

RfG

PPM Reactive Power Capability 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 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 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.

|  |  |
| --- | --- |
| **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 Sytem

PF Power Factor

TSO Transmission System Operator

WFCS Wind Farm Control System

WFPS Wind Farm Power Station

WTG Wind Turbine Generator

Leading Mvar Absorbing Mvar from System

Lagging Mvar Producing Mvar

# 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 (Importing) at the connection point above 12% Active Power Output per Grid Code *Figure PPM1.4* | PPM to Specify  |
| Minimum Lagging Mvar requirement (Exporting) 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 shall be site specific.
2. Generic PQ charts of generators are not 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.  |

PPMPPM1.6.3.1**Controllable PPMPPMs** 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 PPMPPM1.4,* 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 PPMPPM** at 100% **Registered Capacity** and is equivalent to 0.95 power factor leading;

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

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

Point F represents the minimum Mvar production capability of the **Controllable PPMPPM** 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 PPMPPM1.4* represents the minimum expected **Reactive Power** capabilities of the **Controllable PPMPPM**. The **Controllable PPMPPM** 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 PPMPPM1.6.1.

*Figure PPMPPM1.4 –* Minimum**Reactive Power** Capability of **Controllable PPMPPM**

*Figure PPMPPM1.4* represents the minimum expected **Reactive Power** capabilities of the **Controllable PPMPPM**. The **Controllable PPMPPM** 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.**

PPM1.6.3.4 Without 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 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, 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 demonstrate the limits of the PPM reactive power capability curve at the connection point. The test is undertaken at various load levels for both the export of reactive power from the PPM and for the import of reactive power to the PPM.

## Pass Criteria

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

| **Criteria** |
| --- |
| **Reactive Power Capability** |
| Demonstration that the measured P-Q capability is in line with the submitted P-Q capability diagram |
| Demonstration that the measured P-Q capability meets or exceeds the minimum expected reactive power capabilities of the controllable PPM, as defined in Grid Code *Figure PPM1.4,* as measured at the Connection Point |

## 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 shall 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 Y – preferably point Z if available*) | 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 Units are available | # generators installed: \_\_\_\_# generators generating: \_\_\_\_ |
| Generated MW > 60% of Registered Capacity | Generated MW: \_\_\_\_ |
| Grid Connected Transformer Tap range | Tap range: \_\_\_\_ to \_\_\_\_ |
| Size of Mvar step changes agreed with NCC Transmission Desk (*e.g.* 5 Mvar) | \_\_\_\_ Mvar |

## Mvar changes and calculations

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

# Test Steps

## Reactive Power Capability (Importing / Leading Mvar)

The PPM is brought from 0 Mvar at full output to maximum leading Mvar. Once at maximum leading Mvar, the active power is reduced in steps from max output to 0 MW. Reactive Power set-point is changed to require 0 Mvar response, before the PPM is released from 0 MW to max output.

| **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 Reactive Power Capability (Inductive / Leading Mvar) test and confirms the following with NCC: 1. MW output of the PPM
2. APC is OFF
3. Frequency Response is OFF
4. Mvar (Q) control mode is ON
5. The transformer tap position
6. On Load Tap Changer Mode
7. System Voltage
8. Maximum leading Mvar capability of the PPM
9. Mvar Export at the connection point
 |  | 1. \_\_\_\_ MW
2. Status \_\_\_\_
3. Status \_\_\_\_
4. \_\_\_\_ Mode
5. Tap # \_\_\_\_
6. \_\_\_\_ Mode
7. \_\_\_\_ kV
8. \_\_\_\_ Mvar
9. \_\_\_\_ Mvar
 |
| 3 | PPM requests NCC to decrease the Mvar set-point in steps as agreed in section 7.4 until the power park module has reached its maximum leading Mvar limit at the connection point |  | \_\_\_\_ Mvar\_\_\_\_ kV |
| 4 | PPM requests NCC to reduce the Mvar set-point by a further step |  | PPM shall remain at maximum lagging Mvar\_\_\_\_ Mvar\_\_\_\_ kV |
| 5 | PPM requests NCC to turn APC ON and issue a set-point of [insert 90% of Registered Capacity] MW and waits until 1 minute after the set-point has been achieved |  | \_\_\_\_ MW\_\_\_\_ Mvar |
| 6 | PPM requests NCC to issue a set-point of [insert 80% of Registered Capacity] MW and waits until 1 minute after the set-point has been achieved |  | \_\_\_\_ MW\_\_\_\_ Mvar |
| 7 | PPM requests NCC to issue a set-point of [insert 70% of Registered Capacity] MW and waits until 1 minute after the set-point has been achieved |  | \_\_\_\_ MW\_\_\_\_ Mvar |
| 8 | PPM requests NCC to issue a set-point of [insert 60% of Registered Capacity] MW and waits until 1 minute after the set-point has been achieved |  | \_\_\_\_ MW\_\_\_\_ Mvar |
| 9 | PPM requests NCC to issue a set-point of [insert 50% of Registered Capacity] MW and waits until 1 minute after the set-point has been achieved |  | \_\_\_\_ MW\_\_\_\_ Mvar |
| 10 | PPM requests NCC to issue a set-point of [insert 40% of Registered Capacity] MW and waits until 1 minute after the set-point has been achieved |  | \_\_\_\_ MW\_\_\_\_ Mvar |
| 11 | PPM requests NCC to issue a set-point of [insert 30% of Registered Capacity] MW and waits until 1 minute after the set-point has been achieved |  | \_\_\_\_ MW\_\_\_\_ Mvar |
| 12 | PPM requests NCC to issue a set-point of [insert 20% of Registered Capacity] MW and waits until 1 minute after the set-point has been achieved |  | \_\_\_\_ MW\_\_\_\_ Mvar |
|  | **In the following steps, reduction in MW output may cause a change in Mvar. Insert additional MW steps as appropriate to limit the resulting step change to ±5 Mvar. Refer to P-Q chart on p6.** |  |
| 13 | PPM requests NCC to issue a set-point of [insert 12% of Registered Capacity] MW and waits until 1 minute after the set-point has been achieved |  | \_\_\_\_ MW\_\_\_\_ Mvar |
| 14 | PPM requests NCC to issue a set-point of [insert 6% of Registered Capacity] MW and waits until 1 minute after the set-point has been achieved |  | \_\_\_\_ MW\_\_\_\_ Mvar |
| 15 | PPM requests NCC to issue a set-point of 0 MW and waits until 1 minutes after the set-point has been achieved |  | \_\_\_\_ MW\_\_\_\_ Mvar |
| 16 | PPM requests NCC to increase the Mvar set-point in steps as agreed in section 7.4 until the PPM is exporting 0 Mvar at the connection point |  | Mvar output shall be at 0 Mvar\_\_\_\_ Mvar |
| 17 | PPM requests NCC to issue a set-point of [insert 100% of Registered Capacity] MW and turn APC OFF and waits until 1 minute after AAP has been achieved |  |  |
| 18 | PPM ends data recording |  |  |
| 19 | PPM informs NCC that the Reactive Power Capability (Inductive / Leading Mvar) test is complete |  |  |

## Reactive Power Capability (Exporting / Lagging Mvar)

The PPM is brought from 0 Mvar at full output to maximum lagging Mvar. Once at maximum lagging Mvar, the active power is reduced in steps from max output to 0 MW. Reactive Power set-point is changed to require 0 Mvar response, before the PPM is released from 0 MW to max output.

| **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 Reactive Power Capability (Capacitive / Lagging Mvar) test and confirms the following with NCC: 1. MW output of the PPM
2. APC is OFF
3. Frequency Response is OFF
4. Mvar (Q) control mode is ON
5. The transformer tap position
6. On Load Tap Changer Mode
7. System Voltage
8. Maximum lagging Mvar capability of the PPM
9. Mvar Export at the connection point
 |  | 1. \_\_\_\_ MW
2. Status \_\_\_\_
3. Status \_\_\_\_
4. \_\_\_\_ Mode
5. Tap # \_\_\_\_
6. \_\_\_\_ Mode
7. \_\_\_\_ kV
8. \_\_\_\_ Mvar
9. \_\_\_\_ Mvar
 |
| 3 | PPM requests NCC to increase the Mvar set-point in steps as agreed in section 7.4 until the power park module has reached its maximum lagging Mvar limit at the connection point |  | \_\_\_\_ Mvar |
| 4 | PPM requests NCC to increase the Mvar set-point by a further step |  | PPM shall remain at maximum leading Mvar\_\_\_\_ Mvar |
| 5 | PPM requests NCC to turn APC ON and issue a set-point of [insert 90% of Registered Capacity] MW and waits until 1 minute after the set-point has been achieved |  | \_\_\_\_ MW\_\_\_\_ Mvar |
| 6 | PPM requests NCC to issue a set-point of [insert 80% of Registered Capacity] MW and waits until 1 minute after the set-point has been achieved |  | \_\_\_\_ MW\_\_\_\_ Mvar |
| 7 | PPM requests NCC to issue a set-point of [insert 70% of Registered Capacity] MW and waits until 1 minute after the set-point has been achieved |  | \_\_\_\_ MW\_\_\_\_ Mvar |
| 8 | PPM requests NCC to issue a set-point of [insert 60% of Registered Capacity] MW and waits until 1 minute after the set-point has been achieved |  | \_\_\_\_ MW\_\_\_\_ Mvar |
| 9 | PPM requests NCC to issue a set-point of [insert 50% of Registered Capacity] MW and waits until 1 minute after the set-point has been achieved |  | \_\_\_\_ MW\_\_\_\_ Mvar |
| 10 | PPM requests NCC to issue a set-point of [insert 40% of Registered Capacity] MW and waits until 1 minute after the set-point has been achieved |  | \_\_\_\_ MW\_\_\_\_ Mvar |
| 11 | PPM requests NCC to issue a set-point of [insert 30% of Registered Capacity] MW and waits until 1 minute after the set-point has been achieved |  | \_\_\_\_ MW\_\_\_\_ Mvar |
| 12 | PPM requests NCC to issue a set-point of [insert 20% of Registered Capacity] MW and waits until 1 minute after the set-point has been achieved |  | \_\_\_\_ MW\_\_\_\_ Mvar |
|  | **In the following steps, reduction in MW output may cause a change in Mvar. Insert additional MW steps as appropriate to limit the resulting step change to ±5 Mvar. Refer to P-Q chart on p6.** |  |  |
| 13 | PPM requests NCC to issue a set-point of [insert 12% of Registered Capacity] MW and waits until 1 minute after the set-point has been achieved |  | \_\_\_\_ MW\_\_\_\_ Mvar |
| 14 | PPM requests NCC to issue a set-point of [insert 6% of Registered Capacity] MW and waits until 1 minute after the set-point has been achieved |  | \_\_\_\_ MW\_\_\_\_ Mvar |
| 15 | PPM requests NCC to issue a set-point of 0 MW and waits until 1 minutes after the set-point has been achieved |  |  |
| 16 | PPM requests NCC to decrease the Mvar set-point in steps as agreed in section 7.4 until the PPM is exporting 0 Mvar at the connection point |  | Mvar output shall be at 0 Mvar\_\_\_\_ Mvar |
| 17 | PPM requests NCC to issue a set-point of [insert 100% of Registered Capacity] MW and turn APC OFF and waits until 1 minute after AAP has been achieved |  | \_\_\_\_ MW |
| 18 | PPM ends data recording |  |  |
| 19 | PPM informs NCC that the Reactive Power Capability (Capacitive / Lagging Mvar) 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** |
| 2 | PPM confirms the following with NCC: 1. AAP of the PPM
2. MW output of the PPM
3. APC is OFF
4. Frequency Response is ON
5. Frequency Response is in Curve 1
6. AVR (kV) control mode is ON
7. The transformer tap position
8. On Load Tap Changer is in Automatic mode
9. System Voltage
10. kV Set-point = system voltage at connection point
11. Voltage slope setting = 4%
12. Mvar Export at the connection point
 |  | 1. \_\_\_\_ MW
2. \_\_\_\_ MW
3. Status \_\_\_\_
4. Status \_\_\_\_
5. Curve \_\_\_\_
6. \_\_\_\_ Mode
7. Tap # \_\_\_\_
8. \_\_\_\_ Mode
9. \_\_\_\_ kV
10. \_\_\_\_ kV
11. \_\_\_\_%
12. \_\_\_\_ Mvar
 |
| 3 | PPM informs NCC that Reactive Power Control testing is complete |  |  |

## 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)