EIRGRID_2015 Functional Document Template (21

WFPS Reactive Power Control Test Procedure

[Insert Windfarm Name]

Version 0.1

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# Document Version History

EirGrid template version 0.5, published 19 October 2016.

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

# Introduction

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

The WFPS 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 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).

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

The WFPS representative shall coordinate testing. On the day of testing, suitably qualified technical personnel may be needed at the wind farm to assist in undertaking the tests. Such personnel shall have the ability to fully understand the function of the wind farm and its relationship to the network to which the wind farm is connected. Furthermore, such personnel shall have the ability to set up the control system of the wind farm 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 wind turbines shall be available. If on the day of the testing all wind turbines are not available, then the test may proceed where one wind turbine is unavailable for a wind farm of registered capacity of up to 75 MW, if that turbine makes up <20% of Registered Capacity, or two wind turbines are unavailable for a wind farm of registered capacity in excess of 75 MW. Wind conditions need to be sufficient and at a relatively constant level in order adequately perform the test. The required wind capacity for this test is detailed in section 7.4.

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 |

# Abbreviations

APC Active Power Control

AVR Automatic Voltage Regulation

HV High Voltage

MEC Maximum Export Capacity

Mvar Mega Volt Ampere – reactive

MW Mega Watt

NCC National Control Centre

PF Power Factor

TSO Transmission System Operator

WFCS Wind Farm Control System

WFPS Wind Farm Power Station

WTG Wind Turbine Generator

Leading Mvar Absorbing Mvar from System

Lagging Mvar Producing Mvar

# WFPS DATA

|  |  |
| --- | --- |
| WFPS Name | WFPS to Specify |
| WFPS Test Co-Ordinator and contact number: | WFPS to Specify |
| WFPS Location | WFPS to Specify |
| WFPS connection point | WFPS to Specify  (*i.e.* T121 HV bushings) |
| WFPS connection voltage | WFPS to Specify |
| Installed Turbine type, MW size and quantity | WFPS to Specify |
| Contracted MEC | WFPS to Specify |
| Registered Capacity | WFPS to Specify |
| Limiter applied to Exported MW | WFPS to Specify |
| Limiter applied to AAP | WFPS to Specify |
| Minimum Leading Mvar requirement at the connection point above 12% Active Power Output per Grid Code *Figure WFPS1.4* | WFPS to Specify |
| Minimum Lagging Mvar requirement at the connection point above 12% Active Power Output per Grid Code *Figure WFPS1.4* | WFPS to Specify |
| Maximum Leading Mvar at connection point | WFPS to Specify |
| Maximum Lagging Mvar at connection point | WFPS to Specify |
| Grid Connected Transformer Tap range | WFPS 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 WFPS 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 WFPS1.4 of Grid Code* 2. Maximum capability of the WFPS 3. Breakdown of reactive power devices e.g. turbines or STATCOM | 1. Yes / No 2. Yes / No 3. Yes / No |
| Any further information | WFPS 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 of turbines will not be accepted. | |

WFPS shall Insert PQ chart

# Grid Code References

|  |  |
| --- | --- |
| Grid Code Version: | WFPS to specify |

|  |  |
| --- | --- |
| **Voltage Regulation System Slope Setting** | The percentage change in **Transmission System** **Voltage** that would cause the **Reactive Power** output of the **Interconnector** to vary from maximum **Mvar** production to maximum **Mvar** absorption or vice-versa or **Controllable WFPS** to vary from maximum **Mvar** production capability of Q/Pmax of 0.33 to maximum **Mvar** absorption capability of Q/Pmax of -0.33 or vice-versa, as per Figure WFPS1.4. |

SDC2.B.1  The **Mvar Output** of any **CDGU** in respect of which a **Dispatch Instruction** is given under SDC2.4.2.4(b) shall, in accordance with its declared **Technical Parameters**, be adjusted to the new target **Mvar** level so **Instructed**, within, a tolerance of +/- 2% of the target or +/- 2 **Mvar**, whichever is greater. The **Reactive Power** output of a **CDGU** shall not be adjusted (other than under **AVR** action) except in response to a **Dispatch Instruction** from the **TSO**.

**WFPS1.6.2 AUTOMATIC VOLTAGE REGULATION**

WFPS1.6.2.1 **Controllable WFPS’s** shall have a continuously-variable and continuously-acting **Voltage** **Regulation** **System** with similar response characteristics to a conventional **Automatic Voltage Regulator** and shall perform generally as described in BS4999 part 140, or equivalent European Standards.

WFPS1.6.2.2 Under steady state conditions, the **Voltage Regulation System** shall be capable of implementing the following **Reactive Power** control modes which shall be available to the **TSO:**

1. The **Controllable WFPS** shall be capable of receiving a **Power Factor** control (PF) set-point to maintain the **Power Factor** set-point at the **Connection Point;**
2. The **Controllable WFPS** shall be capable of receiving a **Reactive Power** control (Q) set-point to maintain the **Reactive Power** set-point at the **Connection Point**;
3. The **Controllable WFPS** shall be capable of receiving a **Voltage Regulation** (kV) **Set-point** for the **Voltage** at the **Connection Point.** The **Voltage Regulation System** shall act to regulate the **Voltage** at this point by continuous modulation of the **Controllable WFPS’s Reactive Power** output, without violating the rapid **Voltage** changelimits as set out in CC.10.13.1. The **Controllable WFPS’s Reactive Power** output shall be zero when the **Voltage** at the **Connection Point** is equal to the **Voltage Regulation Set-point**.

A change to the **Power Factor** control (PF) set-point, **Reactive Power** control (Q) set-point or **Voltage Regulation** (kV) **Set-Point** shall be implemented by the **Controllable WFPS** within 20 seconds of receipt of the appropriate signal from the **TSO,** within its reactive power capability range as specified in WFPS1.6.3.

WFPS1.6.2.3 The **Voltage Regulation** **System** **Slope Setting** shall be capable of being set to any value between 1 % and 10 %. The setting shall be specified by the **TSO** at least 120 **Business Days** prior to the **Controllable WFPS’s** scheduled **Operational Date.** The **Controllable WFPS** shall be responsible for implementing the appropriate settings during **Commissioning**. The slope setting may be varied from time to time depending on **Transmission System** needs. The **TSO** shall give the **Controllable WFPS** a minimum of two weeks notice if a change is required. The **Controllable WFPS** shall formally confirm that any requested changes have been implemented within two weeks of receiving the **TSO’s** formal request.

WFPS1.6.2.4 The speed of response of the **Voltage** **Regulation System** shall be such that, following a step change in **Voltage** at the **Connection Point** the **Controllable WFPS** shall achieve 90 % of its steady-state **Reactive Power** response within 1 second. The response may require a transition from maximum **Mvar** production to maximum **Mvar** absorption or vice-versa.

WFPS1.6.2.5 *Figure WFPS1.3* shows the relevant points appropriate to the **Voltage Regulation** **System** for a **Controllable WFPS**. *X* is the HV side of the **WTG** transformer, *Y* is the lower voltageside of the **Grid Connected Transformer** and *Z* is the **Connection Point**.

**WTG WTG Grid connected**

**Transformer Transformer GRID**

**HV**

**busbar**

*X**Y**Z*

*Figure WFPS1.3 - Locations for* ***Voltage Regulation*** *set-point (Z) and the* ***Power Factor*** *range (Y). The HV side of the* ***WTG*** *transformer is (X).*

WFPS1.6.3.1 **Controllable WFPSs** operating in **Power Factor** control mode, **Voltage** **Control** mode or constant **Reactive Power** mode shall be at least capable of operating at any point within the P-Q capability ranges illustrated in *Figure WFPS1.4,* as measured at the **Connection Point** over the normal and disturbed **Transmission System Voltage** ranges specified in CC.8.3.2.

Referring to *Figure WFPS1.4:*

Point A represents the minimum Mvar absorption capability of the **Controllable WFPS** at 100% **Registered Capacity** and is equivalent to 0.95 power factor leading;

Point B represents the minimum Mvar production capability of the **Controllable WFPS** at 100% **Registered Capacity** and is equivalent to 0.95 power factor lagging;

Point C represents the minimum Mvar absorption capability of the **Controllable WFPS** at 12% **Registered Capacity** and is equivalent to the same **Mvar** as Point A;

Point D represents the minimum Mvar production capability of the **Controllable WFPS** at 12% **Registered Capacity** and is equivalent to the same **Mvar** as Point B;

Point E represents the minimum Mvar absorption capability of the **Controllable WFPS** at the cut-in speed of the individual **WTGs**;

Point F represents the minimum Mvar production capability of the **Controllable WFPS** at the cut-in speed of the individual **WTGs**;

The **TSO** accepts that the values of Points E and F may vary depending on the number of **WTGs** generating electricity in a low-wind scenario;

*Figure WFPS1.4* represents the minimum expected **Reactive Power** capabilities of the **Controllable WFPS**. The **Controllable WFPS** is obliged to tell the **TSO**/**DSO** if it can exceed these capabilities, and submit the actual P-Q capability diagram based upon the installed plant and **Collector Network** characteristics to the **TSO** during **Commissioning.**

The **Grid Connected Transformer** tap changing range must be capable of ensuring nominal voltage at point Y for any **Voltage** at the **Connection Point** (Point Z) within the ranges specified in WFPS1.6.1.



*Figure WFPS1.4 –* Minimum**Reactive Power** Capability of **Controllable WFPS**

*Figure WFPS1.4* represents the minimum expected **Reactive Power** capabilities of the **Controllable WFPS**. The **Controllable WFPS** is obliged to tell the **TSO**/**DSO** if it can exceed these capabilities, and submit the actual P-Q capability diagram based upon the installed plant and **Collector Network** characteristics to the **TSO** during **Commissioning.**

# 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, WFPS to specify how and when the induction shall be carried out) |
| Any further information | WFPS to specify |

# 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** |
| WFPS 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 |
| WFPS 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** |
| WFPS 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 |
| WFPS maintains the Mvar set-point at the connection point |
| **Power Factor Control** |
| WFPS 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 |
| WFPS 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 WFPS during the test. Failure to provide any of these trends will result in test cancellation.

|  |  |  |  |
| --- | --- | --- | --- |
| **No.** | **Data Trending and Recording** | **Resolution** | **Check On Day Of Test** |
| 1 | Available active power from the prevailing wind in MW, derived by algorithm in the WFCS (*Figure WFPS1.3, Point Y* *– preferably point Z* *if available*) | WFPS to Specify (≥10 Hz) | Yes / No |
| 2 | Actual active power from the wind farm in MW (*Figure WFPS1.3, Point Y – preferably point Z* *if available*) | WFPS to Specify (≥10 Hz) | Yes / No |
| 3 | Wind farm voltage measured at the lower voltage side of the grid connected transformer (*Figure WFPS1.3, Point Y)* | WFPS to Specify (≥10 Hz) | Yes / No |
| 4 | Grid voltage measured at the connection point (*Figure WFPS1.3, Point Z*) | WFPS to Specify (≥10 Hz) | Yes / No |
| 5 | Reactive power measured at the lower voltage side of the grid connected transformer, (*Figure WFPS1.3, Point Y*) | WFPS to Specify (≥10 Hz) | Yes / No |
| 6 | Reactive power measured at the connection point (*Figure WFPS1.3, Point Z*) | WFPS to Specify (≥10 Hz) | Yes / No |
| 7 | Grid transformer tap position | WFPS to Specify (≥10 Hz) | Yes / No |
| 8 | AVR (kV) set-point (*Figure WFPS1.3, Point Z*) | WFPS to Specify (≥10 Hz) | Yes / No |
| 9 | Mvar set-point (*Figure WFPS1.3, Point Z*) | WFPS to Specify (≥10 Hz) | Yes / No |
| 9 | PF set-point (*Figure WFPS1.3, Point Z*) | WFPS to Specify (≥10 Hz) | Yes / No |

## Initial Conditions

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

| **Conditions** | **Check on day of test** |
| --- | --- |
| All WTGs are available | # turbines installed: \_\_\_\_  # turbines generating: \_\_\_\_ |
| Generated MW > 60% of Registered Capacity | Generated MW: \_\_\_\_ |
| Ensure the WFPS is exporting close to 0 Mvar at the connection point by bringing kV set-point to system voltage in 1 kV steps. | Yes / No |
| Grid Connected Transformer Tap range | Tap range: \_\_\_\_ to \_\_\_\_ |

## Mvar changes and calculations

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

# 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 | WFPS begins data recording for all trends noted in Section 7.3, above |  | Operator Name \_\_\_\_\_\_\_\_\_\_\_\_  Date \_\_\_\_\_\_\_\_\_\_\_\_ |
| 2 | WFPS requests permission from NCC to proceed with the AVR response rate test and confirms with NCC the following with NCC:   1. MW output of the WFPS 2. APC is ON 3. APC set-point is [insert 50% of Registered Capacity] MW 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. 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. \_\_\_\_ MW 2. Status \_\_\_\_ 3. \_\_\_\_ MW 4. \_\_\_\_ Mode 5. Tap # \_\_\_\_ 6. \_\_\_\_ Mode 7. \_\_\_\_ kV 8. \_\_\_\_ kV 9. \_\_\_\_% 10. \_\_\_\_ Mvar |
| 3 | WFPS requests NCC to increase the voltage set-point by 0.5 kV and waits 1 minute |  | WFPS shall export a small amount of Mvar  +\_\_\_\_ Mvar  \_\_\_\_ kV |
| 4 | WFPS requests NCC to issue a Mvar set-point of -1 Mvar |  | Mvar output shall not be affected |
| 5 | WFPS requests NCC to select Mvar (Q) control mode and waits 1 minute |  | Mvar output shall not be affected  +\_\_\_\_ Mvar  \_\_\_\_ kV |
| 6 | WFPS requests NCC to issue a Mvar set-point of [insert 10% of lagging Mvar capability] Mvar and waits 1 minute |  | WFPS shall regulate to new Mvar set-point  +\_\_\_\_ Mvar  \_\_\_\_ kV |
| 7 | WFPS requests NCC to issue a PF set-point of 0 degrees |  | Mvar output shall not be affected |
| 8 | WFPS requests NCC to select Power Factor control mode and waits 1 minute |  | Mvar output shall not be affected  +\_\_\_\_ Mvar  \_\_\_\_ kV |
| 9 | WFPS 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 |  | WFPS shall regulate to new PF set-point  +\_\_\_\_ Mvar  \_\_\_\_ kV |
| 10 | WFPS requests NCC to select AVR control mode and waits 1 minute |  | Mvar output shall not be affected  +\_\_\_\_ Mvar  \_\_\_\_ kV |
| 11 | WFPS requests NCC to issue a kV set-point 1 kV lower than system voltage at the connection point |  | WFPS shall regulate to new kV set-point (import Mvar)  -\_\_\_\_ Mvar  \_\_\_\_ kV |
| 12 | WFPS requests NCC to select Power Factor control mode and waits 1 minute |  | Mvar output shall not be affected  -\_\_\_\_ Mvar  \_\_\_\_ kV |
| 13 | WFPS 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 |  | WFPS shall regulate to new PF set-point  -\_\_\_\_ Mvar  \_\_\_\_ kV |
| 14 | WFPS requests NCC to select Mvar (Q) control mode and waits 1 minute |  | Mvar output shall not be affected  -\_\_\_\_ Mvar  \_\_\_\_ kV |
| 15 | WFPS requests NCC to issue a Mvar set-point of [insert 15% of leading Mvar capability] Mvar and waits 1 minute |  | WFPS shall regulate to new Mvar set-point  -\_\_\_\_ Mvar  \_\_\_\_ kV |
| 16 | WFPS requests NCC to select AVR control mode and waits 1 minute |  | Mvar output shall not be affected  -\_\_\_\_ Mvar  \_\_\_\_ kV |
| 17 | WFPS 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 WFPS is producing approximately 0 Mvar at the connection point |  | +/-\_\_\_\_ Mvar  \_\_\_\_ kV |
| 19 | WFPS requests NCC to issue an APC set-point of [insert 100% of Registered Capacity] MW, turn APC Off and wait until APC set-point has been achieved |  | \_\_\_\_ MW |
| 20 | WFPS ends data recording |  |  |
| 21 | WFPS informs NCC that the bumpless transfer test is complete |  |  |

## Automatic Voltage Regulation Mode

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

| **Step No.** | **Action** | **Time** | **Comments** |
| --- | --- | --- | --- |
| 1 | WFPS begins data recording for all trends noted in Section 7.3, above |  | Operator Name \_\_\_\_\_\_\_\_\_\_\_\_  Date \_\_\_\_\_\_\_\_\_\_\_\_ |
| 2 | WFPS requests permission from NCC to proceed with the AVR Mode test and confirms the following with NCC:   1. MW output of the WFPS 2. APC is OFF 3. AVR (kV) control mode is ON 4. Transformer tap position 5. On Load Tap Changer is in Automatic Mode 6. System Voltage 7. kV set-point = system voltage at connection point 8. Voltage slope setting = 4% 9. Mvar export is close to 0 Mvar at the connection point |  | 1. \_\_\_\_ MW 2. Status \_\_\_\_ 3. \_\_\_\_ Mode 4. Tap # \_\_\_\_ 5. \_\_\_\_ Mode 6. \_\_\_\_ kV 7. \_\_\_\_ kV 8. \_\_\_\_ % 9. \_\_\_\_ Mvar |
| 3 | WFPS 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 [WFPS to calculate per section 7.5] Mvar change in output 3. Current Mvar output of WFPS |  | 1. \_\_\_\_%. 2. \_\_\_\_ Mvar 3. \_\_\_\_ Mvar |
| 4 | WFPS requests NCC to increase the voltage set-point by 0.5 kV and waits 1 minute |  | WFPS shall export Mvar according to 2% droop  +\_\_\_\_ Mvar  \_\_\_\_ kV |
| 5 | WFPS 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 | WFPS confirms with NCC that WFPS Mvar output is approximately 0 Mvar at the connection point. If not, WFPS requests NCC to issue a voltage set-point to achieve approximately 0 Mvar |  | +\_\_\_\_ Mvar  \_\_\_\_ kV |
| 7 | WFPS 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 [WFPS to calculate per section 7.5] Mvar change in output 3. Current Mvar output of WFPS |  | 1. \_\_\_\_%. 2. \_\_\_\_ Mvar 3. \_\_\_\_ Mvar |
| 8 | WFPS requests NCC to decrease the voltage set-point by 2 kV and waits 1 minute |  | WFPS shall import Mvar according to 10% droop  -\_\_\_\_ Mvar  \_\_\_\_ kV |
| 9 | WFPS requests NCC to increase the voltage set-point by 2 kV and waits 1 minute |  | Mvar output shall be at 0 Mvar  +/-\_\_\_\_ Mvar |
| 10 | WFPS confirms with NCC that WFPS Mvar output is approximately 0 Mvar at the connection point. If not, WFPS requests NCC to issue a voltage set-point to achieve approximately 0 Mvar |  | \_\_\_\_ Mvar  \_\_\_\_ kV |
| 11 | WFPS 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 [WFPS to calculate per section 7.5] Mvar change in output 3. Current Mvar output of WFPS |  | 1. \_\_\_\_%. 2. \_\_\_\_ Mvar 3. \_\_\_\_ Mvar |
| 12 | WFPS requests NCC to increase the voltage set-point by 1 kV and waits 1 minute |  | WFPS shall export Mvar according to 4% droop  +\_\_\_\_ Mvar  \_\_\_\_ kV |
| 13 | WFPS requests NCC to increase the voltage set-point by 0.5 kV and waits 1 minute |  | WFPS shall export Mvar according to 4% droop  +\_\_\_\_ Mvar  \_\_\_\_ kV |
| 14 | WFPS requests NCC to decrease the voltage set-point by 1 kV and waits 1 minute |  | WFPS shall export Mvar according to 4% droop  +\_\_\_\_ Mvar  \_\_\_\_ kV |
| 15 | WFPS requests NCC to decrease the voltage set-point by 0.5 kV and waits 1 minute |  | Mvar output shall be at 0 Mvar  +/-\_\_\_\_ Mvar |
| 16 | WFPS requests NCC to decrease the voltage set-point by 1 kV and waits 1 minute |  | WFPS shall import Mvar according to 4% droop  -\_\_\_\_ Mvar  \_\_\_\_ kV |
| 17 | WFPS requests NCC to decrease the voltage set-point by 0.5 kV and waits 1 minute |  | WFPS shall import Mvar according to 4% droop  -\_\_\_\_ Mvar  \_\_\_\_ kV |
| 19 | WFPS requests NCC to increase the voltage set-point by 1 kV and waits 1 minute |  | WFPS shall import Mvar according to 4% droop  -\_\_\_\_ Mvar  \_\_\_\_ kV |
| 20 | WFPS requests NCC to increase the voltage set-point by 0.5 kV and waits 1 minute |  | Mvar output shall be at 0 Mvar  +/-\_\_\_\_ Mvar |
| 21 | WFPS confirms with NCC that WFPS Mvar output is approximately 0 Mvar at the connection point. If not, WFPS 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 |
| 22 | WFPS ends data recording |  |  |
| 23 | WFPS informs NCC that the AVR Mode test is complete |  |  |

## 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 WFPS shall carry out a manual tap change to induce a small step change in system voltage.

| **Step No.** | **Action** | **Time** | **Comments** |
| --- | --- | --- | --- |
| 1 | WFPS begins data recording for all trends noted in Section 7.3, above |  | Operator Name \_\_\_\_\_\_\_\_\_\_\_\_  Date \_\_\_\_\_\_\_\_\_\_\_\_ |
| 2 | WFPS requests permission from NCC to proceed with the AVR response rate test and confirms with NCC the following with NCC:   1. MW output of the WFPS 2. APC is OFF 3. AVR (kV) control mode is ON 4. The transformer tap position 5. On Load Tap Changer is in Automatic Mode 6. System Voltage 7. Voltage slope setting = 4% 8. Mvar Export at the connection point |  | 1. \_\_\_\_ MW 2. Status \_\_\_\_ 3. \_\_\_\_ Mode 4. Tap # \_\_\_\_ 5. \_\_\_\_ Mode 6. \_\_\_\_ kV 7. \_\_\_\_% 8. \_\_\_\_ Mvar |
| 3 | WFPS requests NCC to induce a step change in system voltage by carrying out transformer tapping or carrying out switching on the system, if possible. |  | WFPS shall respond to the change at a rate of 90% in 1 second. |
| 4 | WFPS ends data recording |  |  |
| 5 | WFPS 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 | WFPS requests permission from NCC and puts the on-load tap changer into manual mode |  |  |
| 7 | WFPS requests permission from NCC and taps the transformer up 1 tap and waits 1 minute |  | +\_\_\_\_ Mvar  \_\_\_\_ kV |
| 8 | WFPS requests permission from NCC, WFPS taps the transformer up 1 tap and waits 1 minute |  | +\_\_\_\_ Mvar  \_\_\_\_ kV |
| 9 | WFPS requests permission from NCC, WFPS taps the transformer down 1 tap and waits 1 minute |  | -\_\_\_\_ Mvar  \_\_\_\_ kV |
| 10 | WFPS requests permission from NCC, WFPS taps the transformer down 1 tap and waits 1 minute |  | -\_\_\_\_ Mvar  \_\_\_\_ kV |
| 11 | WFPS requests permission from NCC, puts the on-load tap changer into automatic mode and confirms to NCC |  |  |
| 12 | WFPS confirms with NCC that the WFPS is at approximately 0 Mvar at the connection point |  | Mvar output shall be at 0 Mvar  +/-\_\_\_\_ Mvar |
| 13 | WFPS ends data recording |  |  |
| 14 | WFPS informs NCC that the AVR response rate test is complete |  |  |

## Mvar Control Mode

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

| **Step No.** | **Action** | **Time** | **Comments** |
| --- | --- | --- | --- |
| 1 | WFPS begins data recording for all trends noted in Section 7.3, above |  | Operator Name \_\_\_\_\_\_\_\_\_\_\_\_  Date \_\_\_\_\_\_\_\_\_\_\_\_ |
| 2 | WFPS requests permission from NCC to proceed with the AVR response rate test and confirms with NCC the following with NCC:   1. MW output of the WFPS 2. APC is OFF 3. Mvar (Q) control mode is ON 4. The transformer tap position 5. On Load Tap Changer is in Automatic Mode 6. Mvar Set-point = 0 Mvar 7. System Voltage 8. Voltage slope setting = 4% 9. Mvar Export is 0 Mvar at the connection point |  | 1. \_\_\_\_ MW 2. Status \_\_\_\_ 3. \_\_\_\_ Mode 4. Tap # \_\_\_\_ 5. \_\_\_\_ Mode 6. \_\_\_\_ Mvar 7. \_\_\_\_ kV 8. \_\_\_\_% 9. \_\_\_\_ Mvar |
| 3 | WFPS requests NCC to issue a set-point of [insert 25% of lagging Mvar capability] Mvar and waits 1 minute |  | +\_\_\_\_ Mvar  \_\_\_\_ kV |
| 4 | WFPS requests NCC to issue a set-point of [insert 60% of lagging Mvar capability] Mvar and waits 1 minute |  | +\_\_\_\_ Mvar  \_\_\_\_ kV |
| 5 | WFPS requests NCC to issue a set-point of [insert 10% of lagging Mvar capability] Mvar and waits 1 minute |  | +\_\_\_\_ Mvar  \_\_\_\_ kV |
| 6 | WFPS requests NCC to issue a set-point of 0 Mvar and waits 1 minute |  | Mvar output shall be at 0 Mvar  +/-\_\_\_\_ Mvar |
| 7 | WFPS requests NCC to issue a set-point of [insert 25% of leading Mvar capability] Mvar and waits 1 minute |  | -\_\_\_\_ Mvar  \_\_\_\_ kV |
| 8 | WFPS requests NCC to issue a set-point of [insert 60% of leading Mvar capability] Mvar and waits 1 minute |  | -\_\_\_\_ Mvar  \_\_\_\_ kV |
| 9 | WFPS requests NCC to issue a set-point of [insert 10% of leading Mvar capability] Mvar and waits 1 minute |  | -\_\_\_\_ Mvar  \_\_\_\_ kV |
| 10 | WFPS requests NCC to issue a set-point of 0 Mvar and waits 1 minute |  | Mvar output shall be at 0 Mvar  +/-\_\_\_\_ Mvar |
| 11 | WFPS confirms with NCC that the WFPS is at approximately 0 Mvar at the connection point |  | Mvar output shall be at 0 Mvar  +/-\_\_\_\_ Mvar |
| 12 | WFPS ends data recording |  |  |
| 13 | WFPS informs NCC that the Mvar Control Mode test is complete |  |  |

## Power Factor Control Mode

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

| **Step No.** | **Action** | **Time** | **Comments** |
| --- | --- | --- | --- |
| 1 | WFPS begins data recording for all trends noted in Section 7.3, above |  | Operator Name \_\_\_\_\_\_\_\_\_\_\_\_  Date \_\_\_\_\_\_\_\_\_\_\_\_ |
| 2 | WFPS requests permission from NCC to proceed with the AVR response rate test and confirms with NCC the following with NCC:   1. MW output of the WFPS 2. APC is OFF 3. Power Factor (PF) control mode is ON 4. The transformer tap position 5. On Load Tap Changer Mode 6. Voltage Set-point Control (Local/Remote) 7. System Voltage 8. PF set-point = 0 degrees 9. Voltage slope setting = 4% 10. Mvar Export |  | 1. \_\_\_\_ MW 2. Status \_\_\_\_ 3. \_\_\_\_ Mode 4. Tap # \_\_\_\_ 5. \_\_\_\_ Mode 6. \_\_\_\_ 7. \_\_\_\_ kV 8. \_\_\_\_ degrees 9. \_\_\_\_% 10. \_\_\_\_ Mvar |
| 3 | WFPS 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 | WFPS 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 |
| 5 | WFPS requests NCC to turn APC ON |  | Status \_\_\_\_ |
| 6 | WFPS 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 | WFPS 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 | WFPS requests NCC to issue a PF set-point of 0 degrees and waits 1 minute |  | Mvar output shall be at 0 Mvar  +/-\_\_\_\_ Mvar |
| 9 | WFPS 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 | WFPS 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 | WFPS requests NCC to issue an APC set-point of [insert 100% of Registered Capacity] MW 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 until 1 minute after active power output has reached AAP |  | \_\_\_\_ MW  +\_\_\_\_ Mvar |
| 12 | WFPS requests NCC to turn Active Power Control OFF and turn |  | Status \_\_\_\_ |
| 13 | WFPS 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 and waits 1 minute |  | -\_\_\_\_ Mvar  \_\_\_\_ kV |
| 14 | WFPS requests NCC to issue a PF set-point of 0 degrees and waits 1 minute |  | Mvar output shall be at 0 Mvar  +/-\_\_\_\_ Mvar |
| 15 | WFPS requests NCC to select AVR control mode |  | Mode \_\_\_\_ |
| 16 | WFPS confirms with NCC that the WFPS is at approximately 0 Mvar at the connection point |  | Mvar output shall be at 0 Mvar  +/-\_\_\_\_ Mvar |
| 17 | WFPS ends data recording |  |  |
| 18 | WFPS informs NCC that the Power Factor Control Mode test is complete |  |  |

## Return to Standard Settings

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

|  |  |  |  |
| --- | --- | --- | --- |
| **Step No.** | **Action** | **Time** | **Comments** |
| 1 | WFPS informs NCC that Reactive Power Control Testing is complete and confirms the following the following:   1. MW output of the WFPS 2. APC is OFF 3. Frequency Response is ON 4. Frequency Response is in Curve 1 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 at the connection point |  | 1. \_\_\_\_ MW 2. Status \_\_\_\_ 3. Status \_\_\_\_ 4. Curve \_\_\_\_ 5. \_\_\_\_ Mode 6. Tap # \_\_\_\_ 7. \_\_\_\_ Mode 8. \_\_\_\_ kV 9. \_\_\_\_ kV 10. \_\_\_\_% 11. \_\_\_\_ Mvar |

## Comments & Signatures

|  |
| --- |
| **Comments:** |
| WFPS 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)