EIRGRID_2015 Functional Document Template (21

RfG

PPM Reactive Power Control Test Procedure

[Insert Power Park Module Name]

Version 0.1

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# IPP TEST PROCEDURE VERSION History

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

# Introduction

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

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

All yellow sections shall be filled in before the test procedure 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 PPM with a single connection point, this may impact on the test procedure outlined below.

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

PPM Power park Module

PPMCS Power Park Module Control System

PF Power Factor

TSO Transmission System Operator

WFCS Power park module Control System

WFPS Power park module Power Station

WTG Power park module Generator

Leading Mvar Absorbing Mvar from System

Lagging Mvar Producing Mvar

# PPM DATA

|  |  |
| --- | --- |
| PPM Name | PPM to Specify  (name per connection agreement) |
| PPM Test Co-Ordinator and contact number: | PPM to Specify |
| PPM Location | PPM to Specify |
| Associated 110 kV Station | PPM to Specify |
| PPM connection point | PPM to Specify  (*i.e.* T121 in XXX Transmission Station) |
| PPM connection voltage | PPM to Specify |
| Installed Generator type, MW size and quantity | PPM to Specify |
| Contracted MEC | PPM to Specify |
| Registered Capacity | PPM to Specify |
| Limiter applied to Exported MW | PPM to Specify |
| Limiter applied to AAP | PPM to Specify |
| Minimum Leading Mvar requirement at the connection point above 12% Active Power Output per Grid Code *Figure PPM1.4* | PPM to Specify |
| Minimum Lagging Mvar requirement at the connection point above 12% Active Power Output per Grid Code *Figure PPM1.4* | PPM to Specify |
| Maximum Leading Mvar at connection point | PPM to Specify |
| Maximum Lagging Mvar at connection point | PPM to Specify |
| Grid Connected Transformer Tap range | PPM 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 PPM 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 PPM1.4 of Grid Code* 2. Maximum capability of the PPM 3. Breakdown of reactive power devices e.g. generators or STATCOM | 1. Yes / No 2. Yes / No 3. Yes / No |
| Any further information | PPM 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 generators will not be accepted. | |

PPM shall Insert PQ chart

# Grid Code References

|  |  |
| --- | --- |
| Grid Code Version: | PPM 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 PPM** 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 PPM1.4. |

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**.

**PPM1.6.2 AUTOMATIC VOLTAGE REGULATION**

PPM1.6.2.1 **Controllable PPMs** 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.

PPM1.6.2.2 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 PPM** shall be capable of receiving a **Power Factor** control (PF) set-point to maintain the **Power Factor** set-point at the **Connection Point;**

The **Controllable PPM** shall be capable of controlling the **Reactive Power**  at least within the **Reactive Power** ranges specified in PPM1.6.3, with setting steps of no greater than 0.01 p.u.. The **Power Factor** shall be maintained within a tolerance of ± 0.5 %. The tolerance will be measured with reference to the maximum **Reactive Power** at the **Connection Point.**

1. The **Controllable PPM** shall be capable of receiving a **Reactive Power** control (Q) set-point to maintain the **Reactive Power** set-point at the **Connection Point**;

The **Controllable PPM** shall be capable of setting the **Reactive Power** set-point at least within the **Reactive Power** range specified in PPM1.6.3, with setting steps no greater than 5 Mvar or 5 % (whichever is smaller) of maximum **Reactive Power**, controlling the **Reactive Power** at the connection point to an accuracy within ± 5 Mvar or ± 5 % (whichever is smaller) of the maximum **Reactive Power**;

1. The **Controllable PPM** 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 PPM’s Reactive Power** output, without violating the rapid **Voltage** changelimits as set out in CC.10.13.1. **PPM**

The **Controllable PPM** shall be capable of contributing to voltage control at the **Connection Point** by provision of **Reactive Power** exchange with the **Transmission System** with a **Voltage Regulation Set-point** covering 0.95 to 1.05 p.u. in steps no greater than 0.01 p.u.. The **Reactive Power** output shall be zero when the grid voltage value at the connection point equals the **Voltage Regulation Set-point**.

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 PPM** shall achieve 90 % of its steady-state **Reactive Power** response within 1 second. The **Reactive Power** must settle at the steady-state **Reactive Power** response within 5 seconds, with a steady-state **Reactive Power** tolerance no greater than 5 % of the maximum **Reactive Power**.

Subject to agreement with TSO, the **Voltage Regulation Set-point** may be operated with or without a deadband selectable in a range from zero to ±5% of reference 1 p.u **Transmission System** voltage in steps no greater than 0.5%.

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 PPM** within 20 seconds of receipt of the appropriate signal from the **TSO,** within its reactive power capability range as specified in PPM1.6.3.

PPM1.6.2.3 The **Voltage Regulation** **System** **Slope Setting** shall be capable of being set to any value between 2 % and 7 % in steps no greater than 0.5% The setting shall be specified by the **TSO** at least 120 **Business Days** prior to the **Controllable PPM’s** scheduled **Operational Date.** The **Controllable PPM** 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 PPM** a minimum of two weeks notice if a change is required. The **Controllable PPM** shall formally confirm that any requested changes have been implemented within two weeks of receiving the **TSO’s** formal request.

PPM1.6.2.4 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 PPM** 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.

*PPM*PPM1.6.3.1**Controllable PPMs** 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 PPM1.4,* as measured at the **Connection Point** over the normal and disturbed **Transmission System Voltage** ranges specified in CC.8.3.2; subject to the exception in PPM1.6.3.2, where additional Reactive Power compensation may be utilised to compensate for the Reactive Power demand of the connection between the Connection Point and the Controllable PPM.

Referring to *Figure PPM1.4:*

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

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

Point C represents the minimum Mvar absorption capability of the **Controllable PPM** 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 PPM** 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 PPM** at the cut-in speed of the individual Generation Units;

Point F represents the minimum Mvar production capability of the **Controllable PPM** at the cut-in speed of the individual Generation Units;

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

*Figure PPM1.4* represents the minimum expected **Reactive Power** capabilities of the **Controllable PPM**. The **Controllable PPM** 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.**

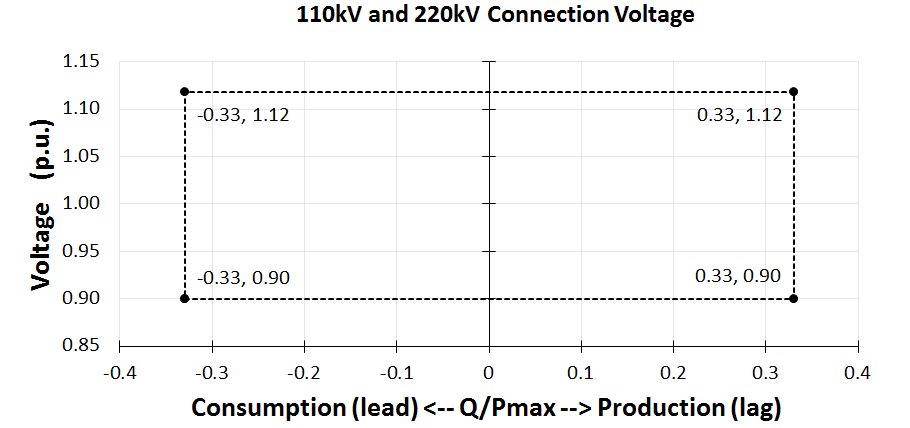
The **Grid Connected Transformer** tap changing range must be capable of ensuring nominal voltage at point Y for any **Voltage** at the **Connection Point** (Point Z) within the ranges specified in PPM1.6.1.

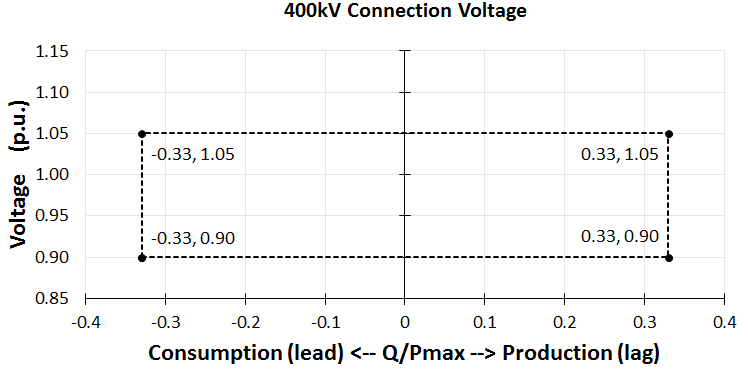


*Figure PPM1.4 –* Minimum**Reactive Power** Capability of **Controllable PPM**

*Figure PPM1.4* represents the minimum expected **Reactive Power** capabilities of the **Controllable PPM**. The **Controllable PPM** 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.**

PPM1.6.3.4Without prejudice to PPM1.6.3.1, **Controllable PPMs** shall comply with the following **Reactive Power** requirements at **Registered Capacity** at the **Connection Point**;





In the event of power oscillations, **Controllable PPMs** shall retain steady-state stability when operating at any operating point of the **Reactive Power** capability.

# site Safety requirements

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

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

# 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** |
| PPM 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 |
| PPM regulates its reactive power at the point of connection correctly based on the voltage slope setting, system voltage and kV set-point |
| Demonstration that the Voltage Regulation System Slope Setting can be set between 2% and 7% |
| Voltage Regulation System responds to a step change in voltage at the connection point, it achieves 90% of its steady-state response within 1 second |
| **Mvar Control** |
| PPM 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 |
| PPM maintains the Mvar set-point at the connection point |
| **Power Factor Control** |
| PPM 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 |
| PPM 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 PPM 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 resource in MW, derived by algorithm in the PPMCS (*Figure PPM1.3, Point Y* *– preferably point Z* *if available*) | PPM to Specify (≥10 Hz) | Yes / No |
| 2 | Actual active power from the power park module in MW (*Figure PPM1.3, Point Y – preferably point Z* *if available*) | PPM to Specify (≥10 Hz) | Yes / No |
| 3 | Power park module voltage measured at the lower voltage side of the grid connected transformer (*Figure PPM1.3, Point Y)* | PPM to Specify (≥10 Hz) | Yes / No |
| 4 | Grid voltage measured at the connection point (*Figure PPM1.3, Point Z*) | PPM to Specify (≥10 Hz) | Yes / No |
| 5 | Reactive power measured at the lower voltage side of the grid connected transformer, (*Figure PPM1.3, Point Y*) | PPM to Specify (≥10 Hz) | Yes / No |
| 6 | Reactive power measured at the connection point (*Figure PPM1.3, Point Z*) | PPM to Specify (≥10 Hz) | Yes / No |
| 7 | Grid transformer tap position | PPM to Specify (≥10 Hz) | Yes / No |
| 8 | AVR (kV) set-point (*Figure PPM1.3, Point Z*) | PPM to Specify (≥10 Hz) | Yes / No |
| 9 | Mvar set-point (*Figure PPM1.3, Point Z*) | PPM to Specify (≥10 Hz) | Yes / No |
| 9 | PF set-point (*Figure PPM1.3, Point Z*) | PPM 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 PPM is not producing 0 Mvar, this test may not proceed.

| **Conditions** | **Check on day of test** |
| --- | --- |
| All Generation Unitss are available | # generators installed: \_\_\_\_  # generators generating: \_\_\_\_ |
| Generated MW > 60% of Registered Capacity | Generated MW: \_\_\_\_ |
| Ensure the PPM 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  (PPM to specify calculation and formula used) |
| 1kV change in set-point with Voltage Regulation System slope of 4% | \_\_\_\_ Mvar  (PPM to specify calculation and formula used) |
| 2kV change in set-point with Voltage Regulation System slope of 7% | \_\_\_\_ Mvar  (PPM to specify calculation and formula used) |
| Mvar for PF set-point of +8 degrees at 30% of Registered Capacity (PPM shall be exporting Mvars) | \_\_\_\_ Mvar  (PPM to specify calculation and formula used) |
| Mvar for PF set-point of -12 degrees at 50% of Registered Capacity (PPM shall be importing Mvars) | \_\_\_\_ Mvar  (PPM 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 | PPM begins data recording for all trends noted in Section 7.3, above |  | Operator Name \_\_\_\_\_\_\_\_\_\_\_\_  Date \_\_\_\_\_\_\_\_\_\_\_\_ |
| 2 | PPM 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 PPM 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 | PPM requests NCC to increase the voltage set-point by 0.5 kV and waits 1 minute |  | PPM shall export a small amount of Mvar  +\_\_\_\_ Mvar  \_\_\_\_ kV |
| 4 | PPM requests NCC to issue a Mvar set-point of -1 Mvar |  | Mvar output shall not be affected |
| 5 | PPM requests NCC to select Mvar (Q) control mode and waits 1 minute |  | Mvar output shall not be affected  +\_\_\_\_ Mvar  \_\_\_\_ kV |
| 6 | PPM requests NCC to issue a Mvar set-point of [insert 10% of lagging Mvar capability] Mvar and waits 1 minute |  | PPM shall regulate to new Mvar set-point  +\_\_\_\_ Mvar  \_\_\_\_ kV |
| 7 | PPM requests NCC to issue a PF set-point of 0 degrees |  | Mvar output shall not be affected |
| 8 | PPM requests NCC to select Power Factor control mode and waits 1 minute |  | Mvar output shall not be affected  +\_\_\_\_ Mvar  \_\_\_\_ kV |
| 9 | PPM 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 |  | PPM shall regulate to new PF set-point  +\_\_\_\_ Mvar  \_\_\_\_ kV |
| 10 | PPM requests NCC to select AVR control mode and waits 1 minute |  | Mvar output shall not be affected  +\_\_\_\_ Mvar  \_\_\_\_ kV |
| 11 | PPM requests NCC to issue a kV set-point 1 kV lower than system voltage at the connection point |  | PPM shall regulate to new kV set-point (import Mvar)  -\_\_\_\_ Mvar  \_\_\_\_ kV |
| 12 | PPM requests NCC to select Power Factor control mode and waits 1 minute |  | Mvar output shall not be affected  -\_\_\_\_ Mvar  \_\_\_\_ kV |
| 13 | PPM 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 |  | PPM shall regulate to new PF set-point  -\_\_\_\_ Mvar  \_\_\_\_ kV |
| 14 | PPM requests NCC to select Mvar (Q) control mode and waits 1 minute |  | Mvar output shall not be affected  -\_\_\_\_ Mvar  \_\_\_\_ kV |
| 15 | PPM requests NCC to issue a Mvar set-point of [insert 15% of leading Mvar capability] Mvar and waits 1 minute |  | PPM shall regulate to new Mvar set-point  -\_\_\_\_ Mvar  \_\_\_\_ kV |
| 16 | PPM requests NCC to select AVR control mode and waits 1 minute |  | Mvar output shall not be affected  -\_\_\_\_ Mvar  \_\_\_\_ kV |
| 17 | PPM 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 PPM is producing approximately 0 Mvar at the connection point |  | +/-\_\_\_\_ Mvar  \_\_\_\_ kV |
| 19 | PPM 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 | PPM ends data recording |  |  |
| 21 | PPM 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 PPM to correctly calculate and maintain these set-points.

| **Step No.** | **Action** | **Time** | **Comments** |
| --- | --- | --- | --- |
| 1 | PPM begins data recording for all trends noted in Section 7.3, above |  | Operator Name \_\_\_\_\_\_\_\_\_\_\_\_  Date \_\_\_\_\_\_\_\_\_\_\_\_ |
| 2 | PPM requests permission from NCC to proceed with the AVR Mode test and confirms the following with NCC:   1. MW output of the PPM 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 | PPM 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 [PPM to calculate per section 7.5] Mvar change in output 3. Current Mvar output of PPM |  | 1. \_\_\_\_%. 2. \_\_\_\_ Mvar 3. \_\_\_\_ Mvar |
| 4 | PPM requests NCC to increase the voltage set-point by 0.5 kV and waits 1 minute |  | PPM shall export Mvar according to 2% droop  +\_\_\_\_ Mvar  \_\_\_\_ kV |
| 5 | PPM 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 | PPM confirms with NCC that PPM Mvar output is approximately 0 Mvar at the connection point. If not, PPM requests NCC to issue a voltage set-point to achieve approximately 0 Mvar |  | +\_\_\_\_ Mvar  \_\_\_\_ kV |
| 7 | PPM sets the Voltage Regulation System slope to 7% confirms the following to NCC:   1. Voltage Slope is now 7% 2. 2 kV change in voltage set-point will cause [PPM to calculate per section 7.5] Mvar change in output 3. Current Mvar output of PPM |  | 1. \_\_\_\_%. 2. \_\_\_\_ Mvar 3. \_\_\_\_ Mvar |
| 8 | PPM requests NCC to decrease the voltage set-point by 2 kV and waits 1 minute |  | PPM shall import Mvar according to 7% droop  -\_\_\_\_ Mvar  \_\_\_\_ kV |
| 9 | PPM requests NCC to increase the voltage set-point by 2 kV and waits 1 minute |  | Mvar output shall be at 0 Mvar  +/-\_\_\_\_ Mvar |
| 10 | PPM confirms with NCC that PPM Mvar output is approximately 0 Mvar at the connection point. If not, PPM requests NCC to issue a voltage set-point to achieve approximately 0 Mvar |  | \_\_\_\_ Mvar  \_\_\_\_ kV |
| 11 | PPM 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 [PPM to calculate per section 7.5] Mvar change in output 3. Current Mvar output of PPM |  | 1. \_\_\_\_%. 2. \_\_\_\_ Mvar 3. \_\_\_\_ Mvar |
| 12 | PPM requests NCC to increase the voltage set-point by 1 kV and waits 1 minute |  | PPM shall export Mvar according to 4% droop  +\_\_\_\_ Mvar  \_\_\_\_ kV |
| 13 | PPM requests NCC to increase the voltage set-point by 0.5 kV and waits 1 minute |  | PPM shall export Mvar according to 4% droop  +\_\_\_\_ Mvar  \_\_\_\_ kV |
| 14 | PPM requests NCC to decrease the voltage set-point by 1 kV and waits 1 minute |  | PPM shall export Mvar according to 4% droop  +\_\_\_\_ Mvar  \_\_\_\_ kV |
| 15 | PPM 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 | PPM requests NCC to decrease the voltage set-point by 1 kV and waits 1 minute |  | PPM shall import Mvar according to 4% droop  -\_\_\_\_ Mvar  \_\_\_\_ kV |
| 17 | PPM requests NCC to decrease the voltage set-point by 0.5 kV and waits 1 minute |  | PPM shall import Mvar according to 4% droop  -\_\_\_\_ Mvar  \_\_\_\_ kV |
| 19 | PPM requests NCC to increase the voltage set-point by 1 kV and waits 1 minute |  | PPM shall import Mvar according to 4% droop  -\_\_\_\_ Mvar  \_\_\_\_ kV |
| 20 | PPM 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 | PPM confirms with NCC that PPM Mvar output is approximately 0 Mvar at the connection point. If not, PPM 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 | PPM ends data recording |  |  |
| 23 | PPM 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 PPM shall carry out a manual tap change to induce a small step change in system voltage.

| **Step No.** | **Action** | **Time** | **Comments** |
| --- | --- | --- | --- |
| 1 | PPM begins data recording for all trends noted in Section 7.3, above |  | Operator Name \_\_\_\_\_\_\_\_\_\_\_\_  Date \_\_\_\_\_\_\_\_\_\_\_\_ |
| 2 | PPM 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 PPM 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 | PPM requests NCC to induce a step change in system voltage by carrying out transformer tapping or carrying out switching on the system, if possible. |  | PPM shall respond to the change at a rate of 90% in 1 second. |
| 4 | PPM ends data recording |  |  |
| 5 | PPM 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 | PPM requests permission from NCC and puts the on-load tap changer into manual mode |  |  |
| 7 | PPM requests permission from NCC and taps the transformer up 1 tap and waits 1 minute |  | +\_\_\_\_ Mvar  \_\_\_\_ kV |
| 8 | PPM requests permission from NCC, PPM taps the transformer up 1 tap and waits 1 minute |  | +\_\_\_\_ Mvar  \_\_\_\_ kV |
| 9 | PPM requests permission from NCC, PPM taps the transformer down 1 tap and waits 1 minute |  | -\_\_\_\_ Mvar  \_\_\_\_ kV |
| 10 | PPM requests permission from NCC, PPM taps the transformer down 1 tap and waits 1 minute |  | -\_\_\_\_ Mvar  \_\_\_\_ kV |
| 11 | PPM requests permission from NCC, puts the on-load tap changer into automatic mode and confirms to NCC |  |  |
| 12 | PPM confirms with NCC that the PPM is at approximately 0 Mvar at the connection point |  | Mvar output shall be at 0 Mvar  +/-\_\_\_\_ Mvar |
| 13 | PPM ends data recording |  |  |
| 14 | PPM 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 PPM to maintain these set-points.

| **Step No.** | **Action** | **Time** | **Comments** |
| --- | --- | --- | --- |
| 1 | PPM begins data recording for all trends noted in Section 7.3, above |  | Operator Name \_\_\_\_\_\_\_\_\_\_\_\_  Date \_\_\_\_\_\_\_\_\_\_\_\_ |
| 2 | PPM 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 PPM 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 | PPM requests NCC to issue a set-point of [insert 25% of lagging Mvar capability] Mvar and waits 1 minute |  | +\_\_\_\_ Mvar  \_\_\_\_ kV |
| 4 | PPM requests NCC to issue a set-point of [insert 60% of lagging Mvar capability] Mvar and waits 1 minute |  | +\_\_\_\_ Mvar  \_\_\_\_ kV |
| 5 | PPM requests NCC to issue a set-point of [insert 10% of lagging Mvar capability] Mvar and waits 1 minute |  | +\_\_\_\_ Mvar  \_\_\_\_ kV |
| 6 | PPM requests NCC to issue a set-point of 0 Mvar and waits 1 minute |  | Mvar output shall be at 0 Mvar  +/-\_\_\_\_ Mvar |
| 7 | PPM requests NCC to issue a set-point of [insert 25% of leading Mvar capability] Mvar and waits 1 minute |  | -\_\_\_\_ Mvar  \_\_\_\_ kV |
| 8 | PPM requests NCC to issue a set-point of [insert 60% of leading Mvar capability] Mvar and waits 1 minute |  | -\_\_\_\_ Mvar  \_\_\_\_ kV |
| 9 | PPM requests NCC to issue a set-point of [insert 10% of leading Mvar capability] Mvar and waits 1 minute |  | -\_\_\_\_ Mvar  \_\_\_\_ kV |
| 10 | PPM requests NCC to issue a set-point of 0 Mvar and waits 1 minute |  | Mvar output shall be at 0 Mvar  +/-\_\_\_\_ Mvar |
| 11 | PPM confirms with NCC that the PPM is at approximately 0 Mvar at the connection point |  | Mvar output shall be at 0 Mvar  +/-\_\_\_\_ Mvar |
| 12 | PPM ends data recording |  |  |
| 13 | PPM 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 PPM to correctly calculate and maintain these set-points.

| **Step No.** | **Action** | **Time** | **Comments** |
| --- | --- | --- | --- |
| 1 | PPM begins data recording for all trends noted in Section 7.3, above |  | Operator Name \_\_\_\_\_\_\_\_\_\_\_\_  Date \_\_\_\_\_\_\_\_\_\_\_\_ |
| 2 | PPM 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 PPM 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 | PPM 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 | PPM 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 | PPM requests NCC to turn APC ON |  | Status \_\_\_\_ |
| 6 | PPM 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 | PPM 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 | PPM requests NCC to issue a PF set-point of 0 degrees and waits 1 minute |  | Mvar output shall be at 0 Mvar  +/-\_\_\_\_ Mvar |
| 9 | PPM 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 | PPM 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 | PPM 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 | PPM requests NCC to turn Active Power Control OFF and turn |  | Status \_\_\_\_ |
| 13 | PPM 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 | PPM requests NCC to issue a PF set-point of 0 degrees and waits 1 minute |  | Mvar output shall be at 0 Mvar  +/-\_\_\_\_ Mvar |
| 15 | PPM requests NCC to select AVR control mode |  | Mode \_\_\_\_ |
| 16 | PPM confirms with NCC that the PPM is at approximately 0 Mvar at the connection point |  | Mvar output shall be at 0 Mvar  +/-\_\_\_\_ Mvar |
| 17 | PPM ends data recording |  |  |
| 18 | PPM informs NCC that the Power Factor Control Mode test is complete |  |  |

## Return to Standard Settings

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

|  |  |  |  |
| --- | --- | --- | --- |
| **Step No.** | **Action** | **Time** | **Comments** |
| 1 | PPM informs NCC that Reactive Power Control Testing is complete and confirms the following the following:   1. MW output of the PPM 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:** |
| PPM 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)