Steady-State Reactive Power (SSRP)

System Services Test Procedure

Battery ESPS

Unit Name

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# Document Version History

Revision 3.0, published 30th July 2021

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Version** | **Date** | **Comment** | **Name** | **Company** |
| 0.1 | Insert Date | Minor version (v0.1) - First submission for review and approval | Insert Name | Unit Company Name |
| 1.0 | Insert Date | Revised to version 1.0 following approval by EirGrid, SONI. | Insert Name | Unit Company Name |

# Introduction

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

The Battery shall submit the latest version of this test procedure template as published on the EirGrid or SONI websites[[1]](#footnote-2).

All yellow sections shall be filled in before the test procedure will 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) or [generator\_testing@soni.ltd.uk](mailto:generator_testing@soni.ltd.uk) as appropriate.

Where a site consists of two separate controllable Batteries with a single connection point, this will impact on the test procedure outlined below. In this case, the Batteries shall insert active power levels for both Batteries as required to achieve the percentage of registered capacity.

The Battery representative shall coordinate testing. On the day of testing, suitably qualified technical personnel may be needed at the Battery to assist in undertaking the tests. Such personnel shall have the ability to fully understand the function of the Battery and its relationship to the network to which the Battery is connected. Furthermore, such personnel shall have the ability to set up the control system of the Battery so as to enable the DS3 System Services test to be correctly undertaken. In addition, the function of the technical personnel is to liaise with NCC/CHCC.

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

All Battery modules shall be available on the day of the testing unless otherwise agreed with the TSO.

Following testing, the following shall be submitted to [generator\_testing@eirgrid.com](mailto:generator_testing@eirgrid.com) or [generator\_testing@soni.ltd.uk](mailto:generator_testing@soni.ltd.uk) as appropriate.

|  |  |
| --- | --- |
| **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 |

# Abbreviations

APC Active Power Control

AVR Automatic Voltage Regulation

AAP Available Active Power

CHCC Castlereagh House Control Centre (SONI)

DMOL Defined Minimum Operating Level

EA Emergency Action

ESPS Energy Storage Power Station

HV High Voltage

Leading MVAr Absorbing MVAr from System

Lagging MVAr Producing MVAr

MEC Maximum Export Capacity

MIC Maximum Import Capacity

MVAr Mega Volt Ampere – reactive

MW Mega Watt

NCC National Control Centre (EirGrid)

PF Power Factor

TSO Transmission System Operator

# Battery Data

|  |  |
| --- | --- |
| 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 |
| DMOL | ESPS to Specify |
| RoCoF Capability | ESPS to Specify |

**Reactive Power Capability chart at connection point**

|  |  |
| --- | --- |
| The PQ chart is based on | Modelled / Real data  (If the data is based on modelled results the Battery shall specify the model reference and confirm that this is as submitted to EirGrid / SONI 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. Maximum capability of the ESPS 2. Breakdown of reactive power devices e.g. inverters or STATCOM | 1. Yes / No 2. 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. | |

Battery shall Insert PQ chart

Provide Steady State Reactive Power Capability chart showing the full PQ capability of the Battery with all key points clearly labelled and displayed. Any limiters applied shall also be displayed.

# System Services

## Steady-State Reactive Power explanation

The definitions referenced in this document are for indicative purposes only. In the event of inconsistency between the definitions in this document and those in the DS3 System Services Agreement, the definitions in the DS3 System Services Agreement shall prevail.

SSRP is defined as the dispatchable reactive power range (QRange) in MVAr that can be provided across the full range of active power output (PRange). For Battery, PRange may or may not be limited by DMOL.

## Reactive Power Factor calculation

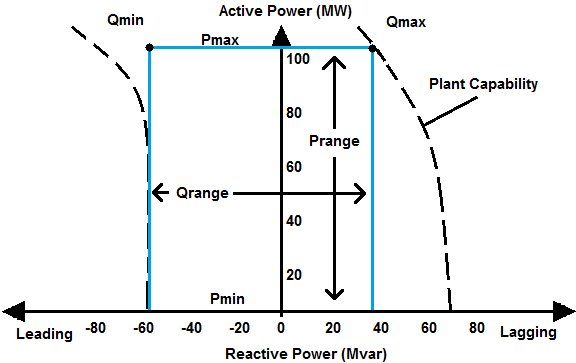


Figure 1: Example graph showing a unit with reactive capability down to 0 MW.

# Site safety requirements

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

|  |  |
| --- | --- |
| Personal Protective Equipment 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, Unit to specify how and when the induction must carried out) |
| Any further information | Unit to specify |

# Test purpose, Initial-conditions and Calculations

## Test Purpose

The purpose of this test is to demonstrate the limits of the Battery reactive power capability curve at the connection point. The test is undertaken at various load levels for both the export of reactive power and for the import of reactive power.

## Initial Conditions

If “No” is answered to any of the following, contact NCC/CHCC and agree next steps in advance of making any corrective actions. If the kV set-point = system voltage at the connection point and Battery is not producing 0 MVAr, this test may not proceed.

|  |  |
| --- | --- |
| **Conditions** | **Check on day of test** |
| All Battery Modules are available | # Modules installed: \_\_\_\_  # Modules generating: \_\_\_\_ |
| Grid Connected Transformer Tap range | Tap range: \_\_\_\_ to \_\_\_\_ |
| Size of MVAr step changes agreed with NCC, CHCC Transmission Desk (*e.g.* 5 MVAr) | \_\_\_\_ MVAr |

## MVAr changes and calculations

|  |  |
| --- | --- |
| **Calculation** | **Value** |
| 1kV change in system voltage with Voltage Regulation System slope of 4% (Ireland Only) | \_\_\_\_ MVAr  (Battery to specify calculation and formula used) |
| 3kV change in system voltage with Voltage Regulation System slope of 4% (Ireland Only) | \_\_\_\_ MVAr  (Battery to specify calculation and formula used) |
| 1kV change in system voltage with Voltage Regulation System slope of 3% (Northern Ireland Only) | \_\_\_\_ MVAr  (Battery to specify calculation and formula used) |
| 3kV change in system voltage with Voltage Regulation System slope of 3% (Northern Ireland Only) | \_\_\_\_ MVAr  (Battery to specify calculation and formula used) |

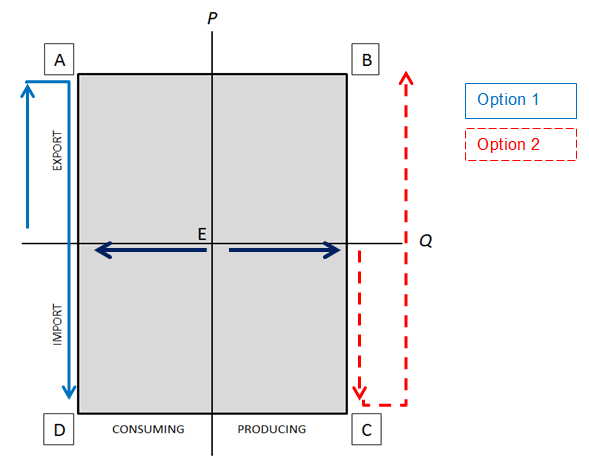
# Instrumentation and onsite data trending

## Onsite Data Trends

All of the following trends shall be recorded by the ESPS during the test. Failure to provide any of these trends shall result in test cancellation.

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

# Test Steps



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 NCC/CHCC.

## Reactive Power Capability (Importing / Leading MVAr)

The ESPS is brought from 0 MVAr (or as agreed with NCC/CHCC) to maximum leading MVAr. Once at maximum leading MVAr, the active power is adjusted in steps to max MW output or full MW import, and then full MW import or max MW output, as per options above.

The MW output is returned to 0 MW and the MVAr output is returned to 0 MVAr in steps. The size of these steps shall be confirmed with NCC/CHCC.

\*Note depending on the ESPS PQ curve, the MVAr output may vary as MW output is varied. Close co-ordination shall be maintained with NCC/CHCC on expected changes in capability during the steps involving changes in MW output.

| **Step No.** | **Action** | **Time** | **Comments** |
| --- | --- | --- | --- |
| 1 | ESPS begins data recording for all trends noted in Section 8.1, above |  | Operator Name \_\_\_\_\_\_\_\_\_\_\_\_  Date \_\_\_\_\_\_\_\_\_\_\_\_ |
| 2 | ESPS requests permission from NCC to proceed with the Reactive Power Capability (Inductive / Leading MVAr) test and confirms the following with NCC/CHCC:   1. MW output of the ESPS 2. APC/EA 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 |  | 1. \_\_\_\_ MW 2. Status \_\_\_\_ 3. Status \_\_\_\_ 4. \_\_\_\_ Mode 5. Tap # \_\_\_\_ 6. \_\_\_\_ Mode 7. \_\_\_\_ kV 8. \_\_\_\_ MVAr 9. \_\_\_\_ MVAr 10. \_\_\_\_ MVAr 11. \_\_\_\_ MVAr 12. Option 1/ Option 2 |
| 3 | ESPS requests NCC/CHCC to decrease the MVAr set-point in steps as agreed with NCC/CHCC until the ESPS has reached its maximum leading MVAr limit at the connection point |  | \_\_\_\_ MVAr  \_\_\_\_ kV |
| 4 | ESPS requests NCC/CHCC to reduce the MVAr set-point by a further step (s).  \*Note: Refer to PQ chart submitted in Section 4. 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. |  | ESPS shall remain at maximum leading MVAr  \_\_\_\_ MVAr  \_\_\_\_ kV |
| 5 | ESPS requests NCC/CHCC to turn APC/EA ON and issue a set-point of [insert 100% Registered Capacity / MIC] 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. |  | ESPS shall ramp at APC ramp rate  \_\_\_\_ MW  \_\_\_\_ MVAr |
| 6 | ESPS requests NCC/CHCC 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. |  | ESPS shall ramp at APC ramp rate.  \_\_\_\_ MW  \_\_\_\_ MVAr |
| 7 | ESPS requests NCC/CHCC to issue a set-point of [insert 100% of MIC/Registered Capacity here]  \*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. |  | \_\_\_\_ MW  \_\_\_\_ MVAr |
| 8 | ESPS requests NCC/CHCC to issue a set-point of 0MW and turn APC/EA 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. |  | \_\_\_\_ MW  \_\_\_\_ MVAr |
| 9 | ESPS requests NCC/CHCC to increase the MVAr set-point in steps as agreed with NCC/CHCC until the ESPS is exporting 0 MVAr at the connection point, or as agreed with NCC/CHCC |  | MVAr output shall be at 0 MVAr, or as agreed with NCC/CHCC  \_\_\_\_\_ MVAr |
| 10 | ESPS ends data recording |  |  |
| 11 | ESPS informs NCC/CHCC that the Reactive Power Capability (Inductive / Leading MVAr) test is complete  If further testing is not being completed, go to Section 9.4 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. | |  | |

## Reactive Power Capability (Exporting / Lagging MVAr)

The ESPS is brought from 0 MVAr (or as agreed with NCC/CHCC) to maximum lagging MVAr. Once at maximum lagging MVAr, the active power is adjusted in steps to max MW output or full MW import, and then full MW import or max MW output, as per options above.

The MW output is returned to 0 MW and the MVAr output is returned to 0 MVAr in steps. The size of these steps shall be confirmed with NCC/CHCC.

\*Note depending on the ESPS PQ curve, the MVAr output may vary as MW output is varied. Close co-ordination shall be maintained with NCC/CHCC on expected changes in capability during the steps involving changes in MW output.

| **Step No.** | **Action** | **Time** | **Comments** |
| --- | --- | --- | --- |
| 1 | ESPS begins data recording for all trends noted in Section 8.1, above |  | Operator Name \_\_\_\_\_\_\_\_\_\_\_\_  Date \_\_\_\_\_\_\_\_\_\_\_\_ |
| 2 | ESPS requests permission from NCC/CHCC to proceed with the Reactive Power Capability (Capacitive / Lagging MVAr) test and confirms the following with NCC/CHCC:   1. MW output of the ESPS 2. APC/EA 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 lagging 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 |  | 1. \_\_\_\_ MW 2. Status \_\_\_\_ 3. Status \_\_\_\_ 4. \_\_\_\_ Mode 5. Tap # \_\_\_\_ 6. \_\_\_\_ Mode 7. \_\_\_\_ kV 8. \_\_\_\_ MVAr 9. \_\_\_\_ MVAr 10. \_\_\_\_ MVAr 11. \_\_\_\_ MVAr 12. Option 1/ Option 2 |
| 3 | ESPS requests NCC/CHCC to increase the MVAr set-point in steps as agreed with NCC/CHCC until the ESPS has reached its maximum lagging MVAr limit at the connection point. |  | \_\_\_\_ MVAr |
| 4 | ESPS requests NCC/CHCC to reduce the MVAr set-point by a further step (s).  \*Note: Refer to PQ chart submitted in Section 4. 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. |  | ESPS shall remain at maximum lagging MVAr  \_\_\_\_ MVAr |
| 5 | ESPS requests NCC/CHCC to turn APC/EA ON and issue a set-point of [insert 100% Registered Capacity / MIC] 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. |  | \_\_\_\_ MW  \_\_\_\_ MVAr |
| 6 | ESPS requests NCC/CHCC 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. |  | \_\_\_\_ MW  \_\_\_\_ MVAr |
| 7 | ESPS requests NCC/CHCC to issue a set-point of [insert 100% of MIC/Registered Capacity here]  \*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. |  | \_\_\_\_ MW  \_\_\_\_ MVAr |
| 8 | ESPS requests NCC/CHCC to issue a set-point of 0 MW and turn APC/EA OFF and waits until the output reaches 0MW.  \*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. |  |  |
| 9 | ESPS requests NCC/CHCC to decrease the MVAr set-point in steps as agreed with NCC/CHCC, until the ESPS is exporting 0 MVAr at the connection point, or as agreed with NCC/CHCC |  | MVAr output shall be at 0 MVAr, or as agreed with NCC/CHCC  \_\_\_\_ MVAr |
| 10 | ESPS ends data recording |  |  |
| 11 | ESPS informs NCC/CHCC that the Reactive Power Capability (Capacitive / Lagging MVAr) test is complete  If further testing is not being completed, go to Section 9.4 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. | |  | |

## Establish Battery Cable Network Charging Capacitance

The steps below establish the charging capacitance of the cable network and balance of plant.

|  |  |  |  |
| --- | --- | --- | --- |
| **Step No.** | **Action** | **Time** | **Comments** |
| 1 | Battery requests permission from NCC/CHCC and shuts down all Battery Modules |  |  |
| 2 | Battery records the MVAr at the connection point |  | \_\_\_\_\_ MVAr |
| 3 | Battery requests permission from NCC/CHCC and restarts all Battery Modules |  |  |
| 4 | Battery informs NCC/CHCC that this test is complete |  |  |

## Return to Standard Settings

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

|  |  |  |  |
| --- | --- | --- | --- |
| **Step No.** | **Action** | **Time** | **Comments** |
| 1 | Battery confirms the following with NCC/CHCC:   1. AAP of the Battery 2. MW output of the Battery 3. APC/EA is OFF 4. Frequency Response is ON 5. Frequency Response is in Curve 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 = 4% (IE) / 3 % (NI) 12. MVAr Export at the connection point |  | 1. \_\_\_\_ MW 2. \_\_\_\_ MW 3. Status \_\_\_\_ 4. Status \_\_\_\_ 5. Curve \_\_\_\_ 6. \_\_\_\_ Mode 7. Tap # \_\_\_\_ 8. \_\_\_\_ Mode 9. \_\_\_\_ kV 10. \_\_\_\_ kV 11. \_\_\_\_% 12. \_\_\_\_ MVAr |
| 2 | Battery informs NCC/CHCC that Reactive Power Capability testing is complete |  |  |

# Comments and Sign-off

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

1. <http://www.eirgridgroup.com/> or <http://www.soni.ltd.uk/> [↑](#footnote-ref-2)