5 MW or ±3% of Registered Capacity) of the Active Power Control Set-point
- ESPS does not respond to any set-points sent while Emergency Action is OFF

Ramp Rates

- Rate of change of output is equal to the Active Power Control set-point Ramp Rate when ramping to Active Power Control Set-points, with temporary deviations not exceeding ±3% of Registered Capacity
- ESPS output ramps to 0MW at the Active Power Control Ramp Rate when Emergency Action is turned OFF (unless acting under Frequency Response Ramp Rate or Capacity Limited Ramp Rate)
- Demonstration that the Active Power Control Set-point Ramp Rate can be set by SONI over a range between 1% and 100% of Registered Capacity per minute

Battery Signals

- Available active power export and import signals are limited to the MEC and MIC of the ESPS respectively
- Available Active Power export and import signals behave correctly when the unit is issued an Emergency Action set-point or is providing a frequency response
- Useable Energy Remaining signal provides real time quantity of energy (MWhr) that the unit is capable of exporting, based on current state of charge.
- Total Useable Storage Capacity signal provides real-time quantity of energy (MWhr) that the unit is capable of importing, based on current state of charge.
- ESPS Charging and Discharging Signals correctly determine if the ESPS is charging or discharging

Capacity/Max On Time

- ESPS Demonstration of Capacity (Registered Characteristic / Technical Offer Data value)

Test Procedures:

The ESPS should, where possible, ensure the unit has sufficient state of charge in advance of commencing testing each day.

Before each test section, the state of charge of the ESPS should be checked and adjusted if required, following approval by SONI.

Throughout the test procedure, for instances where Emergency Action is OFF it is noted that the expected MW output is 0MW. It is understood that there may be small MW imports at the connection point to account for house load, unless otherwise instructed by SONI.

Demonstration of Limiters

The ability of the ESPS to limit its active power flow (and the AAP) to MEC and MIC is demonstrated by sending Emergency Action set-points above MEC and below MIC.

Test 1	**Demonstration of Limiters**
Step No.	**Action**
1	ESPS requests permission from SONI to proceed with the Demonstration of Limiters test and confirms the following with SONI: 1. AAP of the ESPS 2. Frequency Response is OFF 3. Emergency Action is ON 4. Emergency Action set-point [0MW] 5. MW output of the ESPS 6. ESPS Useable Energy Remaining (MWhr)
2	ESPS requests SONI to issue a MW set-point greater than MEC and waits until 1 minute after export has stabilised
Note: intermediate steps may be added to avoid large MW changes during between Step 2 and 3, particularly if the difference between MEC and MIC is greater than 20MW	
3	ESPS requests SONI to issue a MW set-point less than MIC and waits until 1 minute after import has stabilised
4	ESPS informs SONI that the Demonstration of Limiters test is complete. If further testing is not being completed, go to 5: Return to Standard Settings

Ramp Rate Settings

Active Power Control Set-point Ramp Rate is adjusted to values between 1% and 100% of Registered Capacity per minute, with ramps carried out at each ramp rate setting.

Note: Capacity limited ramp rate settings are changed during the Frequency Response Test procedure during the Ramp Rate Priority test. To avoid duplication of testing, it is suggested that data from the Ramp Rate test could be used to demonstrate the ESPS ability to change Capacity Limited Ramp Rate setting.

A selection of ramp rate settings have been proposed here, as it is not practical to test all values with the requirements. In the test report, please include a statement outlining the ranges that these parameters can be set within.

Test 2	**Ramp Rate Settings**
Step No.	**Action**
1	ESPS requests permission from SONI to proceed with the Ramp Rate Settings test and confirms the following with SONI: 1. Emergency Action is OFF 2. MW output of the ESPS 3. Frequency Response is OFF 4. ESPS Useable Energy Remaining (MWhr) 5. ESPS Total Useable Storage Capacity (MWhr)
2	ESPS requests SONI to turn Emergency Action **ON** and issue a MW set-point of 30% of MEC and waits until 1 minute after the set-point has been achieved
3	SONI sets the Active Power Control Set-point Ramp Rate to 1% of Registered Capacity per minute
4	ESPS requests SONI to issue a MW set-point of 35% of Registered Capacity and waits until 1 minute after the set-point has been achieved
5	SONI sets the Active Power Control Set-point Ramp Rate to 100% of Registered Capacity per minute
6	ESPS requests SONI to issue a MW set-point of 20% of Registered Capacity and waits until 1 minute after the set-point has been achieved
7	SONI sets the Active Power Control Set-point Ramp Rate to 50% of Registered Capacity per minute
8	ESPS requests SONI to issue a set-point of 0MW then turn Emergency Action **OFF** and waits until 1 minute after the MW output has reached zero
9	ESPS ends data recording
10	ESPS informs SONI that the Ramp Rate Settings test is complete. If further testing is not being completed, go to 5: Return to Standard Settings

Active Power Control (Emergency Action OFF)
The following test is intended to provide data to demonstrate that the ESPS responds correctly when Emergency Action is turned OFF, and that the ESPS does not respond to any set-points sent while Emergency Action is OFF.

Please also refer to test steps in Frequency Response and Reactive Power Test Procedures where APC set-points are issued. Data from these tests can be used to assess many of the APC pass criteria.

Test 3	**Active Power Control (Emergency Action OFF)**
Step No.	**Action**
1	ESPS requests permission from SONI to proceed with the Active Power Control test and confirms the following with SONI: 1. Frequency Response is OFF 2. Emergency Action is OFF 3. AAP export of the ESPS 4. AAP import of the ESPS 5. MW output of the ESPS 6. ESPS Useable Energy Remaining (MWhr)
2	ESPS requests SONI to turn Emergency Action **ON** and issue a MW set-point of 50% of Registered Capacity and waits until 1 minute after the set-point has been achieved
3	ESPS requests SONI to turn Emergency Action **OFF** and waits until 1 minute after the MW output has reached 0MW
4	ESPS requests SONI to issue a MW set-point of 40% of Registered Capacity
5	ESPS requests SONI to turn Emergency Action **ON** and waits until 1 minute after the set-point has been achieved
6	ESPS requests SONI to issue a MW set-point of 30% of Registered Capacity and waits until 1 minute after the set-point has been achieved
7	ESPS requests SONI to issue a set-point of 0 MW and waits until 1 minute after the set-point has been achieved
8	ESPS informs SONI that the Active Power Control test is complete. If further testing is not being completed, go to 5: Return to Standard Settings

Demonstration of Capacity/Technical Characteristics

Please refer to the Frequency Response ON, Mode 2 test in the Frequency Response Test Procedure. This test includes a step where a frequency injection is held for up to TOR2 timeframe. If this is not sufficient to demonstrate battery capacity as per registered characteristics, then the following test can be completed.

Note for Ramping services such as RRD there may also be a requirement to demonstrate EDIL response time. This should be discussed and agreed with Generator Testing if planning to apply for this service

Test 4	**Demonstration of Capacity/Technical Characteristics**
Step No.	**Action**
1	ESPS requests permission from SONI to proceed with the Active Power Control test and confirms the following with SONI: 1. Emergency Action is OFF 2. MW output of ESPS 3. Frequency Response is OFF 4. AAP export of the ESPS 5. AAP import of the ESPS 6. Useable Energy MWhr remaining 7. Duration of battery at full output 8. Capacity Limited Ramp Rate setting applied
2	ESPS requests SONI to turn Emergency Action **ON** and issue a MW set-point of 100% of Registered Capacity
3	ESPS to remain at full output until Capacity Limited Ramp Rate reduces output to 0MW
4	ESPS requests SONI to issue a set-point of 0 MW and turn Emergency Action **OFF**
5	ESPS informs SONI that the Active Power Control test is complete. If further testing is not being completed, go to 5: Return to Standard Settings

Return to Standard Settings

The ESPS settings are returned to standard following completion of the Active Power Control Test.

5	**Return to Standard Settings**
Step No.	**Action**
1	ESPS confirms the following with SONI: 1. ESPS Useable Energy Remaining (MWhr) 2. Emergency Action Set-point = 0MW 3. Emergency Action is OFF 4. MW output of the ESPS 5. Frequency Response is ON 6. Frequency Response is in Mode 1 (or as agreed with CHCC) 7. ESPS frequency reference is system frequency
2	ESPS informs SONI that Active Power Control testing is complete

3. FREQUENCY CONTROL TESTS

Purpose of Tests:

To establish that the frequency control capability of the Battery ESPS is in compliance with the requirements detailed in Section B.3 of the Battery ESPS Grid Code Implementation Note.

The purpose of this test is to confirm the ability of the ESPS to respond to changes in system frequency. The ESPS shall be capable of operating with a "MW/Hz" slope – e.g. able to continuously adjust its active power output in response to changes in frequency. As the grid frequency cannot be changed at will, the test will require frequency to be simulated by means of injection of a frequency signal into the ESPS control system.

Results Required:

The following data must be captured by the ESPS at the time of testing and submitted to SONI in the format of a time series record and Microsoft Excel Plot:

- ESPS Available Active Power Export (MW)
- ESPS Available Active Power Import (MW)
- ESPS Useable Energy Remaining (MWhr)
- ESPS Total Useable Storage Capacity (MWhr)
- Actual active power from the ESPS in MW
- Emergency Action ON/OFF
- Emergency Action set-point from SONI
- Frequency Response ON/OFF
- Frequency Response Reserve Mode 1-5
- Active under frequency trigger setting
- Active under frequency trajectory setting
- Active Maximum underfrequency response setting
- Active over frequency trigger setting
- Active over frequency trajectory setting
- Active Maximum overfrequency response setting
- Simulated Test Frequency
- Grid Frequency
- Number of modules online

Pass Criteria:

- Frequency response mode settings have been implemented as per unit specific signal list
- The selected Frequency Response Mode (and feedback) shall not be affected by the Frequency Response status (ON / OFF) i.e. the Frequency Response Mode does not change, nor should the feedback signal go suspect. If Frequency Response is OFF, the mode should not change.
- Battery ESPS is capable of operating with parameters set anywhere in the following ranges:
    - Under frequency Trigger F1: 49Hz – 50Hz
    - Under frequency Trajectory F1-F2: 1Hz – 10Hz
    - Maximum Under frequency Response: 0MW – Operating Range
    - Over frequency Trigger F3: 50Hz – 51Hz
    - Over frequency Trajectory F3-F4: 1Hz – 10Hz

- Maximum Over frequency Response: 0MW – Operating Range

Note: A number of settings will be demonstrated as per existing mode settings during this Frequency Response test.
A statement confirming the max and min ranges that can be applied for each parameter is to be provided by the customer in the test report to further support this criteria.

- When Frequency Response is OFF, no response shall be provided.
- For frequency ≥ F1 and ≤ F3, no response shall be provided
- For frequency between F1 and F2, and F3 and F4 MW output is based on a MW/Hz slope, which is defined only by the Maximum Response setting and the trajectory, as defined for each Mode.
- Over frequency Response (ΔP) will be limited by the lesser of availability, Maximum Over frequency Response setting, maximum capacity (accounting for MIC), and application of the Capacity Limited Ramp Rate.
- Under frequency Response (ΔP) will be limited by the lesser of availability, Maximum Under frequency Response setting, maximum capacity (accounting for MEC), and application of the Capacity Limited Ramp Rate.
- ESPS provides ≥60% of its expected response within 5 seconds and 100% of its expected response within 15 seconds.
- Frequency response is achieved by altering the output of all modules as opposed to switching modules on or off, insofar as possible.
- ESPS regulates its active power output to within the greater of:(±0.5 MW or ±3% of Registered Capacity) of the Active Power Control Set-point adjusted for frequency response.
- The PPM controller continuously recalculates its expected response during the frequency excursion.

Ramp Rates

- Demonstration that the Capacity Limited Ramp Rate and Active Power Control Set-point Ramp Rate can each be set over a range between 1% and 100% of Registered Capacity per minute. *Note: APC ramp rate setting is varied in the APC Test Procedure*
- Ramp rate priority is applied as per Implementation Note and signal list settings

Signals

- FFR-TOR Availability signals behave correctly under APC set-point or EDIL dispatch
- Available active power export and import signals behave correctly when the unit is issued an APC set-point or is providing a frequency response

Frequency and Ramp Rate Settings to be implemented in ESPS Control System

Please refer to the published Battery ESPS Grid Code Implementation Note[1] for guidance on technical requirements for Battery ESPS and applicability of specific PPM clauses within the Grid Code.

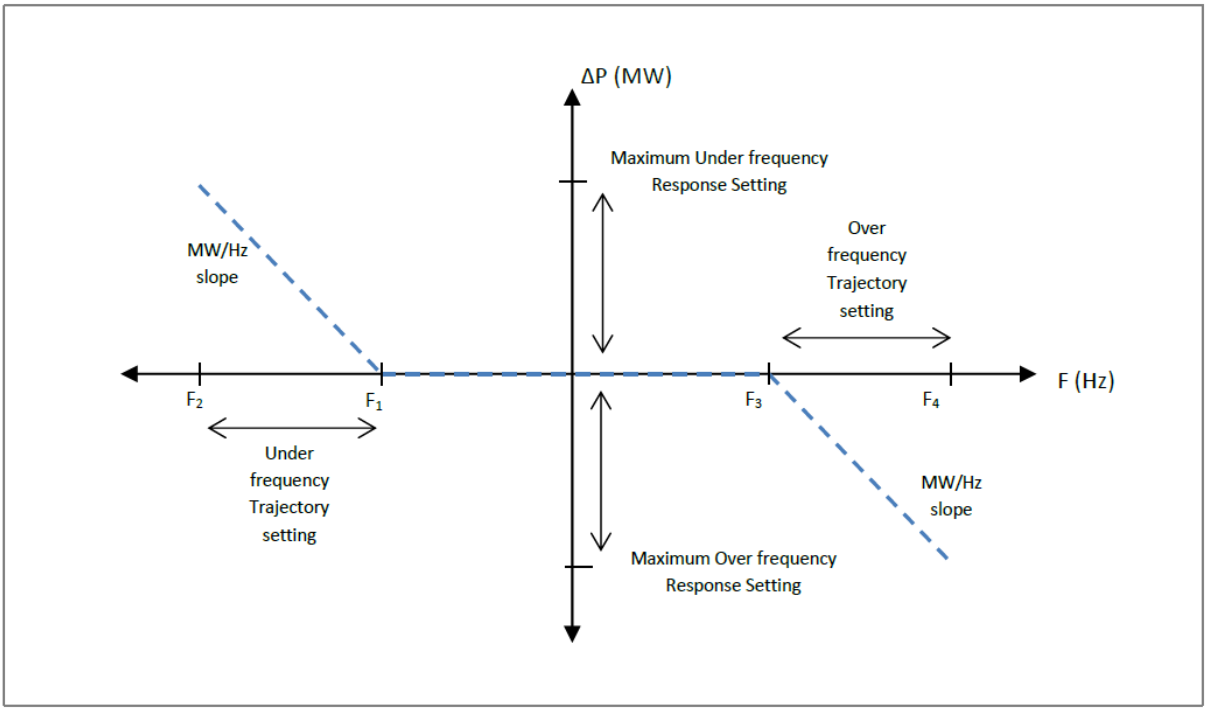


Figure 1 Battery ESPS Frequency Response Characteristics & Parameters

[1] http://www.soni.ltd.uk/media/documents/Integration-of-Batteries-Implementation-Note.pdf

Frequency Mode Settings

	Active under frequency trigger setting (Hz)	*Active under frequency trajectory setting (Hz)*	*Active Maximum underfrequency response setting (MW)*	*Active over frequency trigger setting (Hz)*	*Active over frequency trajectory setting (Hz)*	*Active Maximum overfrequency response setting (MW)*
Mode 1	49.8	0.3	Operating range	50.2	0.3	Operating range
Mode 2	TBC	TBC	Operating range	TBC	TBC	Operating range
Mode 3	49.8	0.5	Operating range	50.2	0.5	Operating range
Mode 4	49.9	2	Operating range	50.1	2	Operating range
Mode 5	49.8	0.5	50% Operating range	50.2	0.5	50% Operating range

Ramp Rates

Mode	**Rate**	**Priority**
Capacity Limited	1-100% of Registered Capacity per Minute (Standard Setting 20%)	1
Frequency Response	As fast as technically possible. 60% of its expected Active Power response within 5 seconds 100% of its expected Active Power response within 15 seconds.	2
Active Power Dispatch	1- 100% of Registered Capacity per Minute (Note: Setting as selected by SONI via SCADA)	3

Note: The ESPS should, where possible, ensure the unit has sufficient state of charge in advance of commencing testing each day.

Before each test section, the state of charge of the ESPS should be checked and adjusted if required, following approval by SONI.

Throughout the test procedure, for instances where Emergency Action is OFF it is noted that the expected MW output is 0MW. It is understood that there may be small MW imports at the connection point to account for house load, unless otherwise instructed by SONI.

The ESPS is to specify:

- Whether frequency is injected using software or external hardware
- Whether frequency can be injected as a ramp or as a step
- Whether frequency is injected as an offset to the system frequency or the governor/control system is isolated from the system frequency

Test 1	Functional Test
Step No.	**Action**
1	ESPS requests permission from SONI to proceed with the Frequency Response functional check and confirms the following with SONI: 1. MW output of the ESPS 2. EMERGENCY ACTION is OFF 3. Frequency Response is ON 4. Frequency Response Mode 1 is ON 5. Active Under frequency Trajectory setting 6. Active Under frequency Trigger setting 7. Active Maximum underfrequency response setting 8. Active Over frequency Trajectory setting 9. Active Over frequency Trigger setting 10. Active Maximum overfrequency response setting
2	ESPS requests SONI to select Reserve Response Mode 2 and manually records the time between the command being issued from SONI and being implemented in the ESPS Control System SONI to verify trajectory and trigger settings have updated in EMS as per expected Mode 2 settings
3	ESPS requests SONI to select Reserve Response Mode 3 and manually records the time between the command being issued from SONI and being implemented in the ESPS Control System SONI to verify trajectory and trigger settings have updated in EMS as per expected Mode 3 settings
4	ESPS requests SONI to select Reserve Response Mode 4 and manually records the time between the command being issued from SONI and being implemented in the ESPS Control System SONI to verify trajectory and trigger settings have updated in EMS as per expected Mode 4 settings
5	ESPS requests SONI to select Frequency Response OFF and manually records the time between the command being issued from SONI and being implemented in the ESPS controller
6	ESPS requests SONI to select Reserve Response Mode 5 and records any change to Frequency Response Mode status
7	ESPS requests SONI to select Frequency Response ON and manually records the time between the command being issued from SONI and being implemented in the ESPS controller
8	ESPS requests SONI to select Reserve Response Mode 5 and manually records the time between the command being issued from SONI and being implemented in the ESPS Control System SONI to verify trajectory and trigger settings have updated in EMS as per expected Mode 5 settings.
9	ESPS requests SONI to select Frequency Response Mode 1

Test 2	Mode 1: Frequency Response ON
Step No.	**Action**
1	ESPS requests permission from SONI to proceed with the Frequency Response ON, Mode 1 test and confirms the following with SONI: 1. AAP of the ESPS 2. MW set-point is 0MW 3. APC is OFF 4. MW output of the ESPS is 0MW 5. Frequency Response is ON 6. Frequency Response is in Mode 1 7. Active Under frequency Trajectory setting 8. Active Under frequency Trigger setting 9. Active Maximum underfrequency response setting 10. Active Over frequency Trajectory setting 11. Active Over frequency Trigger setting 12. Active Maximum overfrequency response setting
2	ESPS replaces the system frequency with a simulated frequency of 50 Hz and waits 1 minute.
3	ESPS requests permission from SONI to inject a simulated frequency step injection of 0.05Hz inside active underfrequency trigger and waits 1 minute
4	ESPS requests permission from SONI to inject a simulated frequency step injection of 0.05Hz outside active underfrequency trigger and waits 1 minute
5	ESPS requests permission from SONI to inject a simulated frequency step injection of 50Hz and waits 1 minute
6	ESPS requests permission from SONI to inject a simulated frequency ramp injection of 49Hz over 10 seconds and waits 1 minute
7	ESPS requests permission from SONI to inject a simulated frequency ramp injection of 50Hz over 10 seconds and waits 1 minute
8	ESPS requests permission from SONI to inject a simulated frequency step injection of 0.05Hz inside active overfrequency trigger and waits 1 minute
9	ESPS requests permission from SONI to inject a simulated frequency step injection of 0.05Hz outside active overfrequency trigger and waits 1 minute
10	ESPS requests permission from SONI to inject a simulated frequency step injection of 50Hz and waits 1 minute
11	ESPS requests permission from SONI to inject a simulated frequency ramp injection of 51Hz over 10 seconds and waits 1 minute
12	ESPS requests permission from SONI to inject a simulated frequency ramp injection of 50Hz over 10 seconds and waits 1 minute
13	ESPS requests SONI to turn Emergency Action ON and issue an MW set-point of 50% MEC and waits 1 minute after set-point has been achieved
14	ESPS confirms simulated frequency of 50Hz is in place
15	ESPS requests permission from SONI to inject a simulated frequency ramp injection of 49Hz over 1 minute and waits 1 minute
16	ESPS requests permission from SONI to inject a simulated frequency ramp injection of 50Hz over 1 minute and waits 1 minute
17	ESPS requests permission from SONI to inject a simulated frequency ramp injection of 51Hz over 1 minute and waits 1 minute

Test 2	Mode 1: Frequency Response ON
Step No.	**Action**
18	ESPS requests permission from SONI to inject a simulated frequency ramp injection of 50Hz over 1 minute and waits 1 minute
19	ESPS requests SONI to issue an Emergency Action MW set-point of 50% MIC and waits 1 minute after set-point has been achieved
20	ESPS confirms simulated frequency of 50Hz is in place
21	ESPS requests permission from SONI to inject a simulated frequency ramp injection of 49Hz over 1 second and waits 1 minute
22	ESPS requests permission from SONI to inject a simulated frequency ramp injection of 50Hz over 1 second and waits 1 minute
23	ESPS requests permission from SONI to inject a simulated frequency ramp injection of 51Hz over 1 second and waits 1 minute
24	ESPS requests permission from SONI to inject a simulated frequency ramp injection of 50Hz over 1 second and waits 1 minute
25	ESPS requests SONI to issue an Emergency Action MW set-point of MEC and waits 1 minute after set-point has been achieved
26	ESPS confirms simulated frequency of 50Hz is in place
27	ESPS requests permission from SONI to inject a simulated frequency ramp injection of 49Hz over 10 seconds and waits 1 minute
28	ESPS requests permission from SONI to inject a simulated frequency ramp injection of 50Hz over 10 seconds and waits 1 minute
29	ESPS requests permission from SONI to inject a simulated frequency ramp injection of 51Hz over 10 seconds and waits 1 minute
30	ESPS requests permission from SONI to inject a simulated frequency ramp injection of 50Hz over 10 seconds and waits 1 minute
31	ESPS requests SONI to issue an Emergency Action MW set-point of MIC and waits 1 minute after set-point has been achieved
32	ESPS confirms simulated frequency of 50Hz is in place
33	ESPS requests permission from SONI to inject a simulated frequency ramp injection of 49Hz over 1 minute and waits 1 minute
34	ESPS requests permission from SONI to inject a simulated frequency ramp injection of 50Hz over 1 minute and waits 1 minute
35	ESPS requests permission from SONI to inject a simulated frequency ramp injection of 51Hz over 1 minute and waits 1 minute

Test 2	Mode 1: Frequency Response ON
Step No.	**Action**
36	ESPS requests permission from SONI to inject a simulated frequency ramp injection of 50Hz over 1 minute and waits 1 minute
37	ESPS requests SONI to issue an Emergency Action set-point of 0MW and turn Emergency Action OFF and waits 1 minute after set-point has been achieved
38	ESPS ends data recording
39	ESPS informs SONI that the Frequency Response ON, Mode 1 test is complete. If further testing is not being completed, go to 6 Return to Standard Settings

Test 3	Mode 2: Frequency Response ON
Step No.	**Action**
1	ESPS requests permission from SONI to proceed with the Frequency Response ON, Mode 2 test and confirms the following with SONI: 1. AAP of the ESPS 2. MW set-point is 0MW 3. EMERGENCY ACTION is OFF 4. MW output of the ESPS is 0MW 5. Frequency Response is ON 6. Frequency Response is in Mode 2 7. Active Under frequency Trajectory setting 8. Active Under frequency Trigger setting 9. Active Maximum underfrequency response setting 10. Active Over frequency Trajectory setting 11. Active Over frequency Trigger setting 12. Active Maximum overfrequency response setting Note: The standard trigger test is an injection of 0.05Hz above and below the Mode 2 trigger setting. In the case that this would result in large MW step changes, for example for units with small trajectory settings, changes to these test steps should be discussed with Generator Testing.
2	ESPS replaces the system frequency with a simulated frequency of 50 Hz and waits 1 minute.
3	ESPS requests permission from SONI to inject a simulated frequency step injection of 0.05Hz inside active underfrequency trigger and waits 1 minute
4	ESPS requests permission from SONI to inject a simulated frequency step injection of 0.05Hz outside active underfrequency trigger and waits 1 minute
5	ESPS requests permission from SONI to inject a simulated frequency step injection of 50Hz and waits 1 minute
6	ESPS requests permission from SONI to inject a simulated frequency step injection of 0.05Hz inside active overfrequency trigger and waits 1 minute
7	ESPS requests permission from SONI to inject a simulated frequency step injection of 0.05Hz outside active overfrequency trigger and waits 1 minute
8	ESPS requests permission from SONI to inject a simulated frequency step injection of 50Hz and waits 1 minute
9	ESPS requests SONI to turn EMERGENCY ACTION ON and issue an EMERGENCY ACTION MW set-point of MIC and waits 1 minute after set-point has been achieved
10	ESPS confirms simulated frequency of 50Hz is in place
11	ESPS requests permission from SONI to inject a simulated frequency step injection of underfrequency trigger-trajectory and waits 20 minutes Note 1: Unless capacity limited, the ESPS should remain at this output until the frequency is returned towards 50Hz in step 12. Note 2: This step is intended to be used to demonstrate System Services Operating Reserve response time and volumes, and will also demonstrate the capacity of the battery ESPS. If the battery ESPS has a greater duration than 20 minutes, this timing for this step should be extended.
12	ESPS requests permission from SONI to inject a simulated frequency ramp injection of 50Hz over 1 minute and waits 1 minute

Test 3	Mode 2: Frequency Response ON
Step No.	**Action**
13	ESPS requests SONI to issue an EMERGENCY ACTION MW set-point of MEC and waits 1 minute after set-point has been achieved
14	ESPS requests permission from SONI to inject a simulated frequency step injection of overfrequency trigger + trajectory and waits 1 minute* *Note if Battery ESPS unit has contracted for over-frequency services as part of the Volume Capped arrangements, the timing of this step should be extended
15	ESPS requests permission from SONI to inject a simulated frequency ramp injection of 50Hz over 1 second and waits 1 minute
16	ESPS requests SONI to issue an EMERGENCY ACTION set-point of 0MW MW and turn EMERGENCY ACTION OFF and waits 1 minute after set-point has been achieved
17	ESPS ends data recording
18	ESPS informs SONI that the Frequency Response ON, Mode 2 test is complete. If further testing is not being completed, go to 6 Return to Standard Settings

Test 4	Mode 5: Frequency Response ON
Step No.	**Action**
1	ESPS requests permission from SONI to proceed with the Frequency Response ON, Mode 5 test and confirms the following with SONI: 1. AAP of the ESPS 2. MW set-point is 0MW 3. EMERGENCY ACTION is ON 4. MW output of the ESPS is 0MW 5. Frequency Response is ON 6. Frequency Response is in Mode 5 7. Active Under frequency Trajectory setting 8. Active Under frequency Trigger setting 9. Active Maximum underfrequency response setting 10. Active Over frequency Trajectory setting 11. Active Over frequency Trigger setting 12. Active Maximum overfrequency response setting
2	ESPS replaces the system frequency with a simulated frequency of 50 Hz and waits 1 minute.
3	ESPS requests permission from SONI to inject a simulated frequency ramp injection of 49Hz over 10 seconds and waits 1 minute
4	ESPS requests permission from SONI to inject a simulated frequency ramp injection of 50Hz over 10 seconds and waits 1 minute
5	ESPS requests permission from SONI to inject a simulated frequency ramp injection of 51Hz over 10 seconds and waits 1 minute
6	ESPS requests permission from SONI to inject a simulated frequency ramp injection of 50Hz over 10 seconds and waits 1 minute
7	ESPS requests SONI to turn EMERGENCY ACTION OFF and waits 1 minute
8	ESPS ends data recording
9	ESPS informs SONI that the Frequency Response ON, Mode 5 test is complete. If further testing is not being completed, go to 6 Return to Standard Settings

Test 5	Frequency Response OFF
Step No.	**Action**
1	ESPS requests permission from SONI to proceed with the Frequency Response OFF test and confirms the following with SONI: 1. EMERGENCY ACTION OFF 2. MW output of the ESPS is 0MW 3. Frequency Response is OFF 4. Frequency Response Mode 4 is selected
2	ESPS replaces the system frequency with a simulated frequency of 50 Hz and waits 1 minute
3	ESPS injects a simulated frequency of 49 Hz and waits 1 minute
4	ESPS injects a simulated frequency of 51 Hz and waits 1 minute
5	ESPS requests SONI to issue an EMERGENCY ACTION MW set-point of 40% Registered Capacity and turn EMERGENCY ACTION ON and waits until EMERGENCY ACTION set-point has been achieved
6	ESPS injects a simulated frequency of 49 Hz and waits 1 minute
7	ESPS injects a simulated frequency of 51 Hz and waits 1 minute
8	ESPS requests SONI to issue an EMERGENCY ACTION set-point of 0MW and turn EMERGENCY ACTION OFF, and waits until output reaches 0MW
9	ESPS ends data recording
10	ESPS informs SONI that the Frequency Response OFF test is complete. If further testing is not being completed, go to 6 Return to Standard Settings

Ramp Rate Priority
This test demonstrates that the three ramp rates are prioritised in correct manner.

Test 6	**Ramp Rate Priority**
Step No.	**Action**
1	ESPS requests permission from SONI to proceed with the test and confirms the following with SONI: 1. EMERGENCY ACTION is OFF 2. MW output of the ESPS 3. Frequency Response is ON 4. Mode 1 is ON 5. ESPS Useable Energy Remaining (MWhr) 6. ESPS Total Useable Storage Capacity (MWhr)
	Under Frequency injection during EMERGENCY ACTION ramp **EMERGENCY ACTION turned OFF during under frequency event**
2	ESPS requests SONI to issue a MW set-point of 50% of Registered Capacity and turn EMERGENCY ACTION ON. While ramping to the EMERGENCY ACTION set-point, ESPS requests permission from SONI to apply a simulated underfrequency step injection and waits until ESPS finishes ramping. *(Note: size of under-frequency injection to be such that the required delta MW is approx. 10-20% Operating Range)*
3	ESPS requests permission from SONI to inject a simulated frequency ramp injection of 50Hz over 10 seconds and waits until output settles
4	ESPS requests permission from SONI to inject a simulated underfrequency step injection and waits until ESPS output settles. *(Note: size of under-frequency injection to be such that the required delta MW is approx. 10-20% Operating Range)*
5	ESPS requests SONI to turn EMERGENCY ACTION OFF and waits until unit output settles
6	ESPS requests permission from SONI to inject a simulated frequency ramp injection of 50Hz over 10 seconds and waits until output reaches 0MW
	Over Frequency injection during EMERGENCY ACTION ramp **EMERGENCY ACTION turned OFF during over frequency event**
7	ESPS requests SONI to issue a MW set-point of 15% of Registered Capacity and turn EMERGENCY ACTION ON. While ramping to the EMERGENCY ACTION set-point, ESPS requests permission from SONI to inject a simulated overfrequency step injection and waits until ESPS finishes ramping. *(Note: size of over-frequency injection to be such that the required delta MW is approx. 20-30% Operating Range)*
8	ESPS requests SONI to turn EMERGENCY ACTION OFF and waits until unit output settles
9	ESPS requests permission from SONI to inject a simulated frequency ramp injection of 50Hz over 10 seconds and waits until output settles

	Over Frequency injection during EMERGENCY ACTION ramp Returning to EMERGENCY ACTION set-point on frequency recovery
10	ESPS requests SONI to issue a MW set-point of 20% of Registered Capacity and turn EMERGENCY ACTION ON. While ramping to the Emergency Action set-point, ESPS requests permission from SONI to inject a simulated overfrequency step injection and waits until ESPS finishes ramping. *(Note: size of over-frequency injection to be such that the required delta MW is approx. 20-30% Operating Range)*
11	ESPS requests permission from SONI to inject a simulated frequency ramp injection of 50Hz over 10 seconds and waits until output settles
	Frequency injections during Capacity Limited Ramp Down
12	ESPS sets the Capacity Limited Ramp Rate to an appropriate value to enable completion of this step. *(Note: The capacity limited ramp rate to be set to different value than the current APC ramp rate setting. This setting should be such that Steps 15 & 16 can be carried out while the unit is ramping down from a 60% registered capacity set-point (Step 13). E.g. 10% Registered Capacity/minute would give 6 minutes of a ramp down to allow Step15 & 16 to be completed.)*
13	ESPS requests SONI to turn Emergency Action ON and issue a MW set-point of 60% of Registered Capacity
14	ESPS output to be held until the unit starts ramping at Capacity Limited Ramp Rate *(Note: State of charge should be low enough so that this wait time is reasonable)*
15	ESPS requests permission from SONI to inject a simulated frequency step injection of 49.5 Hz
16	ESPS requests permission from SONI to inject a simulated overfrequency step injection. *(Note: size of over-frequency injection to be such that the required delta MW is approx. 10-20% Operating Range)* If the unit is still exporting as a result of this injection, this simulated frequency injection is held until the unit output settles and/or Capacity Limited ramp is completed. If the unit has started importing as a result of this injection, this simulated frequency injection should be held for 1 minute.
17	ESPS requests permission from SONI to inject a simulated frequency step injection of 50Hz and waits 1 minute.
18	ESPS sets the Capacity Limited Ramp Rate to 20% of Registered Capacity per minute, as and confirms to SONI.
19	ESPS requests SONI to issue a set-point of 0MW then turn Emergency Action OFF and waits until 1 minute after the MW output has reached 0MW
20	ESPS ends data recording
21	ESPS informs SONI that the Ramp Rate Priority test is complete. If further testing is not being completed, go to 6 Return to Standard Settings

6	Return to Standard Settings
Step No.	**Action**
1	ESPS removes the simulated frequency, returning the ESPS controller reference to system frequency
2	ESPS confirms the following with SONI: 8. EMERGENCY ACTION Set-point = 0MW 9. EMERGENCY ACTION is OFF 10. MW output of the ESPS 11. Frequency Response is ON 12. Frequency Response is in Mode 1 13. ESPS control system frequency reference is system frequency
3	ESPS informs SONI that Frequency Response testing is complete

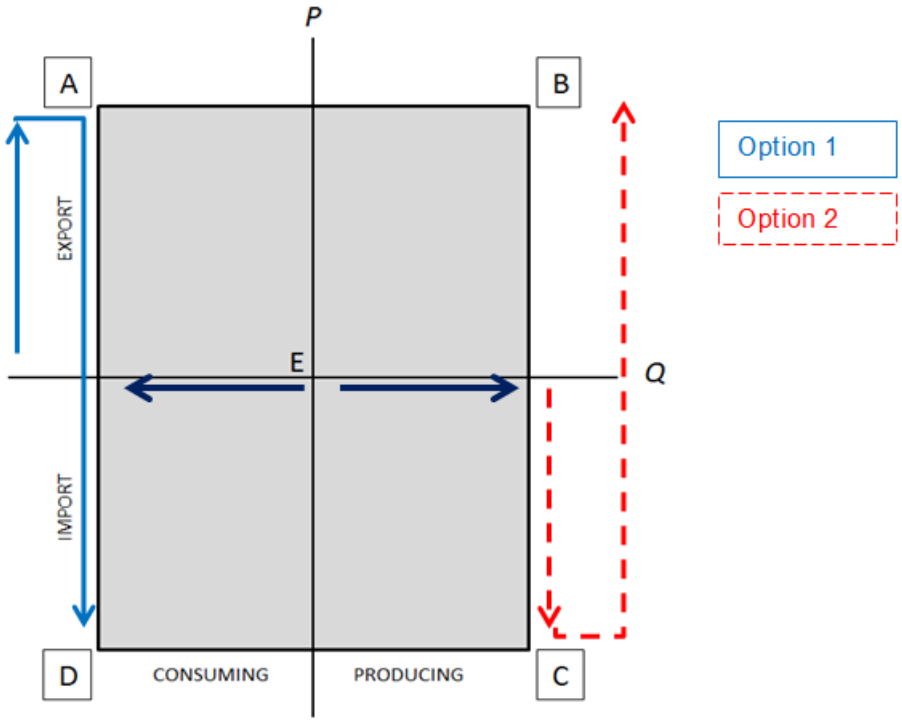
4. REACTIVE POWER CAPABILITY TESTS

Purpose of tests:

To establish that the reactive power capability of the Battery ESPS is in compliance with the requirements detailed in Section B.4 of the Battery ESPS Grid Code Implementation Note.

The tests should demonstrate the limits of the ESPS reactive power capability curve at the connection point. The test is undertaken at various load levels for both the export of reactive power from the ESPS and for the import of reactive power to the ESPS.

Test Methodology:



Depending on state of charge, the ESPS can follow the red or blue path to complete this test. Each option is shown on one side of the capability curve only for illustration purposes.

ESPS to start from a 0MW active power position at MVAr output close to 0 MVAr and increase MVAr set-points until max lagging/leading capability as noted in Section 4 is reached. Note that this set-point shall be large enough to cover the max capability over all of the MW range, such that as the MW output is varied in subsequent test steps, the MVAr output is not limited by the MVAr set-point.

Option 1 (Blue solid line): Once at max leading/lagging capability, the MVAr set-point should be set to ensure the maximum capability as per the PQ chart in Section 4 is achievable. Active power set-points are then issued to increase from 0MW to 100% registered capacity, and then down to full import. Note depending on the capability curve, the MVAr output may vary as MW output is varied.

Option 2 (Red dashed line): Once at max leading/lagging capability, the MVAr set-point should be set to ensure the maximum capability as per the PQ chart in Section 4 is achievable. Active power set-points are then issued to decrease from 0MW to full import, and then increase to 100% registered capacity. Note depending on the capability curve, the MVAr output may vary as MW output is varied.

After each option the MW output is returned to 0MW and the MVAr output is returned to 0MVAr in steps. The size of these steps shall be confirmed with SONI.

Results Required:

The following data must be captured by the ESPS at the time of testing and submitted to SONI in the format of a time series record and Microsoft Excel Plot:

- ESPS Available Active Power Export (MW)
- ESPS Available Active Power Import (MW)
- ESPS Useable Energy Remaining (MWhr)
- ESPS Total Useable Storage Capacity (MWhr)
- Actual active power from the ESPS (MW)
- System Voltage at Connection Point (kV)
- Reactive Power Flow at Connection Point (MVAr)
- Emergency Action ON/OFF
- Emergency Action set-point from SONI
- Frequency Response ON/OFF
- Number of modules online

The ESPS may capture any other signals as necessary to demonstrate compliance.

Pass Criteria:

- Demonstration that the measured P-Q capability is in line with the submitted P-Q capability diagram
- Demonstration that the measured P-Q capability meets or exceeds the minimum expected reactive power capabilities of the controllable ESPS, as defined in the Grid Code and in the published Battery Implementation Note, as measured at the Connection Point
- Completion of cable charging measurement
- Reactive power import availability and reactive power export availability signals provide the real-time availability of MVAr that can be imported/consumed at point of connection, taking into account any relevant factors such as active power output (or import), module availability, faults etc.

Note: The ESPS should, where possible, ensure the unit has sufficient state of charge in advance of commencing testing each day.

Before each test section, the state of charge of the ESPS should be checked and adjusted if required, following approval by SONI.

Throughout the test procedure, for instances where Emergency Action is OFF it is noted that the expected MW output is 0MW. It is understood that there may be small MW imports at the connection point to account for house load, unless otherwise instructed by SONI.

Test Procedures:

Test 1	Reactive Power Capability: Importing
Step No.	**Action**
1	ESPS requests permission from SONI to proceed with the Reactive Power Capability (Importing Mvar) test and confirms the following with SONI: 7. MW output of the ESPS 8. Emergency Action is OFF 9. Frequency Response is OFF 10. Mvar (Q) control mode is ON 11. The transformer tap position 12. On Load Tap Changer Mode 13. System Voltage 14. Maximum leading Mvar capability of the ESPS 15. Mvar Export at the connection point 16. ESPS Reactive Power Export Availability (MVAr) 17. ESPS Reactive Power Import Availability (MVAr) 18. ESPS to confirm which path it wishes to follow for testing, based on state of charge
2	ESPS requests SONI to decrease the MVAr set-point in steps as agreed with SONI until the ESPS has reached its maximum leading MVAr limit at the connection point
3	ESPS requests SONI to reduce the MVAr set-point by a further step (s). *Note: Ensure that the MVAr set-point is sufficient to cover the max capability over all of the MW range, such that as the MW output is varied in subsequent test steps, the MVAr output is not limited by the MVAr set-point.
4	ESPS requests SONI to turn EMERGENCY ACTION ON and issue a MW set-point of Registered Capacity or MIC *Note if Registered Capacity/MIC is larger than 10MW – this step may be split into multiple steps *Note depending on the ESPS PQ curve, the MVAr output may vary as MW output is varied for subsequent steps.
5	ESPS requests SONI to issue a set-point of 0 MW *Note if Registered Capacity/MIC is larger than 10MW – this step may be split into multiple steps *Note depending on the ESPS PQ curve, the MVAr output may vary as MW output is varied for subsequent steps.
6	ESPS requests SONI to issue a MW set-point of Registered Capacity or MIC *Note if Registered Capacity/MIC is larger than 10MW – this step may be split into multiple steps *Note depending on the ESPS PQ curve, the MVAr output may vary as MW output is varied for subsequent steps.
7	ESPS requests SONI to issue a set-point of 0MW and turn EMERGENCY ACTION OFF and waits until output reaches 0 MW. *Note if Registered Capacity/MIC is larger than 10MW – this step may be split into multiple steps

Test 1	Reactive Power Capability: Importing
Step No.	**Action**
	*Note depending on the ESPS PQ curve, the MVAr output may vary as MW output is varied for subsequent steps.
8	ESPS requests SONI to increase the MVAr set-point in steps as agreed with SONI until the ESPS is exporting 0 MVAr at the connection point, or as agreed with SONI
9	ESPS ends data recording
10	ESPS informs SONI that the Reactive Power Capability (Importing MVAr) test is complete If further testing is not being completed, go to Section 4 Return to Standard Settings

Test 2	Reactive Power Capability: Exporting
Step No.	**Action**
1	ESPS requests permission from SONI to proceed with the Reactive Power Capability (Exporting Mvar) test and confirms the following with SONI: 1. MW output of the ESPS 2. Emergency Action is OFF 3. Frequency Response is OFF 4. Mvar (Q) control mode is ON 5. The transformer tap position 6. On Load Tap Changer Mode 7. System Voltage 8. Maximum leading Mvar capability of the ESPS 9. Mvar Export at the connection point 10. ESPS Reactive Power Export Availability (MVAr) 11. ESPS Reactive Power Import Availability (MVAr) 12. ESPS to confirm which path it wishes to follow for testing, based on state of charge
2	ESPS requests SONI to increase the MVAr set-point in steps as agreed with SONI until the ESPS has reached its maximum lagging MVAr limit at the connection point
3	ESPS requests SONI to increase the MVAr set-point by a further step (s). *Note: Ensure that the MVAr set-point is sufficient to cover the max capability over all of the MW range, such that as the MW output is varied in subsequent test steps, the MVAr output is not limited by the MVAr set-point.
4	ESPS requests SONI to turn EMERGENCY ACTION ON and issue a MW set-point of Registered Capacity or MIC *Note if Registered Capacity/MIC is larger than 10MW – this step may be split into multiple steps *Note depending on the ESPS PQ curve, the MVAr output may vary as MW output is varied for subsequent steps.
5	ESPS requests SONI to issue a set-point of 0 MW *Note if Registered Capacity/MIC is larger than 10MW – this step may be split into multiple steps *Note depending on the ESPS PQ curve, the MVAr output may vary as MW output is varied for subsequent steps.
6	ESPS requests SONI to issue a MW set-point of Registered Capacity or MIC *Note if Registered Capacity/MIC is larger than 10MW – this step may be split into multiple steps *Note depending on the ESPS PQ curve, the MVAr output may vary as MW output is varied for subsequent steps.
7	ESPS requests SONI to issue a set-point of 0MW and turn EMERGENCY ACTION OFF and waits until output reaches 0 MW. *Note if Registered Capacity/MIC is larger than 10MW – this step may be split into multiple steps *Note depending on the ESPS PQ curve, the MVAr output may vary as MW output is varied for subsequent steps.

Test 2	Reactive Power Capability: Exporting
Step No.	**Action**
8	ESPS requests SONI to decrease the MVAr set-point in steps as agreed with SONI until the ESPS is exporting 0 MVAr at the connection point, or as agreed with SONI
9	ESPS ends data recording
10	ESPS informs SONI that the Reactive Power Capability (Exporting MVAr) test is complete If further testing is not being completed, go to Section 4 Return to Standard Settings

Test 3	Cable Network Charging Capacitance
Step No.	**Action**
1	ESPS requests permission from SONI and shuts down all Battery Modules
2	ESPS records the MVAr at the connection point
3	ESPS requests permission from SONI and restarts all Battery Modules

4	Return to Standard Settings
Step No.	**Action**
1	ESPS confirms the following with SONI: 1. Emergency Action setpoint is 0MW 2. MW output of the ESPS 3. Emergency Action is OFF 4. Frequency Response is ON 5. Frequency Response is in Mode1 6. AVR (kV) control mode is ON 7. The transformer tap position 8. On Load Tap Changer is in Automatic mode 9. System Voltage 10. kV Set-point = system voltage at connection point 11. Voltage slope setting = 3% 12. MVAr Export at the connection point

5. REACTIVE POWER CONTROL TESTS

Purpose of tests:

To establish that the reactive power control capability of the Battery ESPS is in compliance with the requirements detailed in Section B.4 of the Battery ESPS Grid Code Implementation Note.

The purpose of this test is to confirm correct operation of AVR system in kV, Q and PF control modes, and changing between modes.

It should be noted that in normal operation, and unless otherwise instructed by SONI, the reactive slope characteristic should be set to 3%.

Results Required:

The following data must be captured by the ESPS at the time of testing and submitted to SONI in the format of a time series record and Microsoft Excel Plot:

- ESPS Available Active Power Export (MW)
- ESPS Available Active Power Import (MW)
- ESPS Useable Energy Remaining (MWhr)
- ESPS Total Useable Storage Capacity (MWhr)
- Actual active power from the ESPS (MW)
- System Voltage at Connection Point (kV)
- Reactive Power Flow at Connection Point (MVAr)
- Emergency Action ON/OFF
- Emergency Action set-point from SONI
- Frequency Response ON/OFF
- Number of modules online

Pass Criteria:

AVR Control

- ESPS receives all kV set-points, implements kV all set-points within 20 seconds of receipt of the set-point and provides the correct set-point feedback
- ESPS regulates its reactive power at the point of connection correctly based on the voltage slope setting, system voltage and kV set-point
- Demonstration that the Voltage Regulation System Slope Setting can be set between 2% and 7%
- Voltage Regulation System responds to a step change in voltage at the connection point, it achieves 90% of its steady-state response within 1 second

MVAr Control

- ESPS receives all MVAr set-points, implements MVAr all set-points within 20 seconds of receipt of the set-point and provides the correct set-point feedback
- ESPS maintains the MVAr set-point at the connection point
- The Battery ESPS controller will be required to maintain the effective MVAr setpoint during changes to active power export or import, including through zero MW.

Power Factor Control

- ESPS receives all PF set-points, implements PF all set-points within 20 seconds of receipt of the set-point and provides the correct set-point feedback
- ESPS maintains the PF per phase angle set-point at the connection point

Bumpless Transfer

- Voltage Regulation System implements bumpless transfer between reactive power control modes

Note: The ESPS should, where possible, ensure the unit has sufficient state of charge in advance of commencing testing each day.

Before each test section, the state of charge of the ESPS should be checked and adjusted if required, following approval by SONI.

Throughout the test procedure, for instances where Emergency Action is OFF it is noted that the expected MW output is 0MW. It is understood that there may be small MW imports at the connection point to account for house load, unless otherwise instructed by SONI.

Test Procedures:

Functional Checks and Bumpless Transfer

Bumpless Transfer between reactive power control modes is tested here by changing between each of the modes and sending a positive and a negative set-point in each mode. This also demonstrates that the controls are functioning.

Test 1	**Functional Checks and Bumpless Transfer**
Step No.	**Action**
1	ESPS requests permission from SONI to proceed with the AVR response rate test and confirms the following with SONI: 1. Frequency Response is OFF 2. Emergency Action is ON 3. Emergency Action MW set-point is 50% of Registered Capacity 4. MW output of the ESPS 5. AVR (kV) control mode is ON 6. The transformer tap position 7. On Load Tap Changer is in Automatic Mode 8. System Voltage 9. kV set-point = system voltage at connection point 10. Voltage slope setting = 3% 11. MVAr Export is close to 0 MVAr at the connection point
2	ESPS requests SONI to increase the voltage set-point by 0.5 kV and waits 1 minute
3	ESPS requests SONI to issue a MVAr set-point of -1 MVAr
4	ESPS requests SONI to select MVAr (Q) control mode and waits 1 minute
5	ESPS requests SONI to issue a MVAr set-point of 10% of lagging MVAr capability and waits 1 minute
6	ESPS requests SONI to issue a PF set-point of 0 degrees
7	ESPS requests SONI to select Power Factor control mode and waits 1 minute
8	ESPS requests SONI to issue a PF set-point of +12 degrees noting calculated response and waits 1 minute
9	ESPS requests SONI to select AVR control mode and waits 1 minute
10	ESPS requests SONI to issue a kV set-point 1 kV lower than system voltage at the connection point
11	ESPS requests SONI to select Power Factor control mode and waits 1 minute
12	ESPS requests SONI to issue a PF set-point of -12 degrees noting calculated response and waits 1 minute
13	ESPS requests SONI to select MVAr (Q) control mode and waits 1 minute
14	ESPS requests SONI to issue a MVAr set-point of 15% of leading MVAr capability and waits 1 minute
15	ESPS requests SONI to select AVR control mode and waits 1 minute
16	ESPS requests SONI to issue a kV set-point equal to system voltage at the connection point
17	Ensure that the ESPS is producing approximately 0 MVAr at the connection point

Test 1	Functional Checks and Bumpless Transfer
Step No.	**Action**
18	ESPS requests SONI to issue an Emergency Action set-point of 0 MW, turn Energency Action OFF and wait until set-point has been achieved
19	ESPS ends data recording
20	ESPS informs SONI that the bumpless transfer test is complete If further testing is not being completed, go to 6: Return to Standard Settings

Automatic Voltage Regulation Mode

SONI issues a series of kV set-points both above and below system voltage to demonstrate the ability of the ESPS to correctly calculate and maintain these set-points.

Test 2	**Automatic Voltage Regulation Mode**
Step No.	**Action**
1	ESPS requests permission from SONI to proceed with the AVR Mode test and confirms the following with SONI: 13. Emergency Action is OFF 14. Frequency Response is OFF 15. MW output of the ESPS 16. AVR (kV) control mode is ON 17. Transformer tap position 18. On Load Tap Changer is in Automatic Mode 19. System Voltage 20. kV set-point = system voltage at connection point 21. Voltage slope setting = 3% 22. MVAr export is close to 0 MVAr at the connection point
2	ESPS sets the Voltage Regulation System slope to 2% confirms the following to SONI: 1. Voltage Slope is now 2% 2. Calculated change in MVAr output caused by a 0.5 kV change in voltage set-point 3. Current MVAr output of ESPS
3	ESPS requests SONI to increase the voltage set-point by 0.5 kV and waits 1 minute
4	ESPS requests SONI to decrease the voltage set-point by 0.5 kV and waits 1 minute
5	ESPS confirms with SONI that ESPS MVAr output is approximately 0 MVAr at the connection point. If not, ESPS requests SONI to issue a voltage set-point to achieve approximately 0 MVAr
6	ESPS sets the Voltage Regulation System slope to 7% and confirms the following to SONI: 1. Voltage Slope is now 7% 2. Calculated change in MVAr output caused by a 2kV change in voltage set-point 3. Current MVAr output of ESPS
7	ESPS requests SONI to decrease the voltage set-point by 2 kV and waits 1 minute
8	ESPS requests SONI to increase the voltage set-point by 2 kV and waits 1 minute
9	ESPS confirms with SONI that ESPS MVAr output is approximately 0 MVAr at the connection point. If not, ESPS requests SONI to issue a voltage set-point to achieve approximately 0 MVAr
10	ESPS sets the Voltage Regulation System slope to 3% and confirms the following to SONI: 1. Voltage Slope is now 3% 2. Calculated change in MVAr output caused by a 1kV change in voltage set-point 3. Current MVAr output of ESPS
11	ESPS requests SONI to increase the voltage set-point by 1 kV and waits 1 minute
12	ESPS requests SONI to turn Emergency Action ON and issue an Emergency Action MW set-point of 20% of Registered Capacity and wait until 1 minute after Emergency Action set-point has been achieved
13	ESPS requests SONI to increase the voltage set-point by 0.5 kV and waits 1 minute
14	ESPS requests SONI to issue an Emergency Action MW set-point of -10% of Registered Capacity and wait until 1 minute after Emergency Action set-point has been achieved

Test 2	Automatic Voltage Regulation Mode
Step No.	**Action**
15	ESPS requests SONI to decrease the voltage set-point by 1 kV and waits 1 minute
16	ESPS requests SONI to issue an Emergency Action set-point of 0 MW and turn Emergency Action OFF and wait until 1 minute after set-point has been achieved
17	ESPS requests SONI to decrease the voltage set-point by 0.5 kV and waits 1 minute
18	ESPS requests SONI to decrease the voltage set-point by 1 kV and waits 1 minute
19	ESPS requests SONI to decrease the voltage set-point by 0.5 kV and waits 1 minute
20	ESPS requests SONI to increase the voltage set-point by 1 kV and waits 1 minute
21	ESPS requests SONI to increase the voltage set-point by 0.5 kV and waits 1 minute
22	ESPS confirms with SONI that ESPS MVAr output is approximately 0 MVAr at the connection point. If not, ESPS requests SONI to issue a voltage set-point to achieve approximately 0 MVAr at the connection point
23	ESPS ends data recording
24	ESPS informs SONI that the AVR Mode test is complete If further testing is not being completed, go to 6: Return to Standard Settings

Automatic Voltage Regulation Response Rate

A step change in system voltage is created here to allow analysis of the AVR rate of response. The step change is ideally created by SONI carrying out switching on the system. If this is not possible, the ESPS shall carry out a manual tap change to induce a small step change in system voltage.

Test 3	**Automatic Voltage Regulation Response Rate**
Step No.	**Action**
1	ESPS requests permission from SONI to proceed with the AVR response rate test and confirms with SONI the following with SONI: 1. Frequency Response is OFF 2. Emergency Action is OFF 3. MW output of the ESPS 4. AVR (kV) control mode is ON 5. The transformer tap position 6. On Load Tap Changer is in Automatic Mode 7. System Voltage 8. Voltage slope setting = 3% 9. MVAr Export at the connection point
2	ESPS requests SONI to induce a step change in system voltage by carrying out transformer tapping or carrying out switching on the system, if possible.
3	ESPS ends data recording
4	ESPS informs SONI that the AVR response rate test is complete
If SONI cannot facilitate switching on the system to induce a step change in system voltage, carry out the following steps:	
5	ESPS requests permission from SONI and puts the on-load tap changer into manual mode
6	ESPS requests permission from SONI and taps the transformer up 1 tap and waits 1 minute
7	ESPS requests permission from SONI, ESPS taps the transformer up 1 tap and waits 1 minute
8	ESPS requests permission from SONI, ESPS taps the transformer down 1 tap and waits 1 minute
9	ESPS requests permission from SONI, ESPS taps the transformer down 1 tap and waits 1 minute
10	ESPS requests permission from SONI, puts the on-load tap changer into automatic mode and confirms to SONI
11	ESPS confirms with SONI that the ESPS is at approximately 0 MVAr at the connection point
12	ESPS ends data recording
13	ESPS informs SONI that the AVR response rate test is complete If further testing is not being completed, go to 6: Return to Standard Settings

MVAr Control Mode

SONI issues a series of positive and negative MVAr set-points to demonstrate the ability of the ESPS to maintain these set-points.

Test 4	**MVAr Control Mode**
Step No.	**Action**
1	ESPS requests permission from SONI to proceed with the MVAr Control Mode test and confirms with SONI the following with SONI: 1. Frequency Response is OFF 2. Emergency Action is OFF 3. MW output of the ESPS 4. MVAr (Q) control mode is ON 5. The transformer tap position 6. On Load Tap Changer is in Automatic Mode 7. Mvar Set-point = 0 MVAr 8. System Voltage 9. Voltage slope setting = 3% 10. MVAr Export is 0 MVAr at the connection point
2	ESPS requests SONI to issue a MVAr set-point of 25% of lagging MVAr capability and waits 1 minute
3	ESPS requests SONI to turn Emergency Action ON and issue an Emergency Action MW set-point of 20% of Registered Capacity and wait until 1 minute after Emergency Action set-point has been achieved
4	ESPS requests SONI to issue a MVAr set-point of 60% of lagging MVAr capability and waits 1 minute
5	ESPS requests SONI to issue an Emergency Action MW set-point of -10% of Registered Capacity and wait until 1 minute after Emergency Action set-point has been achieved
6	ESPS requests SONI to issue a MVAr set-point of 10% of lagging MVAr capability and waits 1 minute
7	ESPS requests SONI to issue an Emergency Action set-point of 0 MW and turn Emergency Action OFF and wait until 1 minute after set-point has been achieved
8	ESPS requests SONI to issue a set-point of 0 MVAr and waits 1 minute
9	ESPS requests SONI to issue a MVAr set-point of 25% of leading MVAr capability and waits 1 minute
10	ESPS requests SONI to issue a MVAr set-point of 60% of leading MVAr capability and waits 1 minute
11	ESPS requests SONI to issue a MVAr set-point of 10% of leading MVAr capability and waits 1 minute
12	ESPS requests SONI to issue a set-point of 0 MVAr and waits 1 minute
13	ESPS confirms with SONI that the ESPS is at approximately 0 MVAr at the connection point
14	ESPS ends data recording
15	ESPS informs SONI that the MVAr Control Mode test is complete If further testing is not being completed, go to 6: Return to Standard Settings

Power Factor Control Mode

SONI issues a series of positive and negative PF set-points to demonstrate the ability of the ESPS to correctly calculate and maintain these set-points.

Test 5	**Power Factor Control Mode**
Step No.	**Action**
1	ESPS requests permission from SONI to proceed with the Power Factor Control Mode test and confirms the following with SONI: 1. Frequency Response is OFF 2. Emergency Action is ON 3. Emergency Action setpoint is 100% of Registered Capacity 4. MW output of the ESPS 5. Power Factor (PF) control mode is ON 6. The transformer tap position 7. On Load Tap Changer Mode 8. Voltage Set-point Control (Local/Remote) 9. System Voltage 10. PF set-point = 0 degrees 11. Voltage slope setting = 3% 12. MVAr Export
2	ESPS requests SONI to issue a PF set-point of +8 degrees noting calculated MVAr response to set-point of +8 degrees at 100% of Registered Capacity and waits 1 minute
3	ESPS requests SONI to issue a PF set-point of +12 degrees noting calculated MVAr response to set-point of +12 degrees at 100% of Registered Capacity and waits 1 minute
4	ESPS requests SONI to issue an Emergency Action MW set-point of 30% of Registered Capacity noting calculated MVAr response to set-point of +12 degrees at 30% of Registered Capacity and wait until 1 minute after Emergency Action set-point has been achieved
5	ESPS requests SONI to issue a PF set-point of +8 degrees noting calculated MVAr response to set-point of +8 degrees at 30% of Registered Capacity and waits 1 minute
6	ESPS requests SONI to issue a PF set-point of 0 degrees and waits 1 minute
7	ESPS requests SONI to issue a PF set-point of -8 degrees noting calculated MVAr response to set-point of -8 degrees at 30% of Registered Capacity and waits 1 minute
8	ESPS requests SONI to issue a PF set-point of -12 degrees noting calculated MVAr response to set-point of -12 degrees at 30% of Registered Capacity and waits 1 minute
9	ESPS requests SONI to issue an Emergency Action MW set-point of -10% of Registered Capacity noting calculated MVAr response to set-point of -12 degrees at -10% of Registered Capacity and waits until 1 minute after active power output has reached the setpoint
10	ESPS requests SONI to issue a PF set-point of -8 degrees noting calculated MVAr response to set-point of -8 degrees at -10% of Registered Capacity and waits 1 minute
11	ESPS requests SONI to issue a PF set-point of 0 degrees and waits 1 minute
12	ESPS requests SONI to issue an Emergency Action set-point of 0 MW and turn Emergency Action OFF and wait until 1 minute after set-point has been achieved
13	ESPS requests SONI to select AVR control mode
14	ESPS confirms with SONI that the ESPS is at approximately 0 MVAr at the connection point
15	ESPS ends data recording
16	ESPS informs SONI that the Power Factor Control Mode test is complete If further testing is not being completed, go to 6: Return to Standard Settings

Return to Standard Settings

The steps below return the ESPS to standard settings at the completion of testing.

6	Return to Standard Settings
Step No.	**Action**
1	ESPS informs SONI that Reactive Power Control Testing is complete and confirms the following the following: 1. MW output of the ESPS 2. Emergency Action Setpoint is 0MW 3. Emergency Action is OFF 4. Frequency Response is ON 5. Frequency Response is in Mode 1 6. AVR (kV) control mode is ON 7. The transformer tap position 8. On Load Tap Changer is in Automatic Mode 9. System Voltage 10. kV set-point = system voltage at connection point 11. Voltage slope setting = 3% 12. MVAr Export at the connection point