

WFPS Frequency Response

Test Procedure

[Insert Windfarm Name]

Version 0.1

Contents

[1 Document Version History 3](#_Toc460600486)

[2 Introduction 3](#_Toc460600487)

[3 Abbreviations 4](#_Toc460600488)

[4 WFPS DATA 4](#_Toc460600489)

[5 Grid Code References 5](#_Toc460600490)

[6 site Safety requirements 10](#_Toc460600491)

[7 Test desciption and pre conditions 11](#_Toc460600492)

[7.1 Purpose of the Test 11](#_Toc460600493)

[7.2 Pass Criteria 11](#_Toc460600494)

[7.3 Instrumentation and onsite data trending 12](#_Toc460600495)

[7.4 Initial Conditions 13](#_Toc460600496)

[7.5 Frequency Response Calculations 13](#_Toc460600497)

[7.6 Frequency and Ramp Rate Settings to be implemented in Wind Farm Control System 14](#_Toc460600498)

[8 Test Steps 18](#_Toc460600499)

[8.1 Functional Check 18](#_Toc460600500)

[8.2 Frequency Droop Setting 19](#_Toc460600501)

[8.3 Frequency Response ON, Curve 1, APC ON 20](#_Toc460600502)

[8.4 Frequency Response OFF Curve 1 APC ON 22](#_Toc460600503)

[8.5 Frequency Response ON, Curve 1, APC OFF 23](#_Toc460600504)

[8.6 Frequency Response OFF, Curve 1, APC OFF 25](#_Toc460600505)

[8.7 Frequency Response ON, Curve 2, APC ON 26](#_Toc460600506)

[8.8 Frequency Response OFF Curve 2 APC ON 28](#_Toc460600507)

[8.9 Frequency Response ON Curve 2 APC OFF 29](#_Toc460600508)

[8.10 Frequency Response OFF, Curve 2, APC OFF 30](#_Toc460600509)

[8.11 DMOL Test 31](#_Toc460600510)

[8.12 Frequency Response Ramp Rate Priority in Curve 1 32](#_Toc460600511)

[8.13 Frequency Response Ramp Rate Priority in Curve 2 34](#_Toc460600512)

[8.14 Return to Standard Settings 35](#_Toc460600513)

[8.15 Comments & Signatures 36](#_Toc460600514)

DISCLAIMER:

This Document contains information (and/or attachments) which may be privileged or confidential. All content is intended solely for the use of the individual or entity to whom it is addressed. If you are not the intended recipient please be aware that any disclosure, copying, distribution or use of the contents of this message is prohibited. If you suspect that you have received this Document in error please notify EirGrid or its subsidiaries immediately. EirGrid and its subsidiaries do not accept liability for any loss or damage arising from the use of this document or any reliance on the information it contains or the accuracy or up to date nature thereof. Use of this document and the information it contains is at the user’s sole risk. In addition, EirGrid and its subsidiaries strongly recommends that any party wishing to make a decision based on the content of this document should not rely solely upon data and information contained herein and should consult EirGrid or its subsidiaries in advance.

Further information can be found at: <http://www.eirgridgroup.com/legal/>

# Document Version History

EirGrid template version 0.5, published 03 November 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-2).

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.

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:

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

AAP Available Active Power

APC Active Power Control

DMOL Designed Minimum Operating Level

HV High Voltage

MEC Maximum Export Capacity

MW Mega Watt

NCC National Control Centre

TSO Transmission System Operator

WFCS Wind Farm Control System

WFPS Wind Farm Power Station

WTG Wind Turbine Generator

# WFPS DATA

|  |  |
| --- | --- |
| WFPS Name | WFPS to Specify  |
| WFPS Test Coordinator 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 |
| DMOL | WFPS to Specify  |

# Grid Code References

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

|  |  |
| --- | --- |
| **Design Minimum Operating Level (DMOL):**  | The minimum **Active Power** output of **Controllable WFPS** where all **WTGs** are generating electricity and capable of ramping upwards at any of the specified ramp rates (given available wind), and shall not be greater than 12% of **Registered Capacity**. |
| **Governor Droop**  | The percentage drop in the **Frequency** that would cause the **Generation Unit** under free governor action to change its output from zero to its full **Capacity**. In the case of a **Controllable WFPS**, it is the percentage drop in the **Frequency** that would cause the **Controllable WFPS** to increase its output from zero to its full **Registered Capacity.** |

**WFPS1.5.1** No additional **WTG** shall be started while the **Transmission System Frequency** is above 50.2 Hz.

**WFPS1.5.2 ACTIVE POWER MANAGEMENT**

A **Wind Farm Control System** shall be installed by the **Controllable WFPS** to allow for the provision of **Active Power Control** and **Frequency** **Response** from the **Controllable WFPS**. The **Wind Farm Control System** and **Frequency Response System** shall provide the functionality as specified in this section WFPS1.5.2.

WFPS1.5.3.1 In **Wind Following Mode**, the **Frequency Response System** shall have the capabilities as displayed in the *Power-Frequency Response Curve* in *Figures WFPS1.2,* where the power and frequency ranges required for points A, B, C, D, E are defined below in *Table WFPS1.1 and Table WFPS1.2.* The **Frequency Response System** shall adjust the **Active Power** output of the **Controllable WFPS** according to a **Governor Droop**, settable by the **TSO** in a range from 2% to 10% and defaulting to 4%, when operating in the ranges outside the deadband range FB-FC in the Power-Frequency Response Curve. **Controllable WFPS****Frequency Response**and **Governor Droop** shall be calculated with respect to **Registered Capacity**.

WFPS1.5.3.2 When in **Active Power Control Mode,** the **Controllable WFPS** shall always operate in **Frequency Sensitive Mode** with a **Governor Droop** as set out in WFPS1.5.3.1 and with a deadband of +/-15mHz, or as otherwise agreed with the **TSO.**



*Figure WFPS1.2 –Example of Power-Frequency Response Curve for Wind Following Mode*

WFPS1.5.3.3 When acting to control **Transmission System Frequency**, the **Controllable WFPS** shall provide at least 60% of its expected additional **Active Power** response within 5 seconds, and 100% of its expected additional **Active Power** response within 15 seconds of the start of the **Transmission System Frequency** excursion outside the range FB-FC, or in the case of a **Controllable WFPS** in **Active Power Control Mode**, when the **Transmission System Frequency** goes outside the deadband set out in WFPS1.5.3.2.

WFPS1.5.3.4 When the **Transmission System Frequency** is in the range FC-FD, the **Controllable WFPS** shall ensure that its **Active Power Output** does not increase beyond the **Active Power** value of the **Controllable WFPS** when the **Transmission System Frequency** first exceeded FC, due to an increase in **Available Active Power** in that period.

WFPS1.5.3.5 If the **Frequency** drops below FA, then the **Frequency Response System** shall act to maximise the **Active Power** output of the **Controllable WFPS**, irrespective of the **Governor Droop Setting**. If the **Frequency** rises above FD, then the **Frequency Response System** shall act to reduce the **Active Power** output of the **Controllable WFPS** to its **DMOL** value. If the **Frequency** rises above FE, then the **Frequency Response System** shall act to reduce the **Active Power** output of the **Controllable WFPS** to zero. Any **WTG** which has disconnected shall be brought back on load as fast as technically feasible, provided the **Transmission System Frequency** has fallen below 50.2 Hz.

WFPS1.5.3.6 Points ‘A’, ‘B’, ‘C’, ‘D’ and ‘E’ shall depend on a combination of the **Transmission System Frequency**, **Active** **Power** and **Active Power Control Set-point** settings. These settings may be different for each **Controllable WFPS** depending on system conditions and **Controllable WFPS** location. These settings are defined in *Table WFPS1.1* below.

|  |  |  |
| --- | --- | --- |
| Point | ***Transmission System Frequency*** *(Hz)* | ***Controllable WFPS Active Power*** *Output**(****%*** *of* ***Available******Active Power****)* |
| A | ***FA*** | ***PA*** |
| B | ***FB*** | Minimum of : ***PB*** or**Active Power Control Set-point** (converted to a % of **Available** **Active Power**) |
| C | ***FC*** | Minimum of: ***PC*** or**Active Power Control Set-point** (converted to a % of **Available** **Active Power**) |
| D | ***FD*** | Minimum of: ***PD*or****Active Power Control Set-point** (converted to a % of **Available** **Active Power**) |
| E | ***FE*** | ***PE*** = 0 % |

*Table WFPS1.1:* ***Transmission System Frequency*** *and %* ***Available Active Power*** *Settings for the Points ‘A’, ‘B’, ‘C’, ‘D’ and ‘E’ illustrated in Figure WFPS1.2*

Two settings for each of ***FA, FB, FC, FD, FE, PA, PB, PC, PD*** and ***PE*** shall be specified by the **TSO** at least 120 **Business Days** prior to the **Controllable WFPS’s** scheduled **Operational Date** (refer to WFPS1.5.3.11 below).The **Controllable WFPS** shall be responsible for implementing the appropriate settings during **Commissioning**.

WFPS1.5.3.7 The table below, *Table WFPS1.2,* shows the **Transmission System Frequency** and **Active** **Power** ranges for ***FA, FB, FC, FD, FE, PA, PB, PC, PD*** and ***PE****.*

|  |  |  |  |
| --- | --- | --- | --- |
|  | ***Transmission System Frequency*** *(Hz)* |  | ***Available Active Power*** *(%)* |
|  |  |  | ***Registered Capacity ≥ 5 MW*** |
| ***FA*** | *47.0-49.5* | ***PA*** | *50-100* |
| ***FB*** | *49.5-50* | ***PB*** | *15-100* |
| ***FC*** | *50-50.5* | ***PC*** |
| ***FD*** | *50.5-52.0* | ***PD*** | *15-100 but not less than* ***DMOL*** |
| ***FE*** | ***PE*** | *0* |

*Table WFPS1.2:* ***Transmission System Frequency*** *&* ***Active******Power*** *ranges appropriate to Figure WFPS1.2.*

 For the **Transmission System Frequency** values in *Table WFPS1.2* above, *FA* ≤ *FB* ≤ *FC* ≤ *FD* ≤ *FE*.

WFPS1.5.3.8 Alterations to the **Controllable WFPS’s Active Power** output, triggered by **Transmission System Frequency** changes, shall be achieved by proportionately altering the **Active Power** output of all available **WTG**s as opposed to switching individual **WTG**s on or off, insofar as possible.

WFPS1.5.3.9 No time delays, such as moving average frequency filters, other than those necessarily inherent in the design of the **Frequency Response System** shall be introduced. The **Frequency Response System** shall continuously monitor the **Transmission System Frequency** in order to continuously determine the **Controllable WFPS’s** appropriate **Active Power** output by taking account of the **Controllable WFPS’s** **Available** **Active Power** or **Controlled** **Active Power**.

WFPS1.5.3.10 If the **Transmission System Frequency** rises to a level above ‘D’-’E’, as defined by the *Power-Frequency Response Curve in Figure WFPS1.2*, the **TSO** accepts that **WTG**s may disconnect. Any **WTG** which has disconnected shall be brought back on load as fast as technically feasible (provided the **Transmission System Frequency** has fallen below 50.2 Hz).

**WFPS1.5.3.11 Procedure for Setting and Changing the *Power-Frequency Response Curves***

Two *Power-Frequency Response Curves* (Curve 1 and Curve 2) 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 **Frequency Response System** shall be required to change between the two curves within one minute from receipt of the appropriate signal from the **TSO**. The **TSO** shall give the **Controllable WFPS** a minimum of two weeks’ notice if changes to either of the curve’s parameters ***(i.e. FA, FB, FC, FD, FE, PA, PB, PC, PD*** or ***PE)***, are required. The **Controllable WFPS** shall formally confirm that any requested changes have been implemented within two weeks of receiving the **TSO’s** formal request.

**WFPS1.5.4 RAMP RATES**

**WFPS1.5.4.1** The **Wind Farm Control System** shall be capable of controlling the ramp rate of its **Active Power** output. There shall be three ramp rate capabilities, designated **Wind Following Ramp Rate**, **Active** **Power Control Set-Point Ramp Rate**, and **Frequency Response Ramp Rate**. The **Wind Farm Control System** shall operate the ramp rates with the following order of priority (high to low): **Frequency Response Ramp Rate**; **Active** **Power Control Set-Point Ramp Rate**; **Wind Following Ramp Rate**. The **Wind Following Ramp Rate** shall be used during **Start-Up**, normal operation, and **Shutdown**. The **TSO** shall specify the **Wind Following Ramp Rate** and the **Active** **Power Control Set-Point Ramp Rate** in percentage of **Registered Capacity** per minute. The **Frequency Response Ramp Rate** shall be the maximum possible ramp rate of the **Controllable WFPS** agreed with the **TSO** and with the characteristics as set out in WFPS1.5.3.1**.** The **TSO** acknowledges that rapidly changing wind speeds may cause temporary deviations from the ramp rate settings of the **Controllable WFPS**, but these deviations should not be allowed to exceed 3% of **Registered Capacity**.

WFPS1.7.2.3 **Frequency Response**

The Frequency Response Curve signal shall be sent by the **TSO** to the **Controllable WFPS** in the event that a change from *Power-Frequency Response Curve 1* to *Power Frequency Response Curve 2*, or vice versa, is required.

 The **Controllable WFPS** is required to make it possible for the **TSO** to remotely enable/ disable the **Frequency Response System**. The associated status indication is described in WFPS1.7.1.5.

The **Controllable WFPS** shall make it possible for the **TSO** to set the **Governor Droop** value of the **Frequency Response System** in values from 2% to 10%.

# site Safety requirements

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

|  |  |
| --- | --- |
| Personal Protective Equipment Requirements1. 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 the ability of the WFPS to respond to changes in system frequency. The WFPS shall be capable of operating with a “Governor Droop” – e.g. able to continuously adjust its active power output in response to changes in frequency. As the grid frequency cannot be changed at will, the test will require frequency to be simulated by means of injection of a frequency signal into the WFCS.

## 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** |
| --- |
| **Governor Droop** |
| Governor droop is calculated with respect to Registered Capacity. |
| Governor droop is calculated with respect to 50 Hz. |
| Governor droop is settable in a range from 2% to 10%, online, from NCC. |
| When Frequency Response is OFF, no response shall be provided. |
| The WFCS continuously recalculates its expected response during the frequency excursion. |
| **Rate of Response** |
| WFPS provides ≥60% of its expected response within 5 seconds and 100% of its expected response within 15 seconds. |
| Ramp Rates shall be prioritised with Frequency Response Ramp Rate given the highest priority. |
| **Frequency Response Curve** |
| For frequency < FA, MW output ramps directly to 100% of AAP. |
| For frequency between FA and FB, MW output is based on frequency droop setting |
| For frequency ≥ FB and ≤ FC, no response shall be provided |
| For frequency between FC and FD, MW output is based on frequency droop setting. |
| For frequency > FD, MW output ramps directly to DMOL |
| For frequency > FE, MW output ramps directly to 0 MW |
| Deadband of +/-15 mHz is applied in Active Power Control Mode and in Curve 2 |
| **Latching etc.** |
| For frequency > FC, MW output does not increase above its value at the time frequency exceeded FC, due to AAP increasing. |
| Any WTG which has disconnected due to frequency ≥ FE, shall be brought back on load when frequency falls less than 50.2 Hz. |
| No additional WTG can be started while frequency is above 50.2 Hz. |
| Frequency response is achieved by altering the output of all WTGs as opposed to switching WTGs on or off, insofar as possible. |
| For active power output levels ≥ DMOL, all WTGs shall be generating electricity. |
| WFPS regulates its active power output to within the greater of ±0.5 MW or ±3% of Registered Capacity of the Active Power Control Set-point adjusted for frequency response. |

## 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 WFPS in MW (*Figure WFPS1.3, Point Y – preferably point Z if available*) | WFPS to Specify (≥ 10 Hz) | Yes / No |
| 3 | APC ON/OFF | WFPS to Specify (≥ 10 Hz) | Yes / No |
| 4 | APC set-point from NCC | WFPS to Specify (≥10 Hz) | Yes / No |
| 5 | Frequency Response ON/OFF | WFPS to Specify (≥10 Hz) | Yes / No |
| 6 | Frequency Response Curve1/Curve2 | WFPS to Specify (≥10 Hz) | Yes / No |
| 7 | Frequency Droop Setting | WFPS to Specify (≥10 Hz) | Yes/No |
| 8 | Simulated Test Frequency | WFPS to Specify (≥10 Hz) | Yes / No |
| 9 | Grid Frequency | WFPS to Specify (≥10 Hz) | Yes / No |
| 10 | Number of turbines online | WFPS to Specify (≥10 Hz) | Yes / No |
| 11 | Wind Farm Availability % | 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.

| **Conditions** | **Check on day of test** |
| --- | --- |
| All WTGs are available | # turbines installed: \_\_\_\_# turbines generating: \_\_\_\_ |
| Generated MW > 60% of Registered Capacity | Generated MW: \_\_\_\_ |
| Where NCC has control of the reactive power, ensure WFPS is exporting close to 0 Mvar at the connection point by bringing kV set-point = system voltage in 1 kV steps | Yes / No |

## Frequency Response Calculations

|  |  |
| --- | --- |
| **Calculation** | **Value** |
| Theoretical change in MW for frequency increase of 0.25 Hz with Frequency Droop of 4% | \_\_\_\_ MW(WFPS to specify calculation and formula used) |
| Theoretical change in MW for frequency increase of 0.25 Hz with Frequency Droop of 2% | \_\_\_\_ MW(WFPS to specify calculation and formula used) |
| Theoretical change in MW for frequency decrease of 0.5 Hz with Frequency Droop of 10% | \_\_\_\_ MW(WFPS to specify calculation and formula used) |
| Ramp rate that is applied in frequency response mode | \_\_\_\_ MW/minute |

## Frequency and Ramp Rate Settings to be implemented in Wind Farm Control System



**Frequency Response Mode On**

Table Curve 1 Wind Following Mode

|  |  |  |  |
| --- | --- | --- | --- |
|  | ***Transmission System Frequency*** *f (Hz)* |  | ***Required Active Power Output*** |
|  | *f < 48* |  | *100% of AAP* |
| ***FA*** | *48* | ***PA*** | *100% of AAP* |
| ***Under Frequency Response*** | *48 < f < 49.8* |  | *100% of AAP* |
| ***FB*** | *f = 49.8* | ***PB*** | *100% of AAP* |
| ***+/-0.2Hz Deadband*** | *49.8 < f < 50.2* |  | *100% of AAP* |
| ***FC*** | *f = 50.2* | ***PC*** | *100% of AAP* |
| ***Over Frequency Response*** | *50.2 < f < 51.9* |  | *AAP + ∆MW2* |
| ***FD*** | *f = 51.9* | ***PD*** | *Minimum of: AAP and DMOL* |
| ***FE*** | *f = 52* | ***PE*** | *0%3* |
|  |  *f > 52* |  | *0%3* |

Table Curve 1 Active Power Control Mode

|  |  |  |  |
| --- | --- | --- | --- |
|  | ***Transmission System Frequency*** *f (Hz)* |  | ***Required Active Power Output*** |
|  |  *f < 48* |  | *100% of AAP* |
| ***FA*** | *f = 48* | ***PA*** | *100% of AAP* |
| ***Under Frequency Response*** | *48 < f < 49.985* |  | *Minimum of: APC Setpoint + ∆MW and AAP* |
| ***FB*** | *f = 49.985* | ***PB*** | *Minimum of: APC Setpoint and AAP* |
| ***+/-0.015Hz Deadband*** | *49.985 < f < 50.015* |  | *Minimum of: APC Setpoint and AAP* |
| ***FC*** | *f = 50.015* | ***PC*** | *Minimum of: APC Setpoint and AAP* |
| ***Over Frequency Response*** | *50.015 < f < 51.9* |  | *Minimum of: APC Setpoint + ∆MW and AAP + ∆MW1, 2* |
| ***FD*** | *f = 51.9* | ***PD*** | *Minimum of: APC Setpoint and AAP and DMOL* |
| ***FE*** | *f = 52* | ***PE*** | *0%3* |
|  |  *f > 52* |  | *0%3* |

Table Curve 2 Wind Following Mode

|  |  |  |  |
| --- | --- | --- | --- |
|  | ***Transmission System Frequency*** *f (Hz)* |  | ***Required Active Power Output*** |
|  |  *f <49.3* |  | *100% of AAP* |
| ***FA*** | *f = 49.3* | ***PA*** | *100% of AAP* |
| ***Under Frequency Response*** | *49.3 < f < 49.985* |  | *95% of Available Active Power + ∆MW* |
| ***FB*** | *f = 49.985* | ***PB*** | *95% of Available Active Power. This is = to 5% Reserve.*  |
| ***+/-0.015Hz Deadband*** | *49.985 < f < 50.015* |  | *95% of Available Active Power. This is = to 5% Reserve.*  |
| ***FC*** | *f = 50.015* | ***PC*** | *95% of Available Active Power. This is = to 5% Reserve.*  |
| ***Over Frequency Response*** | *50.015 < f < 51.9* |  | *95% of AAP + ∆MW2* |
| ***FD*** | *f = 51.9* | ***PD*** | *Minimum of: AAP and DMOL* |
| ***FE*** | *f = 52* | ***PE*** | *0%3* |
|  |  *f > 52* |  | *0%3* |

Table Curve 2 Active Power Control Mode

|  |  |  |  |
| --- | --- | --- | --- |
|  | ***Transmission System Frequency*** *f (Hz)* |  | ***Required Active Power Output*** |
|  |  *f < 49.3*  |  | *100% of AAP* |
| ***FA*** | *f = 49.3* | ***PA*** | *100% of AAP* |
| ***Under Frequency Response*** | *49.3 < f < 49.985* |  | *Minimum of: APC Setpoint + ∆MW and 95% of AAP + ∆MW* |
| ***FB*** | *f = 49.985* | ***PB*** | *Minimum of: APC Setpoint and 95% of AAP* |
| ***+/-0.015Hz Deadband*** | *49.985 < f < 50.015* |  | *Minimum of: APC Setpoint and 95% of AAP* |
| ***FC*** | *f = 50.015* | ***PC*** | *Minimum of: APC Setpoint and 95% of AAP* |
| ***Over Frequency Response*** | *50.015 < f < 51.9* |  | *Minimum of: APC Setpoint + ∆MW and 95% of AAP + ∆MW1, 2* |
| ***FD*** | *f = 51.9* | ***PD*** | *Minimum of: APC Setpoint and AAP and DMOL* |
| ***FE*** | *f = 52* | ***PE*** | *0%3* |
|  |  *f > 52* |  | *0%3* |

Minimum reserve level in Curve 2 is 5% of Available Active power, not lower than DMOL (settable between DMOL and 100%).

|  |
| --- |
| 1 APC Setpoint + ∆MW shall have a lower limit of the minimum of: APC Setpoint and DMOL |
| 2 (95% of) AAP + ∆MW shall have a lower limit of the minimum of AAP and DMOL |
| 3 Any WTG which has disconnected due to high frequency shall be brought back on load as fast as technically feasible, provided the Frequency has fallen below 50.2Hz. |
| DMOL shall not be greater than 12% of Registered Capacity |
| If AAP < DMOL and f < FE, maximise output |

**Frequency Response Mode Off**

Table Curves 1 & 2 Wind Following Mode

|  |  |  |
| --- | --- | --- |
| ***Transmission System Frequency*** *(Hz)* |  | ***Required Active Power Output*** |
| ***47.5* ≤ *f* ≥ *52*** | *No governor action* | *100% of AAP* |

Table Curves 1 & 2 Wind Following Mode

|  |  |  |
| --- | --- | --- |
| ***Transmission System Frequency*** *(Hz)* |  | ***Required Active Power Output*** |
| ***47.5 ≤ f ≥ 52*** | *No governor action* | *Minimum of: AAP and APC Setpoint*  |

**Frequency Droop**

|  |  |
| --- | --- |
| **Frequency Droop** | **Droop Calculation** |
| 4% of Registered Capacity |  |

**Ramp Rates**

|  |  |  |
| --- | --- | --- |
| **Mode** | **Rate** | **Priority** |
| Frequency Response | As fast as technically possible.60% of its expected Active Power response within 5 seconds100% of its expected Active Power response within 15 seconds. | 1 |
| Active Power Dispatch | 20% of Registered Capacity per Minute | 2 |
| Wind Following | 20% of Registered Capacity per Minute | 3 |

**Rate of Change of Frequency:**

ROCOF shall be disabled on Transmission System-connected Windfarms. If this is not possible, ROCOF shall be set to max that machine is capable of. Under no circumstances is ROCOF to be set to less than 0.5 Hz/s

# Test Steps

## Functional Check

This WFPS demonstrates that the basic functions of switching on and off frequency response, changing curves and changing droop settings are working prior to conducting the rest of the frequency response test.

|  |  |  |  |
| --- | --- | --- | --- |
| **Step No.** | **Action** | **Time** | **Comments** |
| 1 | WFPS begins data recording for all trends noted in Section 7.3, above |  | Operator Name \_\_\_\_\_\_\_\_\_\_\_\_Date \_\_\_\_\_\_\_\_\_\_\_\_ |
| 1 | WFPS requests permission from NCC to proceed with the Frequency Response functional check and confirms the following with NCC: 1. AAP of the WFPS
2. MW output of the WFPS
3. APC is OFF
4. Frequency Response is ON
5. Frequency Response is in Curve 1
6. Frequency Droop Setting is 4%
 |  | 1. \_\_\_\_ MW
2. \_\_\_\_ MW
3. Status \_\_\_\_
4. Status \_\_\_\_
5. Curve \_\_\_\_
6. \_\_\_\_%
 |
| 2 | WFPS requests NCC to select Frequency Response Curve 2 and manually records the time between the command being issued from NCC and being implemented in the WFCS |  | Curve \_\_\_\_Time delay \_\_\_\_ |
| 3 | WFPS requests NCC to select Frequency Response Curve 1 and manually records the time between the command being issued from NCC and being implemented in the WFCS |  | Curve \_\_\_\_Time delay \_\_\_\_ |
| 4 | WFPS requests NCC to select Frequency Response OFF and manually records the time between the command being issued from NCC and being implemented in the WFCS |  | Status \_\_\_\_Time delay \_\_\_\_ |
| 5 | WFPS requests NCC to select Frequency Response ON and manually records the time between the command being issued from NCC and being implemented in the WFCS |  | Status \_\_\_\_Time delay \_\_\_\_ |
| 6 | WFPS requests NCC to issue a Frequency Droop Setting of 2% and manually records the Frequency Droop Setting implemented in the WFCS |  | \_\_\_\_% |
| 7 | WFPS requests NCC to issue a Frequency Droop Setting of 10% and manually records the Frequency Droop Setting implemented in the WFCS |  | \_\_\_\_% |
| 8 | WFPS requests NCC to issue a Frequency Droop Setting of 4% and manually records the Frequency Droop Setting implemented in the WFCS |  | \_\_\_\_% |
| 9 | WFPS informs NCC that the Functional check is complete |  |  |

## Frequency Droop Setting

The WFPS demonstrates that TSO can set the frequency droop online between 2% and 10% and that the frequency droop functions accordingly.

| **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 Frequency Droop Setting test and confirms the following with NCC: 1. AAP of the WFPS
2. MW output of the WFPS
3. APC is ON
4. APC set-point is [insert 40% of Registered Capacity] MW
5. Frequency Response is ON
6. Frequency Response is in Curve 1
7. Frequency Droop Setting is 4%
 |  | 1. \_\_\_\_ MW
2. \_\_\_\_ MW
3. Status \_\_\_\_
4. \_\_\_\_ MW
5. Status \_\_\_\_
6. Curve \_\_\_\_
7. \_\_\_\_%
 |
| 3 | WFPS requests NCC to issue a Frequency Droop Setting of 2% |  | \_\_\_\_% |
| 4 | WFPS replaces the system frequency with a simulated frequency of 50 Hz and waits 3 minutes |  | AAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 5 | WFPS injects a simulated frequency of 49.75 Hz and waits 3 minutes |  | AAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 6 | WFPS injects a simulated frequency of 50.25 Hz and waits 3 minutes |  | AAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 7 | WFPS injects a simulated frequency of 50 Hz |  | AAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 8 | WFPS requests NCC to issue a Frequency Droop Setting of 10% |  |  |
| 9 | WFPS injects a simulated frequency of 49 Hz and waits 3 minutes |  | AAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 10 | WFPS injects a simulated frequency of 51 Hz and waits 3 minutes |  | AAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 11 | WFPS injects a simulated frequency of 50 Hz |  | AAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 12 | WFPS requests NCC to issue a Frequency Droop Setting of 4% |  |  |
| 13 | WFPS ends data recording |  |  |
| 14 | WFPS informs NCC that the Frequency Droop Setting test is complete |  |  |

## Frequency Response ON, Curve 1, APC ON

The WFPS demonstrates that the active power output is correctly altered for simulated frequencies, based on the settings issued by the TSO. The behaviour of the WFPS to frequency deviations while below DMOL is also examined.

| **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 Frequency Response ON, Curve 1, APC ON test and confirms the following with NCC: 1. AAP of the WFPS
2. MW output of the WFPS
3. APC is ON
4. APC set-point is [insert 40% of Registered Capacity] MW
5. Frequency Response is ON
6. Frequency Response is in Curve 1
7. Frequency Droop Setting is 4%
 |  | 1. \_\_\_\_ MW
2. \_\_\_\_ MW
3. Status \_\_\_\_
4. \_\_\_\_ MW
5. Status \_\_\_\_
6. Curve \_\_\_\_
7. \_\_\_\_%
 |
| 3 | WFPS replaces the system frequency with a simulated frequency of 50 Hz and waits 3 minutes |  | AAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 4 | WFPS injects a simulated frequency of 49 Hz and waits 3 minutes |  | AAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 5 | WFPS injects a simulated frequency of 49.75 Hz and waits 3 minutes |  | AAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 6 | WFPS injects a simulated frequency of 49.984 Hz and waits 3 minutes |  | AAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 7 | WFPS injects a simulated frequency of 49.985 Hz and waits 3 minutes |  | AAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 8 | WFPS injects a simulated frequency of 50.015 Hz and waits 3 minutes |  | WFPS shall not respondAAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 9 | WFPS injects a simulated frequency of 50.016 Hz and waits 3 minutes |  | AAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 10 | WFPS injects a simulated frequency of 50.25 Hz and waits 3 minutes |  | AAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 11 | WFPS injects a simulated frequency of 50 Hz and waits 1 minute |  | AAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 12 | In co-ordination with NCC, WFPS injects a simulated frequency of 51.9 Hz and waits 3 minutes |  | WFPS shall go to DMOLAAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 13 | WFPS injects a simulated frequency of 52 Hz and waits 3 minutes |  | WFPS shall go to 0 MWAAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 14 | WFPS injects a simulated frequency of 50.21 Hz and waits 3 minutes |  | Output shall remain at 0 MWAAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 15 | WFPS injects a simulated frequency of 50.19 Hz and waits 3 minutes |  | Output shall ramp to APC set-point +ΔMW at maximum possible rateAAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 16 | WFPS injects a simulated frequency of 50 Hz |  | AAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 17 | WFPS requests NCC to issue an APC set-point of [insert 50% of DMOL] MW and waits until APC set-point has been achieved |  | AAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 18 | WFPS injects a simulated frequency of 50.5 Hz and waits 3 minutes |  | WFPS shall not turn off any WTGAAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 19 | WFPS injects a simulated frequency of 49.5 Hz and waits 3 minutes |  | WFPS shall provide response at maximum possible rateAAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 20 | WFPS requests NCC to issue an APC set-point of [insert 40% of Registered Capacity] MW and waits until APC set-point, plus required frequency response, has been achieved |  | AAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 21 | WFPS injects a simulated frequency of 50 Hz and waits until the APC set-point has been achieved |  | AAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 22 | WFPS ends data recording |  |  |
| 23 | WFPS informs NCC that the Frequency Response ON, Curve 1, APC ON test is complete |  |  |

## Frequency Response OFF Curve 1 APC ON

The WFPS demonstrates that the active power output is independent of simulated frequency while in Curve 1 with APC ON.

| **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 Frequency Response OFF, Curve 1, APC ON test and confirms the following with NCC: 1. AAP of the WFPS
2. MW output of the WFPS
3. APC is ON
4. APC set-point is [insert 40% of Registered Capacity] MW
5. Frequency Response is OFF
6. Frequency Response is in Curve 1
7. Frequency Droop Setting is 4%
 |  | 1. \_\_\_\_ MW
2. \_\_\_\_ MW
3. Status \_\_\_\_
4. \_\_\_\_ MW
5. Status \_\_\_\_
6. Curve \_\_\_\_
7. \_\_\_\_%
 |
| 3 | WFPS replaces the system frequency with a simulated frequency of 50 Hz and waits 1 minute |  | AAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 4 | WFPS injects a simulated frequency of 49 Hz and waits 1 minute |  | WFPS shall not respondAAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 5 | WFPS injects a simulated frequency of 51 Hz and waits 1 minute |  | WFPS shall not respondAAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 6 | WFPS injects a simulated frequency of 50 Hz |  | WFPS shall not respondAAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 7 | WFPS ends data recording |  |  |
| 10 | WFPS informs NCC that the Frequency Response OFF, Curve 1, APC ON test is complete |  |  |

## Frequency Response ON, Curve 1, APC OFF

The WFPS demonstrates that the active power output is correctly altered for simulated frequencies, based on the settings issued by the TSO.

| **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 Frequency Response ON, Curve 1, APC OFF test and confirms the following with NCC: 1. AAP of the WFPS
2. MW output of the WFPS
3. APC is OFF
4. Frequency Response is ON
5. Frequency Response is in Curve 1
6. Frequency Droop Setting is 4%
 |  | 1. \_\_\_\_ MW
2. \_\_\_\_ MW
3. Status \_\_\_\_
4. Status \_\_\_\_
5. Curve \_\_\_\_
6. \_\_\_\_%
 |
| 3 | WFPS replaces the system frequency with a simulated frequency of 50 Hz and waits 3 minutes |  | AAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 4 | WFPS injects a simulated frequency of 49.5 Hz and waits 3 minutes |  | WFPS shall not respondAAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 5 | WFPS injects a simulated frequency of 50.2 Hz and waits 3 minutes |  | WFPS shall not respondAAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 6 | WFPS injects a simulated frequency of 50.21 Hz and waits 3 minutes |  | AAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 7 | WFPS injects a simulated frequency of 50.8 Hz and waits 3 minutes |  | AAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 8 | WFPS injects a simulated frequency of 51.9 Hz and waits 3 minutes |  | WFPS shall go to DMOLAAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 9 | WFPS injects a simulated frequency of 52 Hz and waits 3 minutes |  | WFPS shall go to 0 MWAAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 10 | WFPS injects a simulated frequency of 50.21 Hz and waits 3 minutes |  | Output shall remain at 0 MWAAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 11 | WFPS injects a simulated frequency of 50.19 Hz and waits 3 minutes |  | Output shall ramp to AAP at the Wind Following Ramp RateAAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 12 | WFPS injects a simulated frequency of 50 Hz |  | AAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 13 | WFPS ends data recording |  |  |
| 14 | WFPS informs NCC that the Frequency Response ON, Curve 1, APC OFF test is complete |  |  |

## Frequency Response OFF, Curve 1, APC OFF

The WFPS demonstrates that the active power output is independent of simulated frequency while in Curve 1 with APC OFF.

| **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 Frequency Response OFF, Curve 1, APC OFF test and confirms the following with NCC: 1. AAP of the WFPS
2. MW output of the WFPS
3. APC is OFF
4. Frequency Response is OFF
5. Frequency Response is in Curve 1
6. Frequency Droop Setting is 4%
 |  | 1. \_\_\_\_ MW
2. \_\_\_\_ MW
3. Status \_\_\_\_
4. Status \_\_\_\_
5. Curve \_\_\_\_
6. \_\_\_\_%
 |
| 3 | WFPS replaces the system frequency with a simulated frequency of 50 Hz and waits 1 minute |  | AAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 4 | WFPS injects a simulated frequency of 49 Hz and waits 1 minute |  | WFPS shall not respondAAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 5 | WFPS injects a simulated frequency of 51 Hz and waits 1 minute |  | WFPS shall not respondAAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 6 | WFPS injects a simulated frequency of 50 Hz |  | WFPS shall not respondAAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 7 | WFPS ends data recording |  |  |
| 8 | WFPS informs NCC that the Frequency Response OFF, Curve 1, APC OFF test is complete |  |  |

## Frequency Response ON, Curve 2, APC ON

The WFPS demonstrates that the active power output is correctly altered for simulated frequencies, based on the settings issued by the TSO.

| **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 Frequency Response ON, Curve 2, APC ON test and confirms the following with NCC: 1. AAP of the WFPS
2. MW output of the WFPS
3. APC is ON
4. APC Set-point is [insert 40% of Registered Capacity] MW
5. Frequency Response is ON
6. Frequency Response is in Curve 2
7. Frequency Response Setting is 4%
 |  | 1. \_\_\_\_ MW
2. \_\_\_\_ MW
3. Status \_\_\_\_
4. \_\_\_\_ MW
5. Status \_\_\_\_
6. Curve \_\_\_\_
7. \_\_\_\_%
 |
| 3 | WFPS replaces the system frequency with a simulated frequency of 50 Hz and waits 3 minutes |  | AAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 4 | WFPS injects a simulated frequency of 49.3 Hz and waits 3 minutes |  | AAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 5 | WFPS injects a simulated frequency of 49.75 Hz and waits 3 minutes |  | AAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 6 | WFPS injects a simulated frequency of 49.984 Hz and waits 3 minutes |  | AAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 7 | WFPS injects a simulated frequency of 49.985 Hz and waits 3 minutes |  | AAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 8 | WFPS injects a simulated frequency of 50.015 Hz and waits 3 minutes |  | WFPS shall not respondAAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 9 | WFPS injects a simulated frequency of 50.016 Hz and waits 3 minutes |  | AAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 10 | WFPS injects a simulated frequency of 50.25 Hz and waits 3 minutes |  | AAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 11 | WFPS injects a simulated frequency of 50 Hz and waits 1 minute |  | AAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 12 | WFPS injects a simulated frequency of 51.9 Hz and waits 3 minutes |  | WFPS shall go to DMOLAAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 13 | WFPS injects a simulated frequency of 52 Hz and waits 3 minutes |  | WFPS shall go to 0 MWAAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 14 | WFPS injects a simulated frequency of 50.21 Hz and waits 3 minutes |  | Output shall remain at 0 MWAAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 15 | WFPS injects a simulated frequency of 50.19 Hz and waits 3 minutes |  | Output shall ramp to APC set-point +ΔMW at the maximum possible rateAAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 16 | WFPS injects a simulated frequency of 50 Hz and waits until the APC set-point has been achieved |  | AAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 17 | WFPS ends data recording |  |  |
| 18 | WFPS informs NCC that the Frequency Response ON, Curve 2, APC ON test is complete |  |  |

## Frequency Response OFF Curve 2 APC ON

The WFPS demonstrates that the active power output is independent of simulated frequency while in Curve 2 with APC ON.

| **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 Frequency Response OFF, Curve 2, APC ON test and confirms the following with NCC: 1. AAP of the WFPS
2. MW output of the WFPS
3. APC is ON
4. APC set-point is [insert 40% of Registered Capacity] MW
5. Frequency Response is OFF
6. Frequency Response is in Curve 2
7. Frequency Droop Setting
 |  | 1. \_\_\_\_ MW
2. \_\_\_\_ MW
3. Status \_\_\_\_
4. \_\_\_\_ MW
5. Status \_\_\_\_
6. Curve \_\_\_\_
7. \_\_\_\_%
 |
| 3 | WFPS replaces the system frequency with a simulated frequency of 50 Hz and waits 1 minute |  | AAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 4 | WFPS injects a simulated frequency of 49 Hz and waits 1 minute |  | WFPS shall not respondAAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 5 | WFPS injects a simulated frequency of 51 Hz and waits 1 minute |  | WFPS shall not respondAAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 6 | WFPS injects a simulated frequency of 50 Hz |  | WFPS shall not respond AAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 7 | WFPS ends data recording |  |  |
| 8 | WFPS informs NCC that the Frequency Response OFF, Curve 2, APC ON test is complete |  |  |

## Frequency Response ON Curve 2 APC OFF

The WFPS demonstrates that the active power output is correctly altered for simulated frequencies, based on the settings issued by the TSO.

| **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 Frequency Response ON, Curve 2, APC OFF test and confirms the following with NCC: 1. AAP of the WFPS
2. MW output of the WFPS
3. APC is OFF
4. Frequency Response is ON
5. Frequency Response is in Curve 2
6. Frequency Response Setting is 4%
 |  | 1. \_\_\_\_ MW
2. \_\_\_\_ MW
3. Status \_\_\_\_
4. Status \_\_\_\_
5. Curve \_\_\_\_
6. \_\_\_\_%
 |
| 3 | WFPS replaces the system frequency with a simulated frequency of 50 Hz and waits 3 minutes |  | WFPS output = 95% AAPAAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 4 | WFPS injects a simulated frequency of 49.3 Hz and waits 3 minutes |  | WFPS ramps to 100% AAPAAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 5 | WFPS injects a simulated frequency of 50.015 Hz and waits 3 minutes |  | WFPS ramps to 95% AAPAAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 6 | WFPS injects a simulated frequency of 50.016 Hz and waits 3 minutes |  | AAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 7 | WFPS injects a simulated frequency of 50.25 Hz and waits 3 minutes |  | AAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 8 | WFPS injects a simulated frequency of 50.8 Hz and waits 1 minute |  | AAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 10 | WFPS injects a simulated frequency of 51.9 Hz and waits 3 minutes |  | WFPS shall go to DMOLAAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 11 | WFPS injects a simulated frequency of 52 Hz and waits 3 minutes |  | WFPS shall go to 0 MWAAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 12 | WFPS injects a simulated frequency of 50.21 Hz and waits 3 minutes |  | Output shall remain at 0 MWAAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 13 | WFPS injects a simulated frequency of 50.19 Hz and waits 3 minutes |  | Output shall ramp to 95% of AAP at the maximum possible rateAAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 14 | WFPS injects a simulated frequency of 50 Hz |  | AAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 15 | WFPS ends data recording |  |  |
| 16 | WFPS informs NCC that the Frequency Response ON, Curve 2, APC OFF test is complete |  |  |

## Frequency Response OFF, Curve 2, APC OFF

The WFPS demonstrates that the active power output is independent of simulated frequency while in Curve 2 with APC OFF.

| **Step No.** | **Action** | **Time** | **Comments** |
| --- | --- | --- | --- |
| 1 | WFPS begins data recording for all trends noted in Section 7.3. |  | Operator Name \_\_\_\_\_\_\_\_\_\_\_\_Date \_\_\_\_\_\_\_\_\_\_\_\_ |
| 2 | WFPS requests permission from NCC to proceed with the Frequency Response OFF, Curve 2, APC OFF test and confirms the following with NCC: 1. AAP of the WFPS
2. MW output of the WFPS
3. APC is OFF
4. Frequency Response is OFF
5. Frequency Response is in Curve 2
6. Frequency Droop Setting is 4%
 |  | 1. \_\_\_\_ MW
2. \_\_\_\_ MW
3. Status \_\_\_\_
4. Status \_\_\_\_
5. Curve \_\_\_\_
6. \_\_\_\_%
 |
| 3 | WFPS replaces the system frequency with a simulated frequency of 50 Hz and waits 1 minute |  | AAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 4 | WFPS injects a simulated frequency of 49 Hz and waits 1 minute |  | WFPS shall not respondAAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 5 | WFPS injects a simulated frequency of 51 Hz and waits 1 minute |  | WFPS shall not respondAAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 6 | WFPS injects a simulated frequency of 50 Hz |  | WFPS shall not respondAAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 7 | WFPS ends data recording |  |  |
| 8 | WFPS informs NCC that the Frequency Response OFF, Curve 2, APC Off test is complete |  |  |

## DMOL Test

The WFPS demonstrates that the WFPS responds correctly to frequency deviations at its declared DMOL.

| **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 DMOL test and confirms the following with NCC: 1. AAP of the WFPS
2. MW output of the WFPS
3. APC is ON
4. APC Set-point is [insert DMOL] MW
5. Frequency Response is ON
6. Frequency Response is in Curve 1
7. Frequency Response Setting is 4%
 |  | 1. \_\_\_\_ MW
2. \_\_\_\_ MW
3. Status \_\_\_\_
4. \_\_\_\_ MW
5. Status \_\_\_\_
6. Curve \_\_\_\_
7. \_\_\_\_%
 |
| 3 | WFPS injects a simulated frequency of 50.02 Hz  |  | WFPS shall not respondAAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 4 | WFPS requests NCC to issue an APC set-point of [insert 100% of Registered Capacity] MW without turning APC off, and waits until exported power has increased to meet AAP. |  | WFPS shall ramp to AAP at the maximum possible rateAAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 5 | WFPS injects a simulated frequency of 50 Hz |  |  |
| 6 | WFPS ends data recording |  |  |
| 7 | WFPS informs NCC that DMOL test is complete |  |  |

## Frequency Response Ramp Rate Priority in Curve 1

The WFPS demonstrates that ramp rates are prioritised and adhered to correctly during frequency response and also that response to set-points is not inhibited by latched Active Power Output.

| **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 Ramp Rates Settings Curve 1 test and confirms the following with NCC: 1. AAP of the WFPS
2. MW output of the WFPS
3. APC is ON
4. APC Set-point
5. Frequency Response is ON
6. Frequency Response is in Curve 1
7. Frequency Response Setting is 4%
 |  | 1. \_\_\_\_ MW
2. \_\_\_\_ MW
3. Status \_\_\_\_
4. \_\_\_\_ MW
5. Status \_\_\_\_
6. Curve \_\_\_\_
7. \_\_\_\_%
 |
| 3 | WFPS requests NCC to issue an APC set-point of [insert DMOL] MW. While the WFPS is ramping, WFPS injects a simulated frequency of 50.02 Hz and waits until exported power has decreased to meet DMOL.  |  | AAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 4 | WFPS injects a simulated frequency of 50 Hz. |  | AAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 5 | WFPS requests NCC to issue an APC set-point of [insert 100% of Registered Capacity] MW. While the WFPS is ramping, WFPS injects a simulated frequency of 50.02 Hz and waits until exported power has increased to meet AAP. |  | AAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 6 | WFPS injects a simulated frequency of 50 Hz |  |  |
| 7 | WFPS requests NCC to issue an APC set-point of [insert DMOL] MW and waits until exported power has decreased to meet DMOL |  | AAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 8 | WFPS requests NCC to issue an APC set-point of [insert 100% of Registered Capacity] MW and turn APC OFF. While the WFPS is ramping, WFPS injects a simulated frequency of 50.21 Hz and waits until exported power has increased to meet AAP |  | AAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 9 | WFPS injects a simulated frequency of 50 Hz. |  | AAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 10 | WFPS ends data recording |  |  |
| 11 | WFPS informs NCC that the Ramp Rate Settings Curve 1 test is complete |  |  |

## Frequency Response Ramp Rate Priority in Curve 2

The WFPS demonstrates that ramp rates are prioritised and adhered to correctly during frequency response and also that response to set-points is not inhibited by latched Active Power Output.

| **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 Ramp Rates Settings Curve 2 and confirms the following with NCC: 1. AAP of the WFPS
2. MW output of the WFPS
3. APC is ON
4. APC Set-point
5. Frequency Response is ON
6. Frequency Response is in Curve 2
7. Frequency Response Setting is 4%
 |  | 1. \_\_\_\_ MW
2. \_\_\_\_ MW
3. Status \_\_\_\_
4. \_\_\_\_ MW
5. Status \_\_\_\_
6. Curve \_\_\_\_
7. \_\_\_\_%
 |
| 3 | WFPS requests NCC to issue an APC set-point of [insert DMOL] MW. While WFPS is ramping, WFPS injects a simulated frequency of 49.98 Hz and waits until exported power has decreased to meet DMOL.  |  | AAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 4 | WFPS injects a simulated frequency of 50 Hz. |  | AAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 5 | WFPS requests NCC to issue an APC set-point of [insert 100% of Registered Capacity] MW. While WFPS is ramping, WFPS injects a simulated frequency of 49.98 Hz and waits until exported power has increased to meet AAP. |  | AAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 6 | WFPS injects a simulated frequency of 50 Hz |  |  |
| 7 | WFPS requests NCC to issue an APC set-point of [insert DMOL] MW and waits until exported power has decreased to meet DMOL |  |  |
| 8 | WFPS requests NCC to issue an APC set-point of [insert 100% of Registered Capacity] MW and turn APC OFF. While WFPS is ramping, WFPS injects a simulated frequency of 49.98 Hz and waits until exported power has increased to meet AAP |  | AAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 9 | WFPS injects a simulated frequency of 50 Hz. |  | AAP = \_\_\_\_ MW MW Output = \_\_\_\_ MW |
| 10 | WFPS ends data recording |  |  |
| 11 | WFPS informs NCC that the Ramp Rate Settings Curve 2 test is complete |  |  |

## Return to Standard Settings

The WFPS settings are returned to standard following completion of the Frequency Response Test.

|  |  |  |  |
| --- | --- | --- | --- |
| **Step No.** | **Action** | **Time** | **Comments** |
| 1 | WFPS removes the simulated frequency, returning the WFCS reference to system frequency |  | Operator Name \_\_\_\_\_\_\_\_\_\_\_\_Date \_\_\_\_\_\_\_\_\_\_\_\_ |
| 2 | WFPS confirms the following with NCC: 1. AAP of the WFPS
2. MW output of the WFPS
3. APC is OFF
4. APC Set-point = [insert 100% of Registered Capacity] MW
5. Frequency Response is ON
6. Frequency Response is in Curve 1
7. Frequency Droop Setting is 4%
8. WFCS frequency reference is system frequency
 |  | 1. \_\_\_\_ MW
2. \_\_\_\_ MW
3. Status \_\_\_\_
4. \_\_\_\_ MW
5. Status \_\_\_\_
6. Curve \_\_\_\_
7. \_\_\_\_%
8. Frequency Reference \_\_\_\_\_\_\_\_\_\_
 |
| 3 | WFPS informs NCC that Frequency Response testing is complete |  |  |

## 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-2)