EIRGRID_2015 Functional Document Template (21

Battery ESPS Reactive Power Control Test Procedure

[Insert PPM Name]

Version 0.1

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# Document Version History

EirGrid test procedure template version published July 2021.

|  |  |  |
| --- | --- | --- |
| **Document Version History** | | |
| **Version** | **Date** | **Comment** |
| 0.1 | dd/mm/yyyy | First submission for review/approval |
| 1.0 |  |  |
|  |  |  |

# Introduction

|  |  |
| --- | --- |
| ESPS Name | ESPS to Specify  (name per connection agreement) |
| ESPS Test Coordinator and contact number: | ESPS to Specify |
| Associated 110 kV Station | ESPS to Specify |
| ESPS connection point | ESPS to Specify  (*i.e.* T121 in XXX Distribution or Transmission Station) |
| ESPS connection voltage | ESPS to Specify |
| ESPS Connection Type | ESPS to Specify  (TSO, DSO Topology 1, DSO Topology 2 etc.) |
| Installed module type, MW size and quantity | ESPS to Specify |
| Contracted MEC | ESPS to Specify |
| Contracted MIC | ESPS to Specify |
| Registered Capacity | ESPS to Specify |
| Energy Storage Capacity | ESPS to Specify |
| % Charge maintained in normal operation | ESPS to Specify |
| Limiter applied to Exported MW | ESPS to Specify |
| Limiter applied to AAP | ESPS to Specify |
| Minimum Leading MVAr requirement at the connection point above 12% Active Power Output per Grid Code *Figure PPM1.4 (or equivalent Implementation Note requirement)* | ESPS to Specify |
| Minimum Lagging MVAr requirement at the connection point above 12% Active Power Output per Grid Code *Figure PPM1.4 (or equivalent Implementation Note requirement)* | ESPS to Specify |
| Maximum Leading MVAr at connection point | ESPS to Specify |
| Maximum Lagging MVAr at connection point | ESPS to Specify |
| Grid Connected Transformer Tap range | ESPS to Specify |

## Test Execution

**PPM shall highlight any changes made to this document or approval will be void.**

The PPM shall submit the latest version of this test procedure template as published on the EirGrid website[[1]](#footnote-1).

All yellow sections shall be filled in before the test procedure shall be approved. All grey sections shall be filled in during testing. If any test requirements or steps are unclear, or if there is an issue with meeting any requirements or carrying out any steps, please contact [generator\_testing@eirgrid.com](mailto:generator_testing@eirgrid.com).

Where a site consists of two separate controllable PPM with a single connection point, this may impact on the test procedure outlined below.

The ESPS representative shall coordinate testing. On the day of testing, suitably qualified technical personnel may be needed at the ESPS to assist in undertaking the tests. Such personnel shall have the ability to fully understand the function of the ESPS and its relationship to the network to which the ESPS is connected. Furthermore, such personnel shall have the ability to set up the control system of the ESPS so as to enable Grid Code compliance test to be correctly undertaken. In addition, the function of the technical personnel is to liaise with NCC.

The availability of personnel at NCC will be necessary in order to initiate the necessary instructions for the test. NCC shall determine if network conditions allow the testing to proceed.

All battery modules shall be available. If on the day of the testing all battery modules are not available, then the test may proceed where the unavailable modules make up <20% of Registered Capacity. All test results shall be based on tested performance only and shall not be extrapolated in the case of reduced availability. Resource conditions need to be sufficient in order adequately perform the test. 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 NCC.

Throughout the test procedure, for instances where APC is OFF the TSO accepts that there may be some level of import required to manage house load in this scenario. The battery should not be discharging or charging while APC is OFF, but may import due to house load.

## Notes

If Automated Test Scripts are being used, Automated Test Scripts generated by the ESPS shall meet the following requirements:

* It must be possible to pause the script at any point.
* The MW Test Profile has been submitted and agreed in advance
* The MW Test Profile must account for timing of each step (note 1 minute is not appropriate for all steps).

Please note a site specific PQ chart is to be provided in Section 4.

Following testing, the following shall be submitted to [generator\_testing@eirgrid.com](mailto:generator_testing@eirgrid.com):

|  |  |
| --- | --- |
| **Submission** | **Timeline** |
| A scanned copy of the test procedure, as completed and signed on site on the day of testing | 1 working day |
| Test data in CSV or Excel format | 1 working day |
| Test report | 10 working days |

## Site Safety requirements

The following is required for the EirGrid witness to attend site:

|  |  |
| --- | --- |
| Personnel Protection Gear Requirements   1. Site Safety boots 2. Hard Hat with chin strap 3. Hi Vis 4. Arc Resistive clothing 5. Safety Glasses 6. Gloves 7. Safe Pass | 1. Yes / No 2. Yes / No 3. Yes / No 4. Yes / No 5. Yes / No 6. Yes / No 7. Yes / No |
| Site Induction requirements | Yes / No  (If Yes, PPM to specify how and when the induction shall be carried out) |
| Any further information | PPM to specify |

# Abbreviations

APC Active Power Control

AVR Automatic Voltage Regulation

ESPS Energy Storage Power Station

HV High Voltage

MEC Maximum Export Capacity

MIC Maximum Import Capacity

MVAr Mega Volt Ampere – reactive

MW Mega Watt

NCC National Control Centre

PF Power Factor

PN Physical Notification

PPM Power Park Module

TSO Transmission System Operator

Leading MVAr Absorbing MVAr from System

Lagging MVAr Producing MVAr

# Reactive Power Capability chart at connection point

The PQ chart provided below chart shall be site specific.

If there are any differences between the PQ chart submitted within this procedure and the studied capability provided in Phase A, this should be highlighted and discussed with Generator Testing.

**If any limiters apply in any of the three control modes, the operation of those limiters shall be detailed here.**

|  |  |
| --- | --- |
| The PQ chart is based on | Modelled / Real data  (If the data is based on modelled results the ESPS shall specify the model reference and confirm that this is as submitted to EirGrid through the connection process) |
| The PQ chart shows the capability at the connection point and accounts for all losses. | Yes / No |
| The PQ chart shows the following.   1. Grid Code Requirements per *Figure PPM 1.4 of Grid Code/Battery Implementation Note* 2. Maximum capability of the ESPS 3. Breakdown of reactive power devices e.g. turbines or STATCOM | 1. Yes / No 2. Yes / No 3. Yes / No |
| Any further information | ESPS to specify how reactive power capability is achieved i.e. fixed / switched cap banks, STATCOM, etc. |
| Note:   1. The PQ chart will be site specific. 2. Generic PQ charts will not be accepted. | |

ESPS shall Insert PQ chart

**Any limiters applied shall also be displayed**

# Grid Code References

|  |  |
| --- | --- |
| Grid Code Version: | ESPS to specify |
| Please also refer to the published Battery ESPS Grid Code Implementation Note[[2]](#footnote-2) for guidance on technical requirements for Battery ESPS and applicability of specific PPM clauses within the Grid Code. |  |

# Test desciption and pre conditions

## Purpose of the Test

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

## Pass Criteria

The following is the pass criteria for the test. Any subsequent report for this test will be assessed against each of these criteria.

| **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 1% and 10% |
| 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 set point 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 |

## Instrumentation and onsite data trending

All of the following trends shall be recorded by the ESPS during the test. The ESPS may capture any other signals as necessary to demonstrate compliance.

The ESPS shall specify the resolution of these signal recordings. As a minimum the resolution should be as specified in the table below.

|  |  |  |  |
| --- | --- | --- | --- |
| **No.** | **Data Trending and Recording** | **Resolution** | **Check On Day Of Test** |
| 1 | ESPS Available Active Power Export (MW) | PPM to Specify (≥ 1 Hz) | Yes / No |
| 2 | ESPS Available Active Power Import (MW) | PPM to Specify (≥ 1 Hz) | Yes / No |
| 3 | ESPS Total Useable Storage Capacity (MWhr) | PPM to Specify (≥ 1 Hz) | Yes / No |
| 4 | ESPS Useable Energy Remaining (MWhr) | PPM to Specify (≥ 1 Hz) | Yes / No |
| 5 | Actual active power from the ESPS in MW | PPM to Specify (≥ 1 Hz) | Yes / No |
| 6 | APC set-point from NCC (MW) | PPM to Specify (≥ 1 Hz) | Yes / No |
| 7 | ESPS voltage measured at the lower voltage side of the grid connected transformer | PPM to Specify (≥ 10 Hz) | Yes / No |
| 8 | Grid voltage measured at the connection point | PPM to Specify (≥ 10 Hz) | Yes / No |
| 9 | Reactive power measured at the lower voltage side of the grid connected transformer | PPM to Specify (≥ 10 Hz) | Yes / No |
| 10 | Reactive power measured at the connection point | PPM to Specify (≥ 10 Hz) | Yes / No |
| 11 | Reactive Power Export Availability (MVAr) | PPM to Specify (≥ 10 Hz) | Yes / No |
| 12 | Reactive Power Import Availability (MVAr) | PPM to Specify (≥ 10 Hz) | Yes / No |
| 13 | Grid transformer tap position | PPM to Specify (≥ 10 Hz) | Yes / No |
| 14 | AVR (kV) set-point | PPM to Specify (≥ 10 Hz) | Yes / No |
| 15 | MVAr set-point | PPM to Specify (≥ 10 Hz) | Yes / No |
| 16 | PF set-point | PPM to Specify (≥ 10 Hz) | Yes / No |

## MVAr changes and calculations

|  |  |
| --- | --- |
| **Calculation** | **Value** |
| 0.5kV change in set-point with Voltage Regulation System slope of 2% | \_\_\_\_ MVAr  (ESPS to specify calculation and formula used) |
| 1kV change in set-point with Voltage Regulation System slope of 4% | \_\_\_\_ MVAr  (ESPS to specify calculation and formula used) |
| 2kV change in set-point with Voltage Regulation System slope of 10% | \_\_\_\_ MVAr  (ESPS to specify calculation and formula used) |
| MVAr for PF set-point of +8 degrees at 30% of Registered Capacity (ESPS shall be exporting MVArs) | \_\_\_\_ MVAr  (ESPS to specify calculation and formula used) |
| MVAr for PF set-point of -12 degrees at 50% of Registered Capacity (ESPS shall be importing MVArs) | \_\_\_\_ MVAr  (ESPS to specify calculation and formula used) |

## Initial Conditions

If “No” is answered to any of the following, contact NCC and agree next steps in advance of making any corrective actions.

| **Conditions** | **Check on day of test** |
| --- | --- |
| All battery modules are available  (or as outlined in Section 2.1 above) | # modules installed: \_\_\_\_  # modules available: \_\_\_\_ |
| State of charge | \_\_\_\_\_ % |
| MW Profile has been submitted if Test Script is automated | Yes / No / N/A |
| Automated Test Script can be paused. | Yes / No / N/A |
| Test PNs have been submitted  Note this will not be applicable if the unit is not registered in the market | Yes / No / N/A |
| Grid Connected Transformer Tap range | Tap range: \_\_\_\_ to \_\_\_\_ |

# Test Steps

## 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.

| **Step No.** | **Action** | **Time** | **Comments** |
| --- | --- | --- | --- |
| 1 | ESPS begins data recording for all trends noted in Section 6.3, above |  | Operator Name \_\_\_\_\_\_\_\_\_\_\_\_  Date \_\_\_\_\_\_\_\_\_\_\_\_ |
| 2 | ESPS requests permission from NCC to proceed with the AVR response rate test and confirms with NCC the following with NCC:   1. Frequency Response is OFF 2. APC is ON 3. APC set-point is [insert 50% of Registered Capacity] MW 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 = 4% 11. MVAr Export is close to 0 MVAr at the connection point |  | 1. Status \_\_\_\_ 2. Status \_\_\_\_ 3. \_\_\_\_ MW 4. \_\_\_\_ MW 5. \_\_\_\_ Mode 6. Tap # \_\_\_\_ 7. \_\_\_\_ Mode 8. \_\_\_\_ kV 9. \_\_\_\_ kV 10. \_\_\_\_% 11. \_\_\_\_ MVAr |
| 3 | ESPS requests NCC to increase the voltage set-point by 0.5 kV and waits 1 minute |  | ESPS shall export a small amount of MVAr  +\_\_\_\_ MVAr  \_\_\_\_ kV |
| 4 | ESPS requests NCC to issue a MVAr set-point of -1 MVAr |  | MVAr output shall not be affected |
| 5 | ESPS requests NCC to select MVAr (Q) control mode and waits 1 minute |  | MVAr output shall not be affected  +\_\_\_\_ MVAr  \_\_\_\_ kV |
| 6 | ESPS requests NCC to issue a MVAr set-point of [insert 10% of lagging MVAr capability] MVAr and waits 1 minute |  | ESPS shall regulate to new MVAr set-point  +\_\_\_\_ MVAr  \_\_\_\_ kV |
| 7 | ESPS requests NCC to issue a PF set-point of 0 degrees |  | MVAr output shall not be affected |
| 8 | ESPS requests NCC to select Power Factor control mode and waits 1 minute |  | MVAr output shall not be affected  +\_\_\_\_ MVAr  \_\_\_\_ kV |
| 9 | ESPS requests NCC to issue a PF set-point of +12 degrees noting calculated response of [insert calculated MVAr for set-point of +12 degrees at 50% of Registered Capacity] MVAr and waits 1 minute |  | ESPS shall regulate to new PF set-point  +\_\_\_\_ MVAr  \_\_\_\_ kV |
| 10 | ESPS requests NCC to select AVR control mode and waits 1 minute |  | MVAr output shall not be affected  +\_\_\_\_ MVAr  \_\_\_\_ kV |
| 11 | ESPS requests NCC to issue a kV set-point 1 kV lower than system voltage at the connection point |  | ESPS shall regulate to new kV set-point (import MVAr)  -\_\_\_\_ MVAr  \_\_\_\_ kV |
| 12 | ESPS requests NCC to select Power Factor control mode and waits 1 minute |  | MVAr output shall not be affected  -\_\_\_\_ MVAr  \_\_\_\_ kV |
| 13 | ESPS requests NCC to issue a PF set-point of  -12 degrees noting calculated response of [insert calculated MVAr for set-point of -12 degrees at 50% of Registered Capacity] MVAr and waits 1 minute |  | ESPS shall regulate to new PF set-point  -\_\_\_\_ MVAr  \_\_\_\_ kV |
| 14 | ESPS requests NCC to select MVAr (Q) control mode and waits 1 minute |  | MVAr output shall not be affected  -\_\_\_\_ MVAr  \_\_\_\_ kV |
| 15 | ESPS requests NCC to issue a MVAr set-point of [insert 15% of leading MVAr capability] MVAr and waits 1 minute |  | ESPS shall regulate to new MVAr set-point  -\_\_\_\_ MVAr  \_\_\_\_ kV |
| 16 | ESPS requests NCC to select AVR control mode and waits 1 minute |  | MVAr output shall not be affected  -\_\_\_\_ MVAr  \_\_\_\_ kV |
| 17 | ESPS requests NCC to issue a kV set-point equal to system voltage at the connection point |  | MVAr output shall be 0 MVAr  +/-\_\_\_\_ MVAr  \_\_\_\_ kV |
| 18 | Ensure that the ESPS is producing approximately 0 MVAr at the connection point |  | +/-\_\_\_\_ MVAr  \_\_\_\_ kV |
| 19 | ESPS requests NCC to issue an APC set-point of 0 MW, turn APC Off and wait until APC set-point has been achieved |  | \_\_\_\_ MW |
| 20 | ESPS ends data recording |  |  |
| 21 | ESPS informs NCC that the bumpless transfer test is complete  If further testing is not being completed, go to Section 7.6 Return to Standard Settings |  |  |
| Note any issues or deviations from test procedure.  For example changes in step size, duration, test operators, parameter changes on site.  Mark as “No Comment” if test proceeded as per procedure. | |  | |

## Automatic Voltage Regulation Mode

NCC 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.

| **Step No.** | **Action** | **Time** | **Comments** |
| --- | --- | --- | --- |
| 1 | ESPS begins data recording for all trends noted in Section 6.3, above |  | Operator Name \_\_\_\_\_\_\_\_\_\_\_\_  Date \_\_\_\_\_\_\_\_\_\_\_\_ |
| 2 | ESPS requests permission from NCC to proceed with the AVR Mode test and confirms the following with NCC:   1. APC is OFF 2. Frequency Response is OFF 3. MW output of the ESPS 4. AVR (kV) control mode is ON 5. Transformer tap position 6. On Load Tap Changer is in Automatic Mode 7. System Voltage 8. kV set-point = system voltage at connection point 9. Voltage slope setting = 4% 10. MVAr export is close to 0 MVAr at the connection point |  | 1. Status \_\_\_\_ 2. Status \_\_\_\_ 3. \_\_\_\_ MW 4. \_\_\_\_ Mode 5. Tap # \_\_\_\_ 6. \_\_\_\_ Mode 7. \_\_\_\_ kV 8. \_\_\_\_ kV 9. \_\_\_\_ % 10. \_\_\_\_ MVAr |
| 3 | ESPS sets the Voltage Regulation System slope to 2% confirms the following to NCC:   1. Voltage Slope is now 2% 2. 0.5 kV change in voltage set-point will cause [ESPS to calculate per section 6.4] MVAr change in output 3. Current MVAr output of ESPS |  | 1. \_\_\_\_%. 2. \_\_\_\_ MVAr 3. \_\_\_\_ MVAr |
| 4 | ESPS requests NCC to increase the voltage set-point by 0.5 kV and waits 1 minute |  | ESPS shall export MVAr according to 2% droop  +\_\_\_\_ MVAr  \_\_\_\_ kV |
| 5 | ESPS requests NCC to decrease the voltage set-point by 0.5 kV and waits 1 minute |  | MVAr output shall be at 0 MVAr  +/-\_\_\_\_ MVAr |
| 6 | ESPS confirms with NCC that ESPS MVAr output is approximately 0 MVAr at the connection point. If not, ESPS requests NCC to issue a voltage set-point to achieve approximately 0 MVAr |  | +\_\_\_\_ MVAr  \_\_\_\_ kV |
| 7 | ESPS sets the Voltage Regulation System slope to 10% confirms the following to NCC:   1. Voltage Slope is now 10% 2. 2 kV change in voltage set-point will cause [ESPS to calculate per section 6.4] MVAr change in output 3. Current MVAr output of ESPS |  | 1. \_\_\_\_%. 2. \_\_\_\_ MVAr 3. \_\_\_\_ MVAr |
| 8 | ESPS requests NCC to decrease the voltage set-point by 2 kV and waits 1 minute |  | ESPS shall import MVAr according to 10% droop  -\_\_\_\_ MVAr  \_\_\_\_ kV |
| 9 | ESPS requests NCC to increase the voltage set-point by 2 kV and waits 1 minute |  | MVAr output shall be at 0 MVAr  +/-\_\_\_\_ MVAr |
| 10 | ESPS confirms with NCC that ESPS MVAr output is approximately 0 MVAr at the connection point. If not, ESPS requests NCC to issue a voltage set-point to achieve approximately 0 MVAr |  | \_\_\_\_ MVAr  \_\_\_\_ kV |
| 11 | ESPS sets the Voltage Regulation System slope to 4% confirms the following to NCC:   1. Voltage Slope is now 4% 2. 1 kV change in voltage set-point will cause [ESPS to calculate per section 6.4] MVAr change in output 3. Current MVAr output of ESPS |  | 1. \_\_\_\_%. 2. \_\_\_\_ MVAr 3. \_\_\_\_ MVAr |
| 12 | ESPS requests NCC to increase the voltage set-point by 1 kV and waits 1 minute |  | ESPS shall export MVAr according to 4% droop  +\_\_\_\_ MVAr  \_\_\_\_ kV |
| 13 | ESPS requests NCC to turn APC ON and issue an APC set-point of [insert 20% of Registered Capacity] MW and wait until 1 minute after APC set-point has been achieved |  | MW  MVAr |
| 14 | ESPS requests NCC to increase the voltage set-point by 0.5 kV and waits 1 minute |  | ESPS shall export MVAr according to 4% droop  +\_\_\_\_ MVAr  \_\_\_\_ kV |
| 15 | ESPS requests NCC to issue an APC set-point of [insert -10% of Registered Capacity\*] MW and wait until 1 minute after APC set-point has been achieved  *\*Or MIC if MIC is less than 10% registered capacity* |  |  |
| 16 | ESPS requests NCC to decrease the voltage set-point by 1 kV and waits 1 minute |  | ESPS shall export MVAr according to 4% droop  +\_\_\_\_ MVAr  \_\_\_\_ kV |
| 17 | ESPS requests NCC to issue an APC set-point of 0 MW and turn APC OFF and wait until 1 minute after APC set-point has been achieved |  |  |
| 18 | ESPS requests NCC to decrease the voltage set-point by 0.5 kV and waits 1 minute |  | MVAr output shall be at 0 MVAr  +/-\_\_\_\_ MVAr |
| 19 | ESPS requests NCC to decrease the voltage set-point by 1 kV and waits 1 minute |  | ESPS shall import MVAr according to 4% droop  -\_\_\_\_ MVAr  \_\_\_\_ kV |
| 20 | ESPS requests NCC to decrease the voltage set-point by 0.5 kV and waits 1 minute |  | ESPS shall import MVAr according to 4% droop  -\_\_\_\_ MVAr  \_\_\_\_ kV |
| 21 | ESPS requests NCC to increase the voltage set-point by 1 kV and waits 1 minute |  | ESPS shall import MVAr according to 4% droop  -\_\_\_\_ MVAr  \_\_\_\_ kV |
| 22 | ESPS requests NCC to increase the voltage set-point by 0.5 kV and waits 1 minute |  | MVAr output shall be at 0 MVAr  +/-\_\_\_\_ MVAr |
| 23 | ESPS confirms with NCC that ESPS MVAr output is approximately 0 MVAr at the connection point. If not, ESPS requests NCC to issue a voltage set-point to achieve approximately 0 MVAr at the connection point |  | MVAr output shall be at 0 MVAr  +/-\_\_\_\_ MVAr  \_\_\_\_ kV |
| 24 | ESPS ends data recording |  |  |
| 25 | ESPS informs NCC that the AVR Mode test is complete  If further testing is not being completed, go to Section 7.6 Return to Standard Settings |  |  |
|  | Note any issues or deviations from test procedure.  For example changes in step size, duration, test operators, parameter changes on site.  Mark as “No Comment” if test proceeded as per procedure. |  |  |

## 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 NCC 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.

| **Step No.** | **Action** | **Time** | **Comments** |
| --- | --- | --- | --- |
| 1 | ESPS begins data recording for all trends noted in Section 6.3, above |  | Operator Name \_\_\_\_\_\_\_\_\_\_\_\_  Date \_\_\_\_\_\_\_\_\_\_\_\_ |
| 2 | ESPS requests permission from NCC to proceed with the AVR response rate test and confirms with NCC the following with NCC:   1. Frequency Response is OFF 2. APC 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 = 4% 9. MVAr Export at the connection point |  | 1. Status \_\_\_\_ 2. Status \_\_\_\_ 3. \_\_\_\_ MW 4. \_\_\_\_ Mode 5. Tap # \_\_\_\_ 6. \_\_\_\_ Mode 7. \_\_\_\_ kV 8. \_\_\_\_% 9. \_\_\_\_ MVAr |
| 3 | ESPS requests NCC to induce a step change in system voltage by carrying out transformer tapping or carrying out switching on the system, if possible. |  | ESPS shall respond to the change at a rate of 90% in 1 second. |
| 4 | ESPS ends data recording |  |  |
| 5 | ESPS informs NCC that the AVR response rate test is complete |  |  |

**If NCC cannot facilitate switching on the system to induce a step change in system voltage, carry out the following steps:**

| **Step No.** | **Action** | **Time** | **Comments** |
| --- | --- | --- | --- |
| 6 | ESPS requests permission from NCC and puts the on-load tap changer into manual mode |  |  |
| 7 | ESPS requests permission from NCC and taps the transformer up 1 tap and waits 1 minute |  | +\_\_\_\_ MVAr  \_\_\_\_ kV |
| 8 | ESPS requests permission from NCC, ESPS taps the transformer up 1 tap and waits 1 minute |  | +\_\_\_\_ MVAr  \_\_\_\_ kV |
| 9 | ESPS requests permission from NCC, ESPS taps the transformer down 1 tap and waits 1 minute |  | -\_\_\_\_ MVAr  \_\_\_\_ kV |
| 10 | ESPS requests permission from NCC, ESPS taps the transformer down 1 tap and waits 1 minute |  | -\_\_\_\_ MVAr  \_\_\_\_ kV |
| 11 | ESPS requests permission from NCC, puts the on-load tap changer into automatic mode and confirms to NCC |  |  |
| 12 | ESPS confirms with NCC that the ESPS is at approximately 0 MVAr at the connection point |  | MVAr output shall be at 0 MVAr  +/-\_\_\_\_ MVAr |
| 13 | ESPS ends data recording |  |  |
| 14 | ESPS informs NCC that the AVR response rate test is complete  If further testing is not being completed, go to Section 7.6 Return to Standard Settings |  |  |
| Note any issues or deviations from test procedure.  For example changes in step size, duration, test operators, parameter changes on site.  Mark as “No Comment” if test proceeded as per procedure. | |  | |

## MVAr Control Mode

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

| **Step No.** | **Action** | **Time** | **Comments** |
| --- | --- | --- | --- |
| 1 | ESPS begins data recording for all trends noted in Section 6.3, above |  | Operator Name \_\_\_\_\_\_\_\_\_\_\_\_  Date \_\_\_\_\_\_\_\_\_\_\_\_ |
| 2 | ESPS requests permission from NCC to proceed with the AVR response rate test and confirms with NCC the following with NCC:   1. Frequency Response is OFF 2. APC 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 = 4% 10. MVAr Export is 0 MVAr at the connection point |  | 1. Status \_\_\_\_ 2. Status \_\_\_\_ 3. \_\_\_\_ MW 4. \_\_\_\_ Mode 5. Tap # \_\_\_\_ 6. \_\_\_\_ Mode 7. \_\_\_\_ MVAr 8. \_\_\_\_ kV 9. \_\_\_\_% 10. \_\_\_\_ MVAr |
| 3 | ESPS requests NCC to issue a set-point of [insert 25% of lagging MVAr capability] MVAr and waits 1 minute |  | +\_\_\_\_ MVAr  \_\_\_\_ kV |
| 4 | ESPS requests NCC to turn APC ON and issue an APC set-point of [insert 20% of Registered Capacity] MW and wait until 1 minute after APC set-point has been achieved |  |  |
| 5 | ESPS requests NCC to issue a set-point of [insert 60% of lagging MVAr capability] MVAr and waits 1 minute |  | +\_\_\_\_ MVAr  \_\_\_\_ kV |
| 6 | ESPS requests NCC to issue an APC set-point of [insert -10% of Registered Capacity\*] MW and wait until 1 minute after APC set-point has been achieved  *\*Or MIC if MIC is less than 10% Registered Capacity* |  |  |
| 7 | ESPS requests NCC to issue a set-point of [insert 10% of lagging MVAr capability] MVAr and waits 1 minute |  | +\_\_\_\_ MVAr  \_\_\_\_ kV |
| 8 | ESPS requests NCC to issue an APC set-point of 0 MW and turn APC OFF and wait until 1 minute after APC set-point has been achieved |  |  |
| 9 | ESPS requests NCC to issue a set-point of 0 MVAr and waits 1 minute |  | MVAr output shall be at 0 MVAr  +/-\_\_\_\_ MVAr |
| 10 | ESPS requests NCC to issue a set-point of [insert 25% of leading MVAr capability] MVAr and waits 1 minute |  | -\_\_\_\_ MVAr  \_\_\_\_ kV |
| 11 | ESPS requests NCC to issue a set-point of [insert 60% of leading MVAr capability] MVAr and waits 1 minute |  | -\_\_\_\_ MVAr  \_\_\_\_ kV |
| 12 | ESPS requests NCC to issue a set-point of [insert 10% of leading MVAr capability] MVAr and waits 1 minute |  | -\_\_\_\_ MVAr  \_\_\_\_ kV |
| 13 | ESPS requests NCC to issue a set-point of 0 MVAr and waits 1 minute |  | MVAr output shall be at 0 MVAr  +/-\_\_\_\_ MVAr |
| 14 | ESPS confirms with NCC that the ESPS is at approximately 0 MVAr at the connection point |  | MVAr output shall be at 0 MVAr  +/-\_\_\_\_ MVAr |
| 15 | ESPS ends data recording |  |  |
| 16 | ESPS informs NCC that the MVAr Control Mode test is complete  If further testing is not being completed, go to Section 7.6 Return to Standard Settings |  |  |
| Note any issues or deviations from test procedure.  For example changes in step size, duration, test operators, parameter changes on site.  Mark as “No Comment” if test proceeded as per procedure. | |  | |

## Power Factor Control Mode

NCC 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.

| **Step No.** | **Action** | **Time** | **Comments** |
| --- | --- | --- | --- |
| 1 | ESPS begins data recording for all trends noted in Section 6.3, above |  | Operator Name \_\_\_\_\_\_\_\_\_\_\_\_  Date \_\_\_\_\_\_\_\_\_\_\_\_ |
| 2 | ESPS requests permission from NCC to proceed with the AVR response rate test and confirms with NCC the following with NCC:   1. Frequency Response is OFF 2. APC is ON 3. APC set point is [insert 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 = 4% 12. MVAr Export |  | 1. Status \_\_\_\_ 2. Status \_\_\_\_ 3. \_\_\_\_ MW 4. \_\_\_\_ MW 5. \_\_\_\_ Mode 6. Tap # \_\_\_\_ 7. \_\_\_\_ Mode 8. \_\_\_\_ 9. \_\_\_\_ kV 10. \_\_\_\_ degrees 11. \_\_\_\_% 12. \_\_\_\_ MVAr |
| 3 | ESPS requests NCC to issue a PF set-point of +8 degrees noting calculated response of [insert calculated MVAr for set-point of +8 degrees at 100% of Registered Capacity] MVAr at 100% of Registered Capacity and waits 1 minute |  | +\_\_\_\_ MVAr  \_\_\_\_ kV |
| 4 | ESPS requests NCC to issue a PF set-point of +12 degrees noting calculated response of [insert calculated MVAr for set-point of +12 degrees at 100% of Registered Capacity] MVAr at 100% of Registered Capacity and waits 1 minute |  | +\_\_\_\_ MVAr  \_\_\_\_ kV |
| 6 | ESPS requests NCC to issue an APC set-point of [insert 30% of Registered Capacity] MW noting calculated response of [insert calculated MVAr for set-point of +12 degrees at 30% of Registered Capacity] MVAr and wait until 1 minute after APC set-point has been achieved |  | \_\_\_\_ MW  +\_\_\_\_ MVAr  \_\_\_\_ kV |
| 7 | ESPS requests NCC to issue a PF set-point of +8 degrees noting calculated response of [insert calculated MVAr for set-point of +8 degrees at 30% of Registered Capacity] MVAr and waits 1 minute |  | +\_\_\_\_ MVAr  \_\_\_\_ kV |
| 8 | ESPS requests NCC to issue a PF set-point of 0 degrees and waits 1 minute |  | MVAr output shall be at 0 MVAr  +/-\_\_\_\_ MVAr |
| 9 | ESPS requests NCC to issue a PF set-point of  -8 degrees noting calculated response of [insert calculated MVAr for set-point of -8 degrees at 30% of Registered Capacity] MVAr and waits 1 minute |  | -\_\_\_\_ MVAr  \_\_\_\_ kV |
| 10 | ESPS requests NCC to issue a PF set-point of  -12 degrees noting calculated response of [insert calculated MVAr for set-point of -12 degrees at 30% of Registered Capacity] MVAr and waits 1 minute |  | -\_\_\_\_ MVAr  \_\_\_\_ kV |
| 11 | ESPS requests NCC to issue an APC set-point of [insert -10% of Registered Capacity] MW noting calculated response of [insert calculated MVAr for set-point of -12 degrees at -10% of Registered Capacity] MVAr at -10% of Registered Capacity and waits until 1 minute after active power output has reached the set point |  | \_\_\_\_ MW  +\_\_\_\_ MVAr |
| 13 | ESPS requests NCC to issue a PF set-point of  -8 degrees noting calculated response of [insert calculated MVAr for set-point of -8 degrees at -10% of Registered Capacity] MVAr and waits 1 minute |  | -\_\_\_\_ MVAr  \_\_\_\_ kV |
| 14 | ESPS requests NCC to issue a PF set-point of 0 degrees and waits 1 minute |  | MVAr output shall be at 0 MVAr  +/-\_\_\_\_ MVAr |
| 15 | ESPS requests NCC to issue an APC set-point of 0 MW and turn APC OFF and wait until 1 minute after APC set-point has been achieved |  |  |
| 16 | ESPS requests NCC to select AVR control mode |  | Mode \_\_\_\_ |
| 17 | ESPS confirms with NCC that the ESPS is at approximately 0 MVAr at the connection point |  | MVAr output shall be at 0 MVAr  +/-\_\_\_\_ MVAr |
| 18 | ESPS ends data recording |  |  |
| 19 | ESPS informs NCC that the Power Factor Control Mode test is complete  If further testing is not being completed, go to Section 7.6 Return to Standard Settings |  |  |
| Note any issues or deviations from test procedure.  For example changes in step size, duration, test operators, parameter changes on site.  Mark as “No Comment” if test proceeded as per procedure. | |  | |

## Return to Standard Settings

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

|  |  |  |  |
| --- | --- | --- | --- |
| **Step No.** | **Action** | **Time** | **Comments** |
| 1 | ESPS informs NCC that Reactive Power Control Testing is complete and confirms the following the following:   1. MW output of the ESPS 2. ACP Set point is 0MW 3. APC is OFF 4. Frequency Response is ON 5. Frequency Response is in Mode 1 (or as agreed with NCC) 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 = 4% 12. MVAr Export at the connection point |  | 1. \_\_\_\_ MW 2. \_\_\_\_\_MW 3. Status \_\_\_\_ 4. Status \_\_\_\_ 5. Mode \_\_\_\_ 6. \_\_\_\_ Mode 7. Tap # \_\_\_\_ 8. \_\_\_\_ Mode 9. \_\_\_\_ kV 10. \_\_\_\_ kV 11. \_\_\_\_% 12. \_\_\_\_ MVAr |

## Comments & Signatures

|  |
| --- |
| **Comments:** |
| ESPS Witness signoff that this test has been carried out according to the test procedure, above.  Signature: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ |
| EirGrid Witness signoff that this test has been carried out according to the test procedure, above.  Signature: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ |

1. <http://www.eirgridgroup.com/library> [↑](#footnote-ref-1)
2. <http://www.eirgridgroup.com/site-files/library/EirGrid/Integration-of-Batteries-Implementation-Note.pdf> [↑](#footnote-ref-2)