

# GPS Test Procedure Template

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**Title:**

**Date:**

## Version Release History

| Version | Effective Date | Summary of Changes  |
|---------|----------------|---|
| 1.1     | 1 July 2022    | Public release of draft GPS Commissioning Test Procedure Form |
| 1.2     | 12 May 2023    | Public release of revised draft GPS Test Procedure Template   |

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# Important notice

## PURPOSE

AEMO publishes this GPS Test Procedure Template to assist WEM Market Participants in developing a proposed GPS Test Procedure. Market Participants must submit GPS Test Procedure that is consistent with the format presented in this template, in accordance with WEM Procedure: GPS Compliance Tests and Generator Monitoring Plans, to AEMO. The *Electricity Industry Act 2004*, the WEM Regulations, the WEM Rules and WEM Procedures prevail over this template to the extent of any inconsistency.

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## USER GUIDE

1. The **red texts** in this template contains explanatory notes to assist Market Participants in providing required information, **red text must** be deleted prior to the submission of a proposed GPS Test Procedure to AEMO.
2. The *italicised* texts are examples. They are to be deleted or modified prior to submission of a proposed GPS Test Procedure to AEMO.

## GPS Test Procedure Submission

| Item              | Description  |
|-------------------|--|
| Contact Name      | [Name/Position of a person responsible for the submission<br>Compulsory, for AEMO to contact relevant personnel of a Market Participant] |
| Address/Phone/Fax | [Address/Phone/Fax.<br>Compulsory, for AEMO to contact relevant personnel of a Market Participant]                                       |
| Author            | [Name/Position.<br>Compulsory, to be entered for the purpose of AEMO's assessment.]  |
| Reviewed By       | [Name/Position.<br>Compulsory, to be entered for the purpose of AEMO's assessment.]  |
| Approved By       | [Name/Position.<br>Compulsory, to be entered for the purpose of AEMO's assessment.]  |

## GPS Test Procedure Release History

| Version | Effective date  | Summary of changes  |
|---------|-----------------|---|
| 1.0     | [dd Month yyyy] | [Enter relevant changes. Compulsory, for the purpose of<br>AEMO's assessment.]<br><i>First submission to AEMO and Western Power</i> |

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# 1. Introduction

## 1.1. Generating System description

**Table 1 Example of a Market Participant and Facility summary table**

| Item  | Description  |
|---|--|
| Market Participant Name                                   | [Enter according to WEM registration]  |
| Market Participant Code                                   | [Enter according to WEM registration]  |
| Facility Code   | [Enter according to WEM registration]  |
| Facility's Registered Generator Performance Standard date | [Enter as the latest date of Registered Generator Performance Standards from all Generating Systems within the Facility] |

[Provide a brief introduction/summary of a Generating System and its Generating Units involved in this GPS Test Procedure. Include summary tables as per examples from Table 2 and 0. When summarizing a Generating System consisting of multiple Generating Units, please include details how the Generating Units are arranged within the Generating System (as per example from Table 4), where this information is relevant in the subsequent sections of this procedure, e.g. include feeders collector group description to demonstrate which collector is used at a Hold Point if not all are used.]

**Table 2 Example of a summary table for a Synchronous Generating System**

| Item  | Description  |
|---|--|
| <i>Generating Unit names associated with the GPS of Generating System</i>     | [As provided in the Registered Generator Performance Standard] |
| <i>Date of Registered Generator Performance Standard of Generating System</i> | [As provided in the GPS System]                                |
| <i>Excitation system make and model</i>                                       |  |
| <i>Turbine make and model</i>   |  |
| <i>Governor make and model</i>  |  |
| <i>Rated Maximum Apparent Power (MVA)</i>                                     |  |
| <i>Rated Maximum Active Power (MW)</i>  |  |
| <i>Nominal voltage (kV)</i>   |  |
| <i>Rated stator current (kA)</i>  |  |
| <i>Rated field current (A)</i>  |  |
| <i>Rated frequency (Hz)</i>   |  |
| <i>Rated field voltage (VDC)</i>  |  |
| <i>Ceiling factor</i>   |  |
| [Include others as appropriate]   |  |

**Table 3 Example of a summary table for an Asynchronous Generating System**

| Item   | Description  |
|--|--|
| Generating Unit names associated with Generating System                    | [As provided in the Registered Generator Performance Standard] |
| Date of Registered Generator Performance Standard of the Generating System | [As provided in the GPS System]                                |
| Generating Units make(s) and model(s)                                      |  |
| Number of Wind Turbine Generators/Inverters                                |  |
| Power Plant Controller make and model                                      |  |
| Rated Maximum Apparent Power (MVA)   |  |
| Rated Maximum Active Power (MW)  |  |
| Nominal voltage (kV)   |  |
| Maximum Continuous Current (A)   |  |
| [Include others as appropriate]  |  |

**Table 4 Example of Generating Unit allocation to collector groups for an asynchronous Generating System**

| Collector Group 1<br>BSC1 <sup>1</sup>               | Collector Group<br>BSC2                               | Collector Group<br>BSC3                               |
|--|---|---|
| Generating Unit 1:<br>PS1-INV1 (1 x 3 MVA inverters) | Generating Unit 7:<br>PS4-INV1 (1 x 3 MVA inverters)  | Generating Unit 13:<br>PS7-INV1 (1 x 3 MVA inverters) |
| Generating Unit 2:<br>PS1-INV2 (1 x 3 MVA inverters) | Generating Unit 8:<br>PS4-INV2 (1 x 3 MVA inverters)  | Generating Unit 14:<br>PS7-INV2 (1 x 3 MVA inverters) |
| Generating Unit 3:<br>PS2-INV1 (1 x 3 MVA inverters) | Generating Unit 9:<br>PS5-INV1 (1 x 3 MVA inverters)  | Generating Unit 15:<br>PS8-INV1 (1 x 3 MVA inverters) |
| Generating Unit 4:<br>PS2-INV2 (1 x 3 MVA inverters) | Generating Unit 10:<br>PS5-INV2 (1 x 3 MVA inverters) | Generating Unit 16:<br>PS8-INV2 (1 x 3 MVA inverters) |
| Generating Unit 5:<br>PS3-INV1 (1 x 3 MVA inverters) | Generating Unit 11:<br>PS6-INV1 (1 x 3 MVA inverters) | Generating Unit 17:<br>PS9-INV1 (1 x 3 MVA inverters) |
| Generating Unit 6:<br>PS3-INV2 (1 x 3 MVA inverters) | Generating Unit 12:<br>PS6-INV2 (1 x 3 MVA inverters) | Generating Unit 18:<br>PS9-INV2 (1 x 3 MVA inverters) |

[A single line diagram of the Generating System/Facility must be attached with marked up equipment and/or locations used in this procedure, e.g., a specific circuit breaker or a specific location used for testing or for recording measurements. An example of a marked-up single line diagram is presented in Figure 1.]

<sup>1</sup> In this example, BSC stands for Big Solar Collector group. Please use naming relevant to the specific project and aligned with the provided single line diagram as well as with Table 10.

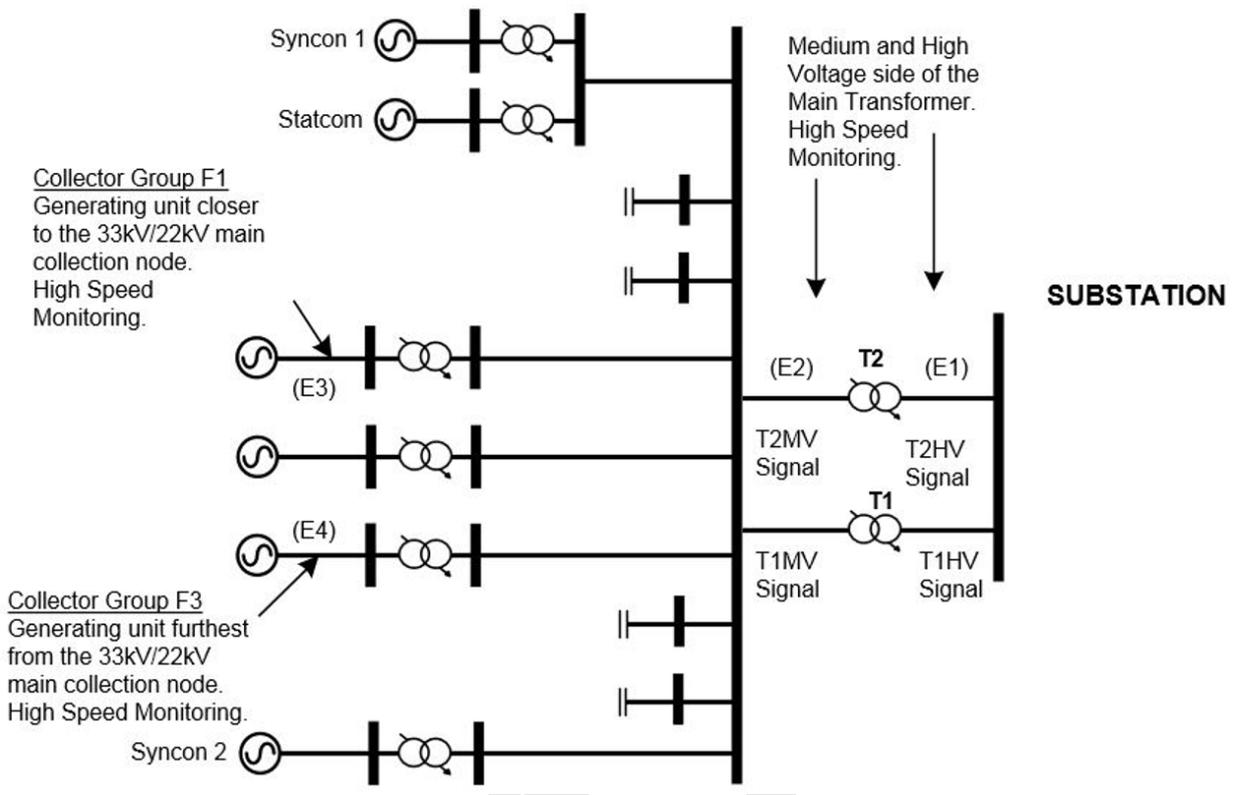


Figure 1 Example of single line diagram with marked locations of measuring equipment.

1.1.1. Other equipment

[Summary of other equipment within the Facility that forms part of the applicable Registered Generating Performance Standards, e.g. harmonic filters, static and dynamic Reactive Power device, special protection schemes.]

1.1.2. Generating System normal operating conditions

[Brief summary of default operating conditions for the Generating System.]

Table 5 provides normal operating setpoint and conditions for the Generating System. The Power Plant Controller monitors and controls the Active Power, Reactive Power and voltage at the Connection Point.

Table 5 Example of summary of normal operating conditions

| Operating condition description                     | Generating System setting                    |
|---|--|
| Nominal control mode                                | Voltage Control                              |
| Target Setpoint for the nominal control mode        | 1.035pu at the Connection Point              |
| Rated Maximum Active Power and Measurement Location | 100MW at the Connection Point                |
| Reactive Power Capability and Measurement Location  | +44 Mvar and -46Mvar at the Connection Point |

## 1.2. Scope and purpose of testing

[Brief description why the Generating System requires GPS testing.

The reasons may include but are not limited to initial generator commissioning i.e. the generator testing requirements to demonstrate compliance with its Registered Generator Performance Standards before an Interim Approval to Generate Notification and an Approval to Generate Notification is issued, testing following a Relevant Generator Modification, or testing following significant maintenance.

The scope of testing may include all Technical Requirements to confirm performance listed in the Registered Generator Performance Standard or can be as narrow as verification of a single Technical Requirement.]

## 1.3. Existing non-compliances (non-applicable for new Generating Systems)

[Include details of any non-compliance and suspected non-compliance, rectification plan and status of compliance at the time of submission of this GPS Test Procedure.]

*There has been no non-compliance identified and/or self-reported by Facility [X] against the Generating System [Y] to date.*

*There has been no non-compliance reported or advised by AEMO and/or established by ERA at the time of submission of this GPS Test Procedure.*

## 1.4. New non-compliance reporting (non-applicable for new Generating Systems)

[Include any internal processes for the Generating System to report any new identified non-compliance. Note that the process to self-report any non-compliance to AEMO is specified in the WEM Rules and WEM Procedure: GPS Compliance Tests and Generator Monitoring Plans.]

*Where non-compliance has been identified at any time for any of the Technical Requirements described in Appendix 12 of the WEM Rules, compliance team must notify Operations Manager according to internal non-compliance notification process, refer to Internal Instructions xxx.*

## 1.5. Proposed timeframe for testing

[Include a proposed commencement date for this GPS Test Procedure.]

*The tests described in this GPS Test Procedure are planned to be executed between 1 July and 1 August 2022, subject to approval of this procedure and subject to AEMO and Western Power's approval of the Commissioning Test Plan which includes the tests specified in this procedure.*

## 1.6. Glossary

[Include any terms and abbreviations necessary to assist AEMO in understanding of this GPS Test Procedure.]

**Table 6** Terms and abbreviations used in this GPS Test Procedure

| Term | Definition |
|------|------------|
|      |            |
|      |            |
|      |            |
|      |            |

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## 2. Communication during Tests

### 2.1. Roles and responsibilities / Main points of contact

[Roles and responsibilities must be included in Table 7. Where relevant, include primary and contact and secondary contacts.]

All personnel involved in preparing, maintaining, executing and approving this GPS Test Procedure are summarised in Table 7.

**Table 7** Example of roles and responsibilities for execution of this GPS Test Procedure

| Role  | Abbreviation | Nominated personnel<br>(Company affiliation) | Phone Number | Email contact       | Responsibility  |
|---|--------------|--|--------------|---------------------|---|
| Facility/Generating System Operations Manager (24h contact)         | OM           |  |              |                     |   |
| GPS Commissioning Test Coordinator                                  | TC           |  |              |                     |   |
| Facility/Generating System Lead Engineer                            | LE           |  |              |                     |   |
| Consulting Engineer (GPS Test Procedure)                            |              |  |              |                     |   |
| Consulting Engineer (GPS test results and compliance demonstration) |              |  |              |                     |   |
| Network Operator Control Room                                       | WP_CR        |  |              |                     |   |
| Network Operator commissioning support engineer                     | WP_CSE       |  |              |                     |   |
| Network Operator GPS Team   | WP_GPS       |  |              |                     | Approving the GPS Test Procedure as well as review and acceptance of test results |
| AEMO GPS Team   | AEMO_GPS     |  |              | WEM.GPS@aemo.com.au | Approving the GPS Test Procedure as well as                                       |

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| Role   | Abbreviation    | Nominated personnel<br>(Company affiliation) | Phone Number | Email contact                          | Responsibility                                   |
|--|-----------------|--|--------------|--|--|
|  |                 |  |              |  | <i>review and acceptance<br/>of test results</i> |
| <i>AEMO commissioning<br/>support engineer</i> | <i>AEMO_CSE</i> |  |              | <i>WA.SM.Planning@aemo<br/>.com.au</i> |  |
| <i>AEMO Control Room</i>                       | <i>AEMO_CR</i>  |  |              |  |  |

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## 2.2. Communication Protocol

[Include specific communication protocols that will be used during testing between the Market Participants (including their contractors), AEMO and Western Power. Include processes to report any identified non-compliance. The final communication protocol must be agreed with AEMO and Western Power prior to final submission of the GPS Test Procedure].

*The following protocol will be used for communication with AEMO and Western Power for the purpose of the GPS commissioning tests:*

1. *TC/LE will submit to AEMO (AEMO\_CR) via the AEMO System Management Operations mailbox (wa.sm.operation@aemo.com.au) and to Western Power (WP\_CR) the Commissioning Test Plan which includes all tests specified in this testing procedure. The complete Commissioning Test Plan must be submitted at least 7 Trading Days as per WEM Rules clause 3.21A.4 before commencement of commissioning.*
2. *TC/LE will inform AEMO (AEMO\_GPS, AEMO\_CSE) and Western Power (WP\_GPS, WP\_CSE) if the testing agreed in this GPS Test Procedure require modifications. All modifications must be agreed by AEMO and Western Power and reflected in the Commissioning Test Plan, if applicable. TC/LE acknowledges that any modifications to this procedure after its initial acceptance by AEMO and Western Power may cause delays in the commissioning schedule.*
3. *TC/LE will continuously ensure that the information provided in the Commissioning Test Plan stays up to date. If changes are required, TC/LE will submit a revised Commissioning Test Plan as early as required for approval before the 8:00am Scheduling Day. AEMO (AEMO\_CR) and Western Power (WP\_CR) will cooperate to review and accept or reject the changes.*
4. *TC/LE and OM will ensure any authority for work required for system switching is provided to AEMO and Western Power (AEMO\_CSE and WP\_CSE) at least one week prior to commencing tests at every Hold Point.*
5. *TC/LE will ensure sure that any changes to contact details listed in the Table 7 are updated in this GPS Test Procedure and communicated to AEMO (AEMO\_GPS, AEMO\_CSE, AEMO\_CR) as well as to Western Power (WP\_GPS, WP\_CR, WP\_CSE).*
6. *TC/LE will ensure at least one week prior to executing the GPS Test Procedure that SCADA signals provided to Western Power and to AEMO have been tested, checked and identified as reliable. If the SCADA signals are not verified positively, TC/LE will inform AEMO (AEMO\_CR, AEMO\_CSE, AEMO\_GPS) and Western Power (WP\_CR, WP\_CSE) about that and discuss rectification options.*
7. *TC/LE will request permission to proceed from AEMO (AEMO\_CR) and Western Power (WP\_CR) at the beginning of each testing day.*
8. *Where non-compliance has been identified at any time for any of the Technical Requirements described in Appendix 12 of the WEM Rules, TC/LE will notify AEMO (AEMO\_GPS, AEMO\_CSE) and Western Power (WP\_GPS, WP\_CSE) and discuss the severity of non-compliance, potential impact for further testing and rectification options.*
9. *At the end of each day's testing, TC/LE will inform AEMO (AEMO\_CR, AEMO\_GPS, AEMO\_CSE) and Western Power (WP\_GPS, WP\_CR, WP\_CSE) that the tests have been completed for the day and will provide update about the current state of the Generating System.*
10. *At the end of each Hold Point, AEMO (AEMO\_GPS) and Western Power (WP\_GPS) will receive a Hold Point Report (as described in section 3.2.1). The reports will be provided by TC/LE and AEMO with Western Power will review and accept/reject it.*
11. *The Generating System will not progress with Active Power output level and will not progress with next Hold Point testing until the Hold Point Report at a current Active Power output level is accepted by AEMO (AEMO\_GPS) and Western Power (WP\_GPS).*

12. *After a Hold Point Report acceptance TC/LE will seek advice from AEMO (AEMO\_GPS) and Western Power (WP\_CSE) for any changes required to the further execution of this GPS Test Procedure and from AEMO (AEMO\_CSE) and Western Power (WP\_CSE) if any changes are required to the relevant sections of the Commissioning Test Plan.*
13. *The Generating System will follow its dispatch target during GPS commissioning tests. TC/LE acknowledges that a dispatch target can be below the Hold Point level.*

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## 3. GPS Compliance Assessment Plan

### 3.1. Pre-requisites for GPS commissioning testing (including model validation testing)

[Market Participant shall include in the GPS Test Procedure the list of pre-requisites including the items listed below. The Market Participant must confirm that all pre-requisites are met before executing tests described in this test procedure].

*The following documents are checked and confirmed by OM, TC and LE before the execution of this GPS Test Procedure:*

- *The Facility is registered;*
- *Generating System has Registered Generator Performance Standards;*
- *SCADA signals of good quality are received by AEMO and Western Power;*
- *All Generator Protection Systems are in service;*
- *All Control Systems are in service;*
- *Inter-trip, Protection Scheme, runback scheme relevant to the Generating System and Facility are in service;*
- *The following have been provided to Western Power and AEMO:*
  - Final connection study reports;
  - Generating System control block diagrams;
  - Generating System operating philosophy report;
  - Generating System final single line diagrams which includes full Facility layout (Generating Unit(s), Generating System transformers, transmission line/cable arrangement, other static and dynamic reactive support devices, if available) and the closest Western Power substation;
  - R1 (or R2 for an existing generator) model package;
  - A final user manual for the generation system model;
  - Physical setting downloads of the Generating System's Control Systems;
  - Summary table which compares and confirms that the physical settings are identical (or equivalent, where relevant) to the Generating System model settings provided in the R1 model package;
  - A proposed Generator Monitoring Plan reviewed by AEMO;
  - An approved GPS Test Procedure being a standalone document or a part of the Market Participant's overall commissioning test procedure;
  - An approved Commissioning Test Plan which includes generation profiles over the time of testing;
  - The High Voltage Submission which includes the site plans, SLDs and all electrical design drawings;
  - Start-up and shut-down procedure;
  - Documented communication failsafe mechanism (e.g. central park controller to Generating Units and central park controller to measurement meters);
  - Valid calibration certificates of measurement equipment;
  - (If requested by AEMO or Western Power) Pre-test simulation studies.

[This is particularly necessary when connecting inverter-based generation to weak networks to ensure that the extent of changes applied to Reactive Power and voltage at the Connection Point would not adversely impact the area in which the Generating System is connected.]

- Energisation plan and switching instructions. All pre-energisation checks/tests (e.g. protection tests) are completed and confirmed that it is safe to energise.
- Type test, factory acceptance test and any relevant off-site test reports;
- Photographic evidence of Nameplate Ratings of major Generating System components installed on site (e.g. transformers, solar inverter / wind turbine generator) and evidence to confirm any connection assessment and assumptions (e.g. transformer fixed tap positions);
- Proof of required skills and qualifications of the personnel involved in commissioning;
- Confirmation of compliance with all workplace health and safety requirements;
- Any other compliance evidence to the Registered Generator Performance Standard.

*(a) Operational communication facilities functional.*

- *Any other requirements relevant to GPS commissioning and requested by AEMO and/or Western Power, including those specified in Deliverables for Energisation and Commissioning template provided by Western Power.*

## 3.2. Commissioning results verification mechanism

[A Market Participant must propose verification mechanisms for the verification of GPS commissioning tests results. This may have already been discussed and agreed with AEMO and Western Power before submitting this procedure. These agreements shall be included in this section as well as reflected in the Communication Protocol in section 2.2 of this procedure.

The following should be taken into considerations:

- Have AEMO and/or Western Power requested to witness the testing in person or remotely? If so, what are the necessary arrangements to facilitate witnessing?
- What confirmations are required from AEMO and Western Power to continue with testing at progressively higher Active Power output levels when Hold Points are completed?]

*The GPS commissioning tests included in this GPS Test Procedure are agreed to be executed with Hold Points with remote supervision from AEMO and Western Power based on documentation and tests data provided by Market Participant, as described in the section 3.2.1 and 3.2.2 of this procedure. After accomplishing testing at each Hold Point defined in section 3.3 of this procedure, Market Participant will provide Hold Point Report to AEMO and Western Power for their review and acceptance. Market Participant will not progress to Active Power output level defined at a subsequent Hold Point and will not initiate any testing activities related to a subsequent Hold Point until they receive the Hold Point approval as described in the communication protocol (section 2.2 of this procedure).*

### 3.2.1. Reporting on testing results

[Describe when/how testing results will be reported to AEMO and Western Power. If AEMO and Western Power do not require a specific reporting method, a reporting method proposed by the Market Participant can be reviewed and accepted.

The following should be taken into consideration:

- Will AEMO and/or Western Power witness tests, either in person or remotely?
- When and how and in what form will Hold Point be submitted to AEMO and Western Power for review and approval after each Hold Point?
- How will the Market Participant provide the required data within 10 Business Days? (as specified in section 2.4.8 of WEM Procedure GPS Compliance Tests and Generator Monitoring Plans).
- How will the Market Participant provide the required data within 3 months? (as specified in section 2.4.9 of WEM Procedure GPS Compliance Tests and Generator Monitoring Plans).

Hold Point reports required to demonstrate that the Generating System being tested can meet its Registered Generator Performance Standard, including demonstration that the generation system model is reasonably representative of the Generating System performance. Results should be presented so that compliance can be assessed and approved for each Hold Point before the Generating System is allowed to change its Active Power to progressively higher output levels.

The following information should be included in a Hold Point Report at minimum:

- Brief background;
- Summary of tests for a given Hold Point;
- Applicable controller firmware and simulation models version summary.
- Test results:
  - Details of the test record, including test conditions (temperature, wind speed, irradiance, Active Power levels, Reactive Power levels, initial and applied reference values, number of Generating Units in service and transformer tap positions etc.) as required under pre-test conditions;
  - File name summary, including test, time stamp and file name;
  - Screenshots of the human machine interface (HMI) (if required) under pre-test conditions;
  - Plots and calculations of all signals agreed under each test. Any plotted result should be on an appropriate scale and include any relevant analysis to allow AEMO and Western Power to confirm compliance with the Registered Generator Performance Standard;
  - Overlays of all measured and simulated results including  $\pm 10\%$  accuracy bands for simulated responses;
  - Summary of test results to confirm compliance for each test;
  - Methodology of compliance assessment;
  - Conclusion section clearly analysing the test compliance with the agreed acceptance criteria.
- If relevant, the setpoint value that is being modified should be included in the results and on all plots;

- Information needed to replicate the measured and simulated results in the provided Generating System Model, including the case type used (SWIS or SMIB) and Connection Point voltage. If relevant, the value used for the grid impedance and the method of deriving the grid impedance must be included;
- Information on any model parameters updated or modified during simulations to allow replication of the response (e.g. frequency control mode enabled in the model).
- Information about Hold Point tests data files consistent with format, resolution and naming convention specified in this procedure.
- Applicable setting summary table which compares physical settings downloaded from actual controllers on site with the R1 model settings.

At the end of testing at each Hold Point, the Market Participant must summarize their findings at each progressively higher Active Power output level with regards to obtained results and Generating System compliance with its Registered Generator Performance Standard. Table 8 provides an example summary of results.]

**Note: Variations to reporting requirements may be negotiated in advance by agreement with AEMO and Western Power.**

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**Table 8 Example of compliance summary table provided after finishing each Hold Point**

| Test Reference | Assessed GPS clause | Performance level | Tested GPS performance requirement <sup>2</sup>  | Test Results | Compliance (Yes/No) |
|----------------|---------------------|-------------------|--|--------------|---------------------|
| HP3_VCT        | A12.4.2.2(a)        |                   | <i>Power system oscillations are Adequately Damped</i>   |              |                     |
|                | A12.4.2.2(c)        |                   | <i>Operation of Generating System does not cause instability that would adversely impact other Equipment connected to SWIS</i> |              |                     |
|                | A12.4.2.5(a)        |                   | <i>Voltage control accuracy to within 0.5% of the setpoint</i>   |              |                     |
|                | A12.4.2.5(c)        |                   | <i>Voltage is continuously controllable in the range 95% to 105% of the target voltage</i>                                     |              |                     |
|                | A12.4.2.5(d)        |                   | <i>Generating System is capable of stable operation for indefinite periods while under the control of any limiter.</i>         |              |                     |

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<sup>2</sup> Performance requirement as per Statement of Compliance from the Registered Generator Performance Standard

### 3.2.2. Test data file format and naming

[The Market Participant must specify how the data collected during the tests will be structured and named. Data should be named in a way that allows for clear and unique identification what Generating System was tested, what is the Measurement Location, what is the Hold Point number, what is the type of the test and test number or an operating point if the same test is repeated at different levels of Reactive Power output].

After each test the relevant data will be collected from the measuring devices and combined by the commissioning engineers (LC) to a file(s). The file(s) will be saved as the .csv format and a unique file name(s) will be provided to identify the data from a specific test. The following naming convention will be applied:

“GeneratingSystemName  
\_HoldPointNo\_GeneratingTech<sup>3</sup>\_TestName\_TNo\_MeasuringLocation.CSV”,

where:

- *GeneratingSystemName* - Abbreviated name of the Generating System, Facility Code or Generating Unit as relevant;
- *HoldPointNo* - Hold Point number associated with a specific Active Power output level;
- *GeneratingTech* – Abbreviated name of generating technology;
- *TestName* - Abbreviated test name as per test description;
- *TNo* - Test Number; and
- *MeasuringLocation* - Location of the measuring device as per section 3.4 of this procedure (e.g. Inverter 1 terminal).

For example, data recorded for the Big Solar Project with Facility Code “BigSP” and measured at the Inverter 1 of the Medium Voltage Power Station 2 (MVPS2-INV1) for the test number 3 of Voltage Reference Step Test (VCT) in Hold Point 4 is stored as “BigSP\_HP4\_VCT\_Test3\_MVPS2-INV1.CSV”.

[Where practical for data collection and further data analysis, the data file can be split but the naming structure is to be maintained as presented in Table 9.]

**Table 9 Table of test names and associated data filenames**

| Test                | Timestamp           | Filename                                  |
|---------------------|---------------------|---|
| BigSP_HP4_VCT_Test3 | YYYY/MM/DD HH:mm:ss | BigSP_HP4_VCT_Test3_MVPS2-INV1.CSV        |
|                     |                     | BigSP_HP4_VCT_Test3_CP.CSV                |
|                     |                     | BigSP_HP4_VCT_Test3_HVUnitTransformer.CSV |

### 3.3. Testing Hold Points

[Hold Points are pre-defined stages during the GPS commissioning process whereby the Generating System’s Active Power output is constrained to specified limits for the purpose of demonstrating compliance with its Registered Generator Performance Standard. After successful completion and acceptance of each Hold Point, Active Power output is progressively increased to allow for commissioning tests at a subsequent Hold Point . The tests carried out at

<sup>3</sup> To be used only if the Generating System consists of multiple generating technologies, e.g. a hybrid generation which includes both a wind farm (WF) and a solar farm (SF), and a test is repeated separately for each generating technology. In this example, the HP4\_VCT test would become HP4\_WF\_VCT and HP4\_SF\_VCT with data file naming following the test naming convention.

each Hold Point are to be summarised and captured in this section of this procedure. This process allows for releasing the generating capacity in stages, subject to successful demonstration of Generating System compliance with its Registered Generator Performance Standard, including confirmation of simulation model(s) against measured responses for all tests that can be replicated by performing dynamic simulation studies.

The number of Hold Points can vary depending on the size of the Generating System and its impact on the power system. Typical Hold Points include:

- HP 0 – For asynchronous Generating Systems prior to energisation of Generating Units and for synchronous Generating Systems when the machine is unsynchronised (i.e. spinning off-line, 0MW generation);
- HP 1 – For asynchronous Generating Systems at approximately 20% of Rated Maximum Active Power and at approximately 1/3 of Generating Units in service (i.e. one full Collector Group) and for synchronous Generating Systems at minimum stable loading;
- HP 2 – For asynchronous Generating Systems at approximately 60% of Rated Maximum Active Power with all Generating Units in service and for synchronous Generating Systems at approximately 50% of Rated Maximum Active Power (if greater than the minimum stable loading of the Generating System);
- HP 3 – For asynchronous Generating Systems at least 90% of Rated Maximum Active Power with all Generating Units in service and for synchronous Generating Systems at 100% of Rated Maximum Active Power.

This should only be considered a guide on the number of required Hold Points. AEMO and/or Western Power may request different number of Hold Points (with different Active Power output levels) based on Measurement Location, number of Generating Units available for tests and size of the Generating System.

Hold Points are based on Active Power output level, assuming that measured responses are stable, and that a reasonable correlation exists between measured and simulated responses. Additional Hold Points may be introduced if testing show there is no reasonable correlation between measured and simulated responses.

The minimum generation level and number of Generating Units online must be separately agreed with AEMO and Western Power in this procedure.

AEMO and Western Power release generating capacity at levels indicated for each Hold Point for commissioning testing only. A Generating System should not operate for an extended period without tests being undertaken. If pre-defined Hold Point tests are not completed or Hold Point reports are not submitted to AEMO and Western Power within the agreed timeframes, AEMO may constrain a Generating System's output to the previous Hold Point generation level that demonstrated acceptable testing results.

If Hold Point tests cannot be completed due to primary energy source availability, an interim Hold Point may be tested, subject to agreement with AEMO and Western Power.]

*This GPS commissioning of the Generating System is executed in pre-defined stages, which are called Hold Points (HP), with Active Power output being constrained to specified limits for the purpose of demonstrating Generating System compliance with its Registered Generator Performance Standard. After successful completion and acceptance of each Hold Point, the Active Power output is progressively increased to allow for continuation of GPS commissioning testing at a subsequent Hold Point.*

It has been agreed between the Market Participant, AEMO and Western Power that the testing described in this procedure will be executed in four Hold Points, named HP0 to HP3. The specific Active Power output levels for each Hold Point and the necessary Generating System arrangements are collected in Table 10.

**Table 10 Hold Point summary table – example for a Generating System with 54 MW Rated Maximum Active Power and 18 Generating Units**

| Hold Point No. and associated Active Power output level <sup>4</sup> | Number of MVPS <sup>5</sup> and inverters in service | Maximum Active Power | Minimum Active power | Max/min Reactive Power                   | Reactive plant device status (if any) | Harmonic filter banks status (if any) <sup>6</sup> | Feeder name/ number <sup>7</sup> |
|--|--|----------------------|----------------------|--|---------------------------------------|--|----------------------------------|
| <b>HP0<br/>(0 MW)</b>  | 0  | 0                    | 0                    | 0  | OFF                                   | Bank1 <sup>8</sup> :<br>OFF<br>Bank2: OFF          | 0                                |
| <b>HP1<br/>(18 MW)</b>   | 3 x 6 MVA MVPS<br>(6 x 3 MVA inverters)              | 18 MW                | 15MW <sup>9</sup>    | -10 to 10 MVA <sub>r</sub> <sup>10</sup> | ON                                    | Bank1: ON<br>Bank2: ON                             | BSC1 <sup>11</sup>               |
| <b>HP2<br/>(36 MW)</b>   | 9 x 6 MVA MVPS<br>(18 x 3 MVA inverters)             | 36 MW                | 33 MW <sup>12</sup>  | -20 to 20 MVA <sub>r</sub>               | ON                                    | Bank1: ON<br>Bank2: ON                             | BSC1,<br>BSC2,<br>BSC3           |
| <b>HP3<br/>(54MW)</b>  | 9 x 6 MVA MVPS<br>(18 x 3 MVA inverters)             | 54 MW                | 50 MW                | -20 to 20 MVA <sub>r</sub>               | ON                                    | Bank1: ON<br>Bank2: ON                             | BSC1,<br>BSC2,<br>BSC3           |

<sup>4</sup> Active Power output level measured at Connection Point or other location agreed in the Registered Generator Performance Standard.

<sup>5</sup> In this example, MVPS stands for Medium Voltage Power Station which is a naming convention commonly used in solar PV Generating System. Please modify this column to reflect on the naming used in the actual project and align this naming with data provided in section 1 of this procedure, including alignment with the provided single line diagram.

<sup>6</sup> Alter this column to reflect on the actual equipment installed in the Generating System and align names with the provided single line diagram.

<sup>7</sup> Alter this column to reflect on the layout of the Generating System and align names with the provided single line diagram

<sup>8</sup> Use equipment names which are aligned with the provided single line diagram.

<sup>9</sup> For certain tests such as Generating Unit Reactive Power capability test and power quality tests during night-time, this level can be 0 MW as per descriptions of the specific tests.

<sup>10</sup> Limits to be update if needed to limit frequent and infrequent voltage fluctuations.

<sup>11</sup> In this example, BSC stands for Big Solar Collector group. Please use naming relevant to the specific project and aligned with the provided single line diagram as well as Table 4.

<sup>12</sup> For specific tests such as run-back, Active Power Control, frequency control, or harmonic filter trip test, minimum Active Power output may vary as per specific tests description.

### 3.4. Measurement equipment and location

[This section is to identify measurement equipment and its placement within and outside the Generating System that will be used to record test data for GPS compliance tests.

This GPS Test Procedure must provide details of the measurement equipment and its location, including:

- Manufacturer, model and serial number of the equipment;
- Type of equipment:
  - Continuous monitoring, event triggering, manual triggering, etc.;
  - Note: The use of instrument transformers with a higher accuracy class is recommended to minimise measuring errors. The use of High-Resolution Time Synchronised Data Recorders are recommended where available, and when they meet the specific requirements of GPS commissioning tests. Detailed information about High-Resolution Time Synchronised Data Recorders is described in the WEM Procedure Communications and Control Systems;
- Location of measurement equipment needs to be marked on a single line diagram, e.g. as presented in Figure 1;
- For asynchronous Generating Systems such as wind and solar farms, which typically consist of multiple Generating Units and reactive support devices, measurement equipment must be provided at various locations, including:
  - Connection point or HV terminals of plant transformers;
  - MV collector bus where the Generating Units are connected;
  - Generating units:
    - a) At least one for each different type of Generating Unit and the most common Generating Unit type would need to have high-speed data recorders at both the electrically closest and furthest Generating Units with respect to the MV collection grid;
    - b) As an example, a wind farm comprising (30) x 3 MW type 3 WTGs, (15) x 3 MW type 4 WTGs, and (15) x 2 MW type 4 WTGs would need to have two high-speed data recorders for the 3 MW type 3 WTGs, and one for each of the other two types.
  - Inverter-based generation technologies may have Generating Units with multiple LV terminals, e.g. some designs of doubly fed asynchronous Generating Units have two LV terminals. Measurement locations for these technologies should cover each LV terminal;
  - Each type of dynamic reactive support device, such as STATCOMs and synchronous condensers (if applicable);
  - Central park level controller / Power Plant Controller (PPC) and signals within the control systems of the Generating Unit, where these signals are proposed by Market Participant or requested by AEMO and/or Western Power to demonstrate compliance with the Registered Generator Performance Standard. Typically, these signals include

Vref, Pref, Qref, voltage and frequency droop calculations, recorded ramp rates, LVRT/HVRT flags, etc.

- High speed measurement equipment that can capture the dynamic response adequately, where asynchronous Generating Systems that include fast acting power electronic converter controls are being tested. (Typical sampling rate of such measurement equipment is over 10 kHz);
- Measurement equipment must be installed at the Generating System terminals, Connection Point, or other locations as necessary to demonstrate compliance with a Registered Generator Performance Standard;
- With regards to signals within the control system of the Generating Units, these typically include AVR, PSS, control system limiters, governor control system and any other needed to demonstrate compliance with Registered Generator Performance Standard;
- The sampling rate for each measurement, and each signal and time window available for configuration. Sampling rate information should be presented in a table form as per the examples in Table 11 to 0;
- Format of measurement data (CSV or COMTRADE);
- The following data and information should be made available to AEMO and Western Power:
  - All pre-processed measurement (raw) data with minimum resolution of 100 Hz for electrical quantities and 1 kHz for control signals;
  - Scaling factors for all signals;
  - Information on post-processing of raw measurement data, such as re-sampling, filtering, averaging and calculations of the signals.
- Acceptance testing report for the measurement equipment;
- Valid and up-to-date calibration certificates of measurement equipment;
- Exact signals to be measured at each measurement location;
- Details of how measurement results will be synchronised where multiple recording devices are to be used;
- Generating units with high-speed measurement equipment must be in-service for all tests;
- Measured voltages and currents must be available in three-phase instantaneous waveforms, three-phase root mean square (RMS), and per-phase RMS (magnitude and angle).
- Measured reference signals (Vref, Qref, Pref, Fref etc), irradiance, wind speed and temperature.
- Voltage and frequency thresholds are defined for triggered power system events to trigger, record and save event data automatically for GPS compliance and R2 validation requirements.
- Measurement equipment power is supplied via an uninterruptable power supply (UPS) to ensure continuous recording during network disturbances.]

**Table 11** Signals recorded at the Generating Unit terminals - example

| Signal Description   | Sampling rate |
|--|---------------|
| <i>Nearest and furthest inverters terminal 3-phase RMS phase-to-phase voltages</i> | 2 kHz         |
| <i>Nearest and furthest inverters terminal Active Power</i>                        | 2 kHz         |
| <i>Nearest and furthest inverters Reactive Power</i>                               | 2 kHz         |
| <i>Nearest and furthest inverters Active Current</i>                               | 2 kHz         |
| <i>Nearest and furthest inverters Reactive Current</i>                             | 2 kHz         |

**Table 12** Signals recorded at the Connection Point - example

| Signal Description  | Sampling rate |
|---|---------------|
| <i>3-phase voltage RMS and each phase instantaneous values</i>                          | 2 kHz         |
| <i>3-phase current RMS and each phase instantaneous values</i>                          | 2 kHz         |
| <i>3-phase voltage positive sequence</i>  | 2 kHz         |
| <i>3-phase voltage negative sequence</i>  | 2 kHz         |
| <i>Active Power</i>   | 2 kHz         |
| <i>Reactive Power</i>   | 2 kHz         |
| <i>Frequency</i>  | 2 kHz         |
| <i>Active current</i>   | 2 kHz         |
| <i>Reactive current</i>   | 2 kHz         |
| <i>Voltage harmonic contents (individual and total) up to 50<sup>th</sup> harmonics</i> |               |

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**Table 13 Signals recorded from SCADA and Power Plant Controller (PPC) - example**

| Signal Description  | Signal source | Sampling rate |
|---|---------------|---------------|
| <i>Setpoint signals for Active Power, Reactive Power, Power Factor, Voltage reference</i> | SCADA         |               |
| <i>Frequency control setpoint reference</i>   | PPC           |               |
| <i>All Generating Units terminal RMS voltage</i>  | SCADA         |               |
| <i>All Generating Units terminal Active Power</i>   | SCADA         |               |
| <i>All Generating Units terminal Reactive Power</i>                                       | SCADA         |               |
| <i>All Generating Units terminal Active Current</i>                                       | SCADA         |               |
| <i>All Generating Units terminal Reactive Current</i>                                     | SCADA         |               |
| <i>All Generating Units Fault Ride Through (FRT) signals</i>                              | SCADA         |               |
| <i>PPC freezing signals to support FRT functionality</i>                                  | PPC           |               |
| <i>DC voltage and current in closest and furthest inverter</i>                            | SCADA         |               |
| <i>Inverter temperatures</i>  | SCADA         |               |
| <i>Ambient temperature</i>  | SCADA         |               |
| <i>Global horizontal solar irradiance</i>   | SCADA         |               |
| <i>Plane of array solar irradiance</i>  | SCADA         |               |
| <i>Active power local limit</i>   | SCADA         |               |
| <i>Reactive power local limit</i>   | SCADA         |               |
| <i>Generating System transformer tap position</i>   | SCADA         |               |
| <i>Status of all Generating Units (online, trip, pause)</i>                               | SCADA         |               |

### 3.5. Overview of GPS compliance tests

[Provide an overview of which GPS clauses from the Registered Generator Performance Standard are demonstrated at each Hold Point. Table 14 depicts an example of a suitable overview.]

Table 14 An overview of GPS compliance tests at each Hold Point - example

| GPS clause  | HP0<br>(0 MW)                  | HP1<br>(XX<br>MW) | HP2<br>(XX MW) | HP3<br>(XX MW) | Alternative<br>assessment<br>method | Description/notes<br>(e.g. notes on alternative assessment<br>methodology if required) |
|---|--------------------------------|-------------------|----------------|----------------|-------------------------------------|--|
| A12.2. Active Power Capability                              | No                             | Partially         | Partially      | Yes            |                                     | Partially – Active Power assessed at progressively higher Active Power output levels   |
| A12.3. Reactive Power Capability                            | No                             | Partially         | Yes            | Yes            |                                     | Partially – based on one collector group feeder  |
| A12.4. Voltage and Reactive Power Control                   | No/<br>Partially <sup>13</sup> | Yes               | Yes            | Yes            |                                     |  |
| A12.5. Active Power Control                                 |                                |                   |                |                |                                     |  |
| A12.6. Inertia and Frequency Control                        |                                |                   |                |                |                                     |  |
| A12.7. Disturbance Ride Through for a Frequency Disturbance |                                |                   |                |                |                                     |  |
| A12.8. Disturbance Ride Through for a Voltage Disturbance   |                                |                   |                |                |                                     |  |
| A12.9. Disturbance Ride Through for Multiple Disturbances   |                                |                   |                |                |                                     |  |
| A12.10. Disturbance Ride Through for Partial Load Rejection |                                |                   |                |                |                                     |  |
| A12.11. Disturbance Ride Through for Quality of Supply      |                                |                   |                |                |                                     |  |
| A12.12. Quality of Electricity Generated                    |                                |                   |                |                |                                     |  |
| A12.13. Generation Protection Systems                       |                                |                   |                |                |                                     |  |
| A12.14. Remote Monitoring Requirements                      |                                |                   |                |                |                                     |  |
| A12.15. Remote Control Requirements                         |                                |                   |                |                |                                     |  |
| A12.16. Communications Equipment Requirements               |                                |                   |                |                |                                     |  |
| A12.17. Generation System Model                             |                                |                   |                |                |                                     |  |

<sup>13</sup> Answers will vary for synchronous and asynchronous Generating Systems, e.g. a synchronous Generating System must demonstrate Settling Time when is unsynchronised.

## 4. Risk Assessment

[The GPS Test Procedure must identify potential health, safety and security risks associated with undertaking each test, as well as describe the applicable risk mitigation controls.

Risks identified should include risks related to:

- Power System Security and Power System Reliability;
- health and safety of personnel on-site;
- health and safety of the public; and
- damage to equipment.

The Test Lead/Manager must sign-off on each risk control before the commencement of tests at each Hold Point.]

Each test specified in this GPS Test Procedure is analysed with regards to associated risks of the test execution. This risk assessment evaluates each identified risk against the likelihood of occurrence and severity of consequences to provide a Risk Score as presented in the matrix from Table 15.

Table 15 Risk assessment matrix - example

| Probability of occurrence <sup>14</sup> | Severity of consequence <sup>15</sup> |        |          |         |
|---|---------------------------------------|--------|----------|---------|
|   | Insignificant                         | Minor  | Moderate | Major   |
| Most Likely                             | Medium                                | High   | Extreme  | Extreme |
| Likely                                  | Medium                                | Medium | High     | Extreme |
| Unlikely                                | Low                                   | Medium | Medium   | High    |
| Most Unlikely                           | Low                                   | Low    | Medium   | Medium  |

All risks identified for the tests defined in this procedure are evaluated and captured in Table 16 with identification which tests are impacted by specific risk.

<sup>14</sup> Market Participant may define the probability of occurrence for their specific project (e.g. Unlikely = between 1% of 10% chance to occur)

<sup>15</sup> Market Participant to define the severity of consequence. e.g. insignificant (commissioning program delay less than 1 week, cost overrun up to 10%, minimum rework to address the issue).

**Table 16 Risk identification table - example**

| Risk ID | Risk description  | Tests impacted                  | Likelihood | Consequence   | Risk Score |
|---------|---|---------------------------------|------------|---------------|------------|
| 1       | Non-compliance to work health and safety requirements   | ALL                             | Unlikely   | Major         | High       |
| 2       | Voltage outside the equipment withstand level   | HP1_VCT,<br>HP2_VCT,<br>HP3_VCT | Unlikely   | Moderate      | Medium     |
| 3       | Connection point voltage outside the normal operating level   |                                 | Likely     | Insignificant | Medium     |
| 4       | Unexpected protection trip due to incorrect setting or malfunction  |                                 | Unlikely   | Insignificant | Low        |
| 5       | High Active Power output poses a risk for power system security and stability at low loading network conditions |                                 | Likely     | Insignificant | Medium     |
| 6       | Instability of the plant during the test  |                                 | Unlikely   | Major         | High       |

For all identified risks which are having a Risk Score of medium or above, the mitigation strategy has been introduced and signed off by Commissioning Lead Engineer. This mitigation strategy is summarised in Table 17 for AEMO and Western Power review.

**Table 17 Risk mitigation table - example**

| Risk ID | Risk mitigation description   | Sign off <sup>16</sup> |
|---------|---|------------------------|
| All     | Commissioning lead/manager in attendance at all times   |                        |
| All     | Commissioning engineer in direct line of sight and communication at all times   |                        |
| All     | Confirm all plant quantities are within normal equipment withstand levels   |                        |
| 2       | Pre-test simulations are executed to confirm an impact of the risk for the day of testing.  |                        |
| 2       | Based on pre-test simulation outcomes the Reactive Power step size is limited to xx pu.   |                        |
| 2       | It has been arranged with Western Power to keep connection point voltage at minimum xx pu level to avoid...   |                        |
| 2       | Confirm step size and reference change consistency with the test plan   |                        |
|         | Communicate with Western Power / AEMO's Control Centre to configure network reactive plants, OLTC, etc. to allow tests to be conducted as required. |                        |
|         | Any deviation to the test plan pre-approved and appended to the test plan.  |                        |

<sup>16</sup> Provide full name together with and electronic signature or with a signature on a printed copy of this procedure.

## 5. Typical Tests for Asynchronous Generating Systems

[This section provides the typical tests at each Hold Point for the connection of a new Transmission Connected Generating System and the expected level of information required for each test. Development of a test procedure for a Generating System should consider the following:

- 1) Refer to Appendix B of the WEM Procedure: GPS Compliance Tests and Generator Monitoring Plans for the tests required to establish compliance with the Registered Generator Performance Standards.
- 2) The example tests in this section serves as a guide to cover the a typical asynchronous Generating System such as an inverter-based generator. Market Participants must provide all necessary tests specific to their Generating System to demonstrate compliance with its Registered Generator Performance Standards.
- 3) Where a test described is not suitable for the technology of a Generating System and/or verifying the compliance with an applicable Registered Generator Performance Standard, a modified or alternative version must be provided that can verify full performance of the technology and/or establish compliance with Registered Generator Performance Standards.
- 4) Typical tests that should be undertaken for a synchronous Generating Unit are described in section 5.5.9 of this procedure.
- 5) There will be aspects of the Generating System's Registered Generator Performance Standards and R2 models that cannot be fully demonstrated/validated through staged tests. In these circumstances, the Market Participant must specify an alternative assessment methodology that establishes compliance with the Registered Generator Performance Standards.]

### 5.1. Hold Point 0 tests

#### 5.1.1. Background power quality measurements (HPO\_PQT)

##### **Purpose**

[Provide the purpose of testing with respect to the Generating System's compliance with its Registered Generator Performance Standard and other information required by WEM Procedure: GPS Compliance Tests and Generator Monitoring Plans.]

*To determine background voltage imbalance, voltage fluctuation and harmonic voltage distortion at the Connection Point before connecting the Generating System to the network. The background power quality measurements will be used to assess compliance with the Registered Generator Performance Standard Technical Requirement A12.12.*

##### **Pre-test conditions**

[The pre-test conditions are the combination of all necessary preparatory steps needed for executing this test procedure.]

- *The Power Quality measurements are at the Connection Point and other locations within the Facility as required in the Registered Generator Performance Standard.*
- *Measurement systems are calibrated, tested and checked accordingly.*

- *The Connection Point is energised.*
- *All Generating Units and balance of plant components are disconnected.*

#### Methodology and procedure

[Describe the series of steps that will be taken to accomplish the testing.]

- *The power quality recording equipment will continuously measure the steady-state voltage imbalance, voltage fluctuation and harmonic voltage distortion at the Connection Point (and other relevant locations) for at least a week and in accordance with the Registered Generator Performance Standard.*

#### Signals to be measured and plotted

[Provide a table of signals to be measured and plotted for this test. Table 18 shows an example of all signals available for measurement and highlights those that need to be plotted and compared against the respective simulated response.]

*Following signals will be recorded:*

- *Phase to neutral voltages of each phase;*
- *Fundamental frequency;*
- *Harmonics voltage distortions up to the 50<sup>th</sup> harmonic order and the total harmonic distorted;*
- *Voltage fluctuation/flicker levels (including Pst and Plt); and*
- *Voltage imbalance levels (positive sequence voltage, negative sequence voltage and negative phase sequence component of voltage (in percent of the positive phase sequence component)).*

#### Measurement data file name and format

[Follow the test data naming convention and file format described in section 3.2.2 of this procedure.]

#### Acceptance Criteria

[List the criteria that this test must satisfy for it to be accepted as completed. The acceptance criteria are to include all relevant performances stated in the Generating System's Registered Generator Performance Standard.]

- *Measurement data is successfully downloaded and confirmed.*

#### 5.1.2. Generating unit signal injection tests (HPO\_SIT)

##### Purpose

[Provide the purpose of testing with respect to the Generating System's compliance with its Registered Generator Performance Standard and other information required by WEM Procedure: GPS Compliance Tests and Generator Monitoring Plans and where relevant, specify all model parameters being validated.]

- *To partially assess compliance with Registered Generator Performance Standard Technical Requirements A12.7 and A12.8 with respect to frequency and voltage protection settings of the Generating Unit.*
- *To validate voltage and frequency protection settings implemented in dynamic models of Generating Units.*

### Pre-test conditions

- *Measurement systems are calibrated, tested and checked accordingly.*
- *Confirm all Generating Unit protection settings consistent with the Registered Generator Performance Standard.*
- *All Generating Unit protection settings uploaded and in service.*

### Methodology and procedure

- *A signal is injected to the Generating Units connected with measurement equipment to verify Generating Unit protection settings, primarily the over- and under-voltage and frequency protection settings.*
- *Measure the communication signals delay with synchronised measurement equipment.*

### Signals to be measured and plotted

[Provide a table of signals to be measured and plotted for this test. Table 18 shows an example of all signals available for measurement and highlights those that need to be plotted and compared against the respective simulated response.]

### Measurement data file name and format

[Follow the test data naming convention and file format described in section 3.2.2 of this Procedure.]

### Acceptance Criteria

- *Measurement data is successfully downloaded and confirmed.*
- *Generating Units trip and delay consistent with the applied settings and the Registered Generator Performance Standard.*

## 5.1.3. End to end communication delay test (HP0\_CDT)

### Purpose

[Provide the purpose of testing with respect to the Generating System's compliance with its Registered Generator Performance Standard and other information required by WEM Procedure: GPS Compliance Tests and Generator Monitoring Plans.]

- *Confirm end-to-end communication delay is consistent with the Registered Generator Performance Standard Technical Requirement A12.6 and A12.17.*

### Pre-test conditions

- *Measurement systems are calibrated, tested and checked accordingly.*
- *All Generating Unit protection settings uploaded and in service.*

### Methodology and procedure

- *Signals are issued from central park controller to the Generating Units and reactive support devices. Measure the communication signals delay with synchronised measurement equipment.*

### Signals to be measured and plotted

[Provide a table of signals to be measured and plotted for this test. Table 18 shows an example of all signals available for measurement and highlights those that need to be plotted and compared against the respective simulated response.]

### Measurement data file name and format

[Follow the test data naming convention and file format in section 3.2.2 of this procedure.]

### Acceptance Criteria

- *Measurement data is successfully downloaded and confirmed.*
- *Confirm measured communication delays consistent with:*
  - *the dynamic simulation models time delays; and*
  - *design specifications of the Control System.*

#### 5.1.4. Asynchronous dynamic/static reactive support device control system test (HPO\_DRD)

[This test is applicable to static reactive support device devices such as capacitor bank or dynamic reactive support device such as an SVC and STATCOM.]

### Purpose

- *To assess the response of voltage Control System and step response characteristics of voltage and Reactive Power in accordance with the Registered Generator Performance Standard Technical Requirement A12.4.*
- *To validate the asynchronous dynamic/static reactive support device control system model parameters including:*
  - *Reactive power capability.*
  - *Switching logic.*
  - *Control model parameters such as control gains, time constants and limits.*
- *To validate transformer and tap changer control logic.*

### Pre-test conditions

- *Measurement systems are calibrated, tested and checked accordingly.*
- *All Generating Units are off-line.*
- *Generating system Connection Point is energised.*
- *All other reactive support devices are off-line.*
- *A range of steady state and dynamic tests studies are performed to ensure that the extent of changes in network voltage and Reactive Power at the Connection Point that would not adversely impact Technical Rules voltage performance.*
- *Control system of asynchronous dynamic support device is in service and configured to default control mode.*
- *The Generating System transformers are in manual control (fixed tap).*
- *Risk assessment complete.*
- *Communicate and confirm test with the AEMO and Western Power's Control Centre.*

### Methodology and procedure

[Refer to section 5.2 to carry out Reactive Power control tests, voltage reference step tests, power factor reference step tests and transformer manual tap positions change tests.]

### Signals to be measured and plotted

[Provide a table of signals to be measured and plotted for this test. Table 18 shows an example of all signals available for measurement and highlights those that need to be plotted and compared against the respective simulated response.]

### Measurement data file name and format

[Follow the naming convention in section 3.2.2 of this procedure.]

### Acceptance Criteria

[Acceptance criteria must include all relevant performance as described in the Generating System's Registered Generator Performance Standard.]

- *Reactive power output follows the reference setpoint correctly.*
- *Reactive power response able to return to stable operation after each step.*
- *Reactive power limits demonstrated in the tests are consistent with those in the submitted Power System Design Data Sheets and Power System Setting Data Sheets.*
- *The device can generate maximum Reactive Power (capacitive and inductive) continuously.*
- *Measurement data is successfully downloaded and confirmed.*

#### 5.1.5. Synchronous dynamic reactive and/or system strength support device control test (HP0\_SDRD)

[The operation of synchronous dynamic reactive and/or system strength support devices, commonly referred to as synchronous condensers, is identical to that of synchronous Generating Systems with an Excitation Control System. Tests conducted on a synchronous condenser are similar to those for a synchronous Generating System, except that a synchronous condenser is tested as part of the Generating System and does not have any direct GPS compliance requirements.

Further information on tests required for synchronous Generating Systems and other synchronous machines can be found in section 5.5.9 of this procedure.]

## 5.2. Hold Point 1 tests

### 5.2.1. Power quality test (HP1\_PQT)

#### Purpose

- *To assess compliance with Technical Requirement A12.12 with respect to the quality of electricity generated.*

#### Pre-test conditions

- *Confirm measurement systems are calibrated, tested and checked accordingly.*
- *Generating system's Connection Point is energised; and*
- *Generating units and balance of plant components as agreed in the commissioning plan are connected.*

### Signals to be measured and plotted

[Provide a table of signals to be measured and plotted for this test. Table 18 shows an example of all signals available for measurement and highlights those that need to be plotted and compared against the respective simulated response.]

### Measurement data file name and format

[Follow the test data naming convention and file format in section 3.2.2 of this procedure.]

### Methodology and procedure

- *Continuous measurement is captured at the Connection Point and other locations within Facility as required in the relevant standards in the Registered Generator Performance Standard Technical Requirement A12.12.*
- *Measurements will be taken at high (80% of HP1 MW level) and low generation conditions whenever possible. The final compliance assessment will compare the results obtained from the background measurements before and after the connection of the Generating System. The measurements used in the final report include one week of continuous measurements for both pre- and post-connection periods.*

### Acceptance criteria

- *Measurement data is successfully downloaded and confirmed.*
- *Assessment is conducted by comparing results obtained from the background measurements (HP0\_PQT) and after HP1 testing period.*
- *The quality of the electricity generated (harmonic voltage distortion, voltage fluctuation and voltage imbalance) is within the Registered Generator Performance Standard limits.*

### 5.2.2. Generating unit capability test (HP1\_GUC)

#### Purpose

- *To validate Reactive Power capability of the Generating Units.*
- *To validate Generating Unit model parameters related to Active Power and Reactive Power limits.*
- *To partially assess compliance with Technical Requirement A12.17.*

#### Pre-test conditions

- *Measurement systems are calibrated, tested and checked accordingly.*
- *Monitor and record the ambient temperature before, during and after the test.*
- *Generating units under test are operated with the park dispatch control enabled.*
- *One inverter is energised. All other inverters are deenergised.*
- *The park dispatch controller is in Active Power and Reactive Power control mode.*
- *All reactive support and energy storage devices are off-line.*
- *The Generating System transformers are in manual control (fixed tap).*

#### Methodology and procedure

- *Confirm measurement systems are ready to record data.*
- *Generating units are operated at a wide range of operating conditions including output Active Power of at least 80% of maximum output for the given Hold Point, and boundaries of Reactive Power supply and absorption. Figure 2 shows a typical Reactive Power capability of an inverter-based Generating Unit with minimum operating points required to be captured during the test.*

- *Measurement is required for at least two Generating Units for each different type of Generating Unit installed.*
- *View test data file to ensure it has been successfully saved.*

### Signals to be measured and plotted

[Provide a table of signals to be measured and plotted for this test. Table 18 shows an example of all signals available for measurement and highlights those that need to be plotted and compared against the respective simulated response.]

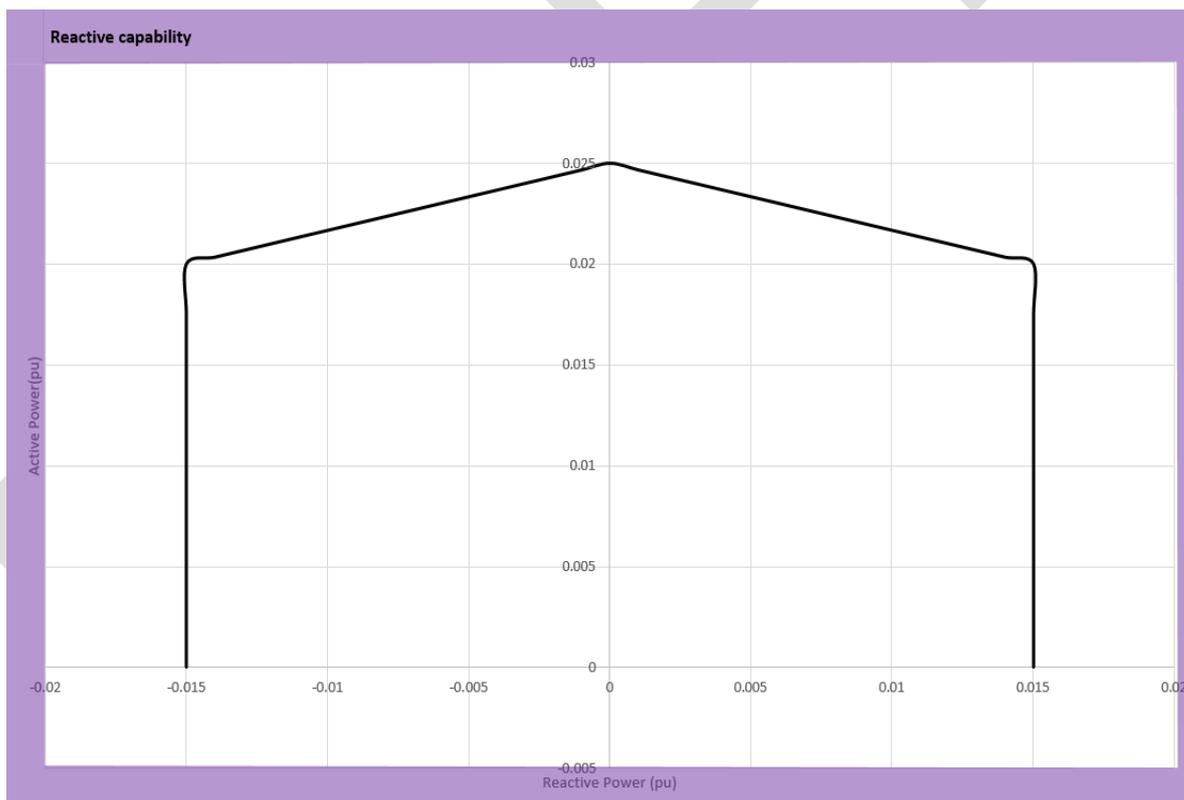
### Measurement data file name and format

[Follow the test data naming convention and file format in section 3.2.2 of this procedure.]

### Acceptance criteria

- *Measurement data covers the entire operating range.*
- *The Generating Units can continuously operate at Reactive Power boundaries.*
- *Measurement data is successfully downloaded and confirmed.*

Figure 2 Typical Reactive Power capability of a solar inverter Generating Unit



### 5.2.3. Generating unit park dispatch control test (HP1\_GUDP, HP1\_GUDQ)

#### Purpose

- *To validate Active Power dispatch and Reactive Power dispatch of the Generating Units.*
- *To validate Generating Unit model parameters related to Active Power and Reactive Power limits.*

- To partially assess compliance with Technical Requirement A12.17.

### Generating unit Active Power dispatch test (HP1\_GUDP)

#### Pre-test conditions

- *Generating units are operated with the park dispatch control enabled.*
- *Central park controller is configured to local control and is in Active Power and Reactive Power control mode.*
- *All reactive support devices are off-line.*
- *The Generating System transformers are in manual control (fixed tap).*
- *The Generating Units are operating at above 80% of rated active power output<sup>17</sup>.*

#### Methodology and procedure

- *Pre-test conditions are confirmed.*
- *Confirm measurement systems are calibrated, tested and checked accordingly, and ready to record data;*
- *Apply a -20% step to the active power dispatch setpoint (Pdsp).*
- *Allow at least 10 seconds pre-triggered recording and at least 60 seconds recording time after the response has settled at its steady-state value before the next test (step) commences.*
- *Return Pdsp to the pre-test value.*
- *Wait until the response settles.*
- *Confirm the Generating Units are still generating over 80% of rated output.*
- *Repeat the test with a -50% step.*
- *View test data file to ensure it has been successfully saved.*

#### Signals to be measured and plotted

[Provide a table of signals to be measured and plotted for this test. Table 18 shows an example of all signals available for measurement and highlights those that need to be plotted and compared against the respective simulated response.]

#### Measurement data file name and format

[Follow the naming convention in section 3.2.2 of this procedure.]

#### Acceptance criteria

[Acceptance criteria must include all relevant performance as described in the Generating System's Registered Generator Performance Standard.]

- *The Active Power response accurately follows the reference setpoint.*
- *Generating unit Active Power rate of change (ramp rate) consistent with the configured ramp rate in the controller.*
- *The Generating Unit is able to return to stable operation after each step.*
- *Overlays of measured and simulated responses for the Generating Unit park dispatch control test are submitted as part of Hold Point reports. To assess compliance,  $\pm 10\%$  accuracy bands are superimposed on the graphs in accordance with the Generator and Load Model Guidelines.*

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<sup>17</sup> Specific minimum generation level must be agreed with AEMO and Western Power.

- *Measurement data is successfully downloaded and confirmed.*

### Generating unit Reactive Power dispatch test (HP1\_GUDQ)

#### Pre-test conditions

- *Confirm measurement systems are calibrated, tested and checked accordingly, and ready to record data;*
- *Generating units under test are operated with the park dispatch control enabled.*
- *Central park controller is configured to local control and is in Active Power and Reactive Power control mode.*
- *All reactive support devices are off-line.*
- *Generating system transformers are in manual control (fixed tap).*
- *Generating units are operating at above 80% of rated Active Power output<sup>17</sup>.*

#### Methodology and procedure

- *Pre-test conditions are confirmed.*
- *The reactive dispatch (Qdsp) is set to 0 MVar, i.e. the Generating Unit generates 0 MVar at its terminals.*
- *Apply a small positive Reactive Power step to the Reactive Power dispatch setpoint Qdsp.*
- *Wait until the response settles.*
- *Allow at least 10 seconds pre-triggered recording and at least 60 seconds recording time after the response has settled at its steady-state value before the next test (step) commences.*
- *Return the Qdsp to 0 MVar.*
- *Wait until the response settles.*
- *Allow at least 10 seconds pre-triggered recording and at least 60 seconds recording time after the response has settled at its steady-state value before the next test (step) commences.*
- *Confirm the Generating Units are still above 80% of rated output.*
- *Repeat the test with a  $\pm 25\%$  steps,  $\pm 50\%$  steps and  $\pm 75\%$  steps.*
- *View test data file to ensure it has been successfully saved.*

#### Signals to be measured and plotted

[Provide a table of signals to be measured and plotted for this test. Table 18 shows an example of all signals available for measurement and highlights those that need to be plotted and compared against the respective simulated response.]

#### Measurement data file name and format

[Follow the test data naming convention and file format in section 3.2.2 of this procedure.]

#### Acceptance criteria

[Acceptance criteria must include all relevant performance as described in the Generating System's Registered Generator Performance Standard.]

- *The Reactive Power response follows the reference correctly.*
- *The Generating Unit returns to stable operation after each step.*
- *Measurement data is successfully downloaded and confirmed.*

- Overlays of measured and simulated responses for the Generating Unit park dispatch control test are submitted as part of Hold Point reports. To assess compliance,  $\pm 10\%$  accuracy bands are superimposed on the graphs in accordance with the Generator and Load Model Guidelines.

**Table 18 Signals to be measured for Generating Unit and park dispatch control tests - example**

| Signals to be measured  | Signals for model overlay | Sampling rate   | Record time window  |
|---|---------------------------|---|---|
| Voltage at Connection Point   | ✓                         | Min. sampling rate of 100 Hz for steady state tests and 2 kHz for dynamic tests | Allow at least 10 seconds pre-triggered recording and at least 60 seconds recording time after the response has settled at its steady-state value |
| Active power at Connection Point  | ✓                         |   |   |
| Reactive power at Connection Point  | ✓                         |   |   |
| Voltage at T1HV   |                           |   |   |
| Active power at T1HV  |                           |   |   |
| Reactive power at T1HV  |                           |   |   |
| Voltage at T2HV   |                           |   |   |
| Active power at T2HV  |                           |   |   |
| Reactive power at T2HV  |                           |   |   |
| Voltage at the central park level controller (if at a different location to above locations)        |                           |   |   |
| Active power at the central park level controller (if at a different location to above locations)   |                           |   |   |
| Reactive power at the central park level controller (if at a different location to above locations) |                           |   |   |
| Voltage at T1MV   | ✓                         |   |   |
| Active power at T1MV  | ✓                         |   |   |
| Reactive power at T1MV  | ✓                         |   |   |
| Voltage at T2MV   | ✓                         |   |   |
| Active power at T2MV  | ✓                         |   |   |
| Reactive power at T2MV  | ✓                         |   |   |
| Terminal voltage of all Generating Units with high-speed data recorders                             | ✓                         |   |   |
| Active power of all Generating Units with high-speed data recorders                                 | ✓                         |   |   |
| Reactive power of all Generating Units with high-speed data recorders                               | ✓                         |   |   |
| Active current of all Generating Units with high-speed data recorders                               | ✓                         |   |   |
| Reactive current of all Generating Units with high-speed data recorders                             | ✓                         |   |   |
| Wind speed variations   |                           |   |   |
| Solar irradiance variations   |                           |   |   |
| Status of reactive support plant before and after test  |                           |   |   |

| Signals to be measured  | Signals for model overlay | Sampling rate | Record time window |
|---|---------------------------|---------------|--------------------|
| Status of all Generating Units (online, trip, pause) before and after the test  |                           |               |                    |
| Voltage reference   | ✓                         |               |                    |
| Active power dispatch reference   | ✓                         |               |                    |
| Reactive power dispatch reference   | ✓                         |               |                    |
| Power factor setpoint reference   | ✓                         |               |                    |
| Frequency control setpoint reference  | ✓                         |               |                    |
| Any other applicable command signal   |                           |               |                    |
| <i>Other signals as agreed in the Registered Generator Performance Standard</i> |                           |               |                    |

#### 5.2.4. Static reactive support device manual switching test (HP1\_SRS)

##### Purpose

[This test may alternatively be conducted at other Hold Points]

- To partially assess compliance with Technical Requirement A12.4 with respect to voltage and Reactive Power control of the Generating System.
- To partially assess compliance with Technical Requirement A12.8 with respect to the Generating System and each of its operating Generating Units to remain in Continuous Uninterrupted Operation.
- To assess response of coordinated voltage control strategy of the Generating System and validate associated simulation models, i.e. between the dynamic reactive support devices and Generating Units (if applicable).
- To assess compliance with Technical Requirement A12.14 with respect to confirmation of:
  - SCADA feedback signals.
  - Communication equipment.
- To assess compliance with Technical Requirement A12.17 with respect to validation of:
  - the dynamic reactive support control system model and parameters (if applicable).
  - the park dispatch control model and parameters.

##### Pre-test conditions

[The minimum generation level at each Hold Point must be agreed with AEMO and Western Power]

- Measurement systems are calibrated, tested and checked accordingly.
- Risk assessment complete and risk mitigation controls applied.
- Obtain a screen shot of the plant's HMI demonstrating operational state of the plant before and after testing.
- Maximum Generating System output is at the agreed HP1 MW level.
- Total output of the Generating Units is above 80% of HP1 MW level.
- Generating units are under park dispatch control.
- The Generating System is in default control mode (voltage control mode).
- The dynamic reactive support control system is in service.
- The static reactive support devices are in service but in local manual control.
- The Generating System transformer is under auto control.

### Methodology and procedure

- *Communicate and confirm test with AEMO and Western Power's Control Centre.*
- *Confirm measurement systems are ready to record data.*
- *Configure the Generating System control to local control mode.*
- *Switch-in a static reactive support device, such as a capacitor bank.*
- *Wait until the response settles.*
- *Switch-in another static reactive support device (if available).*
- *Wait until the response settles.*
- *Switch-off the static reactive support device that switched in first.*
- *Wait until the response settles.*
- *Switch-off another static reactive support device (if available).*
- *Wait until the response settles.*
- *Allow at least 10 seconds pre-triggered recording and at least 60 seconds recording time after the response has settled at its steady-state value before the next test (step) commences.*
- *View test data file to ensure it has been successfully saved.*

### Signals to be measured and plotted

[Provide a table of signals to be measured and plotted for this test. Table 18 shows an example of all signals available for measurement and highlights those that need to be plotted and compared against the respective simulated response.]

### Measurement data file name and format

[Follow the test data naming convention and file format in section 3.2.2 of this procedure]

### Acceptance criteria

[Acceptance criteria must include all relevant performance as described in the Generating System's Registered Generator Performance Standard.]

- *The Generating System is able to return to stable operation after each switching action.*
- *The Settling Time of the Generating System's voltage response and Reactive Power response following the switching action complies with the Registered Generator Performance Standard.*
- *The Generating System and each of its operating Generating Units are capable of Continuous Uninterrupted Operation as per the Registered Generator Performance Standard.*
- *The control systems are Adequately Damped.*
- *Measurement data is successfully downloaded and confirmed.*
- *Overlays of measured and simulated responses for the static reactive support device manual switching test are submitted as part of Hold Point reports. To assess compliance,  $\pm 10\%$  accuracy bands are superimposed on the graphs in accordance with the Generator and Load Model Guidelines.*

## 5.2.5. Generating System Active Power control test (HP1\_LOC, HP1\_DIS)

### Purpose

- *To assess compliance with Technical Requirement A12.5 with respect to Active Power control of the Generating System. (e.g. ability to receive instruction electronically, change*

*Active Power linearly at a constant rate and limit the Active Power level or below the dispatch target).*

- *To confirm the Active Power dispatch command from the AEMO Control Centre and the Generating System local control.*
- *To validate ramp up and down rates to a Dispatch Instruction from the AEMO Control Centre (e.g. linear ramping at the end of the dispatch interval as required under Dispatch Systems Requirements).*
- *To validate effective ramp rates with the bid ramp rates.*
- *To confirm the dispatch instruction delivery and processing time delay of the dispatch instruction.*
- *To validate the ramp rate algorithm accuracy.*
- *To assess compliance with Technical Requirement A12.14, A12.15 and A12.16 with respect to:*
  - SCADA feedback signals.
  - Remote monitoring and control of the Generating System's Active Power output.
  - Communication paths.
- *To assess compliance with Technical Requirement A12.17 with respect to model validation of Active Power Control System model and parameters.*

#### **Generating System Active Power control (local control) test (HP1\_LOC)**

##### **Pre-test conditions**

- *If required, pre-test simulation studies to verify the extent of changes in Active Power at the Connection Point that would not adversely impact the area to which the Generating System is connected. Measurement systems are calibrated, tested and checked accordingly.*
- *Obtain a screenshot of the plant's HMI demonstrating operational state of the plant before and after testing.*
- *Confirm implemented ramp rates in the controller.*
- *Maximum Generating System output is at the agreed HP1 MW level.*
- *Total output of the Generating Units is above 80%<sup>18</sup> of HP1 MW level.*
- *Generating units are under park dispatch control.*
- *The Generating System is in default control mode, e.g. voltage control mode.*
  - The dynamic reactive support control system is in service.
  - The static reactive support devices are in service and in auto control (if applicable).
- *The Generating System step-up transformer automatic voltage regulator is enabled.*

##### **Methodology and procedure**

- *Communicate and confirm test with AEMO and Western Power's Control Centre.*
- *Confirm measurement systems are ready to record data.*
- *This test is generally conducted in two stages and carried out in HP1, HP2 and HP3.*
- *The first stage of the test involves Active Power control test initiated through local Generating System park controller (HP1\_LOC), and conducted as follows:*
  - Configure the Generating System control to local control mode.
  - Apply a -20% step (20% of HP1 output level) to the Active Power reference of the park dispatch controller.

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<sup>18</sup> Specific minimum *generation* level at each hold point must be agreed with AEMO and Western Power.

- Wait until the response settles.
- Allow at least 10 seconds pre-triggered recording and at least 60 seconds recording time after the response has settled at its steady-state value before the next test (step) commences.
- Return the Pdsp to pre-test level.
- Wait until the response settles.
- Allow at least 10 seconds pre-triggered recording and at least 60 seconds recording time after the response has settled at its steady-state value before the next test (step) commences.
- Confirm the Generating System output is above 80% of HP1 MW level.
- Repeat the test with -50% and -90% steps.
- View test data file to ensure it has been successfully saved.

### Signals to be measured and plotted

[Provide a table of signals to be measured and plotted for this test. Table 18 shows an example of all signals available for measurement and highlights those that need to be plotted and compared against the respective simulated response.]

### Measurement data file name and format

[Follow the test data naming convention and file format in section 3.2.2 of this procedure]

### Acceptance criteria

[Acceptance criteria must include all relevant performance as described in the Generating System's Registered Generator Performance Standard.]

- *The Generating System is able to return to stable operation after each step.*
- *There are no unplanned trips.*
- *Active power output ramps linearly (Ramp up and down rate) at a rate as required by the Registered Generator Performance Standard.*
- *Active Power Control System is Adequately Damped.*
- *Measurement data is successfully downloaded and confirmed.*
- *Overlays of measured and simulated responses of the Generating System Active Power dispatch test are submitted as part of Hold Point reports. To assess compliance,  $\pm 10\%$  accuracy bands are superimposed on the graphs in accordance with the Generator and Load Model Guidelines.*

### Generating System Active Power control (dispatch instruction) test (HP1\_DIS)

[This is the second stage of the Active Power control test and is conducted after the successful completion of Generating System level testing. It represents the functional/operational tests which complement the compliance tests defined by GPS and is required for the Participant's eventual dispatch in the WEM. This test is initiated by a dispatch signals from the AEMO Control Centre. The purpose of these set of tests is to ensure that the Facility is controllable and dispatchable by AEMO for power system security purposes.

The Market Participant submits bids to achieve the required Active Power dispatch levels, which must be captured in an approved Commissioning Test Plan (CTP). The dispatch signal from AEMO's Control Centre and subsequent Generating System response must be monitored to confirm end-to-end communication of Active Power dispatch command from the AEMO Control Centre through to each Generating Unit.

The set of tests are dependent on configuration and technology type and sent through AEMO's Automatic Generation Control (AGC) system via SCADA. Subject to discussion with AEMO, the tests should include:

- Dispatch Instructions: higher and lower, injection and withdrawal (where applicable), crossing 0MW, DI to 0MW (from injection and withdrawal)
- Ramp – Up, Down, changing ramp rates
- Remote control – arbitrary Dispatch Instructions (no response to remote signals)]

#### Pre-test conditions

- *Confirm measurement systems are calibrated, tested and checked accordingly, and ready to record data.*
- *Obtain a screenshot of the plant's HMI demonstrating operational state of the plant before and after testing.*
- *Maximum Generating System output is at the agreed Hold Point MW level.*
- *Total output of the Generating Units is above 80%<sup>19</sup> of HP1 MW level.*
- *Generating units are under park dispatch control.*
- *The Generating System is in default control mode, e.g. voltage control mode.*
- *The dynamic reactive support control system is in service.*
- *The static reactive support devices are in service and in auto control (if applicable).*
- *The Generating System step-up transformer automatic voltage regulator is enabled.*
- *AGC tests complete during SCADA tests.*

#### Methodology and procedure

*This test is initiated by an Active Power dispatch signal from the AEMO Control Centre and conducted as follows:*

- *Communicate and confirm test with AEMO and Western Power's Control Centre.*
- *Configure the Generating System to remote control mode.*
- *The Market Participant submits bids to demonstrate AGC dispatch functionality (DI, ramping, remote control).*
- *The dispatch signal from the AEMO Control Centre and subsequent Generating System response will be monitored to confirm end-to-end communication of Active Power dispatch command from the AEMO Control Centre through to each Generating Unit.*
- *Record dispatch instruction delivery and processing time delay.*
- *View test data file to ensure it has been successfully saved.*

#### Signals to be measured and plotted

[Provide a table of signals to be measured and plotted for this test. Table 18 shows an example of all signals available for measurement and highlights those that need to be plotted and compared against the respective simulated response.]

#### Measurement data file name and format

[Follow the test data naming convention and file format in section 3.2.2 of this procedure]

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<sup>19</sup> Specific minimum generation level at each hold point must be agreed with AEMO and Western Power.

## Acceptance criteria

[Acceptance criteria must include all relevant performance as described in the Generating System's Registered Generator Performance Standard.]

- *The Generating System meets the Dispatch Systems Requirements.*
- *There are no unplanned trips.*
- *Active power output ramps linearly at the desired MW per minute (per SCADA signal control) from one level of dispatch to another at the end of dispatch interval.*
- *The Generating System ramp rate algorithm is consistent with the Dispatch Systems Requirements.*
- *Effective ramp up and down rates consistent with the ramp rate algorithm.*
- *Dispatch Instruction delivery delay time and processing time meet Dispatch Systems Requirements.*
- *Measurement data is successfully downloaded and confirmed.*

### 5.2.6. Generating System Reactive Power Capability test (HP1\_RPC)

#### Purpose

- *To partially assess compliance with Technical Requirement A12.2 with respect to Active Power capability of the Generating System.*
- *To partially assess compliance with Technical Requirement A12.3 with respect to Reactive Power Capability of the Generating System.*

#### Pre-test conditions

- *Measurement systems are calibrated, tested and checked accordingly.*
- *If required, pre-test simulation studies to verify the extent of changes in network voltage and Reactive Power at the Connection Point that would not adversely impact the area to which the Generating System is connected.*
- *Risk assessment complete and risk mitigation controls applied.*
- *Monitor and record the ambient temperature before, during and after the test.*
- *Obtain a screenshot of the plant's HMI demonstrating operational state of the plant before and after testing.*
- *The total output of the Generating Units is above 80% of HP1 MW level<sup>17</sup>.*
- *One collector group feeder is energised. All other collector group feeders are deenergised.*
- *The Generating Units are in park dispatch control.*
- *The Generating System is in default control mode.*
- *The dynamic and static reactive support plant are in service (if applicable).*
- *The Generating System transformers are under auto control.*

#### Methodology and procedure

- *Communicate and confirm test with AEMO and Western Power's Control Centre.*
- *Confirm measurement systems are ready to record data.*
- *The Generating System is operated at a wide range of operating conditions including Reactive Power supply and absorption boundaries. Figure 2 shows a typical inverter-based Generating System Generator Performance Chart with minimum operating points that are required to be captured during an HP1 test.*
- *Configure the Generating System control to local control mode.*

- *Configure the Generating System control mode to Reactive Power control.*
- *Load the Generating System to the operating condition specified in Figure 2.*
- *Wait until the response settles to ensure no control system limitation, protection system or other limiting device in operation that would prevent the Generating System from providing the Reactive Power output*
- *Allow the Generating Units to run for 10-15 minutes at each operating point.*
- *While the Generating System is continuously running, view test data file to ensure it has been successfully saved before moving to the next operating condition.*

#### **Signals to be measured and plotted**

[Provide a table of signals to be measured and plotted for this test. Table 18 shows an example of all signals available for measurement and highlights those that need to be plotted and compared against the respective simulated response.]

#### **Measurement data file name and format**

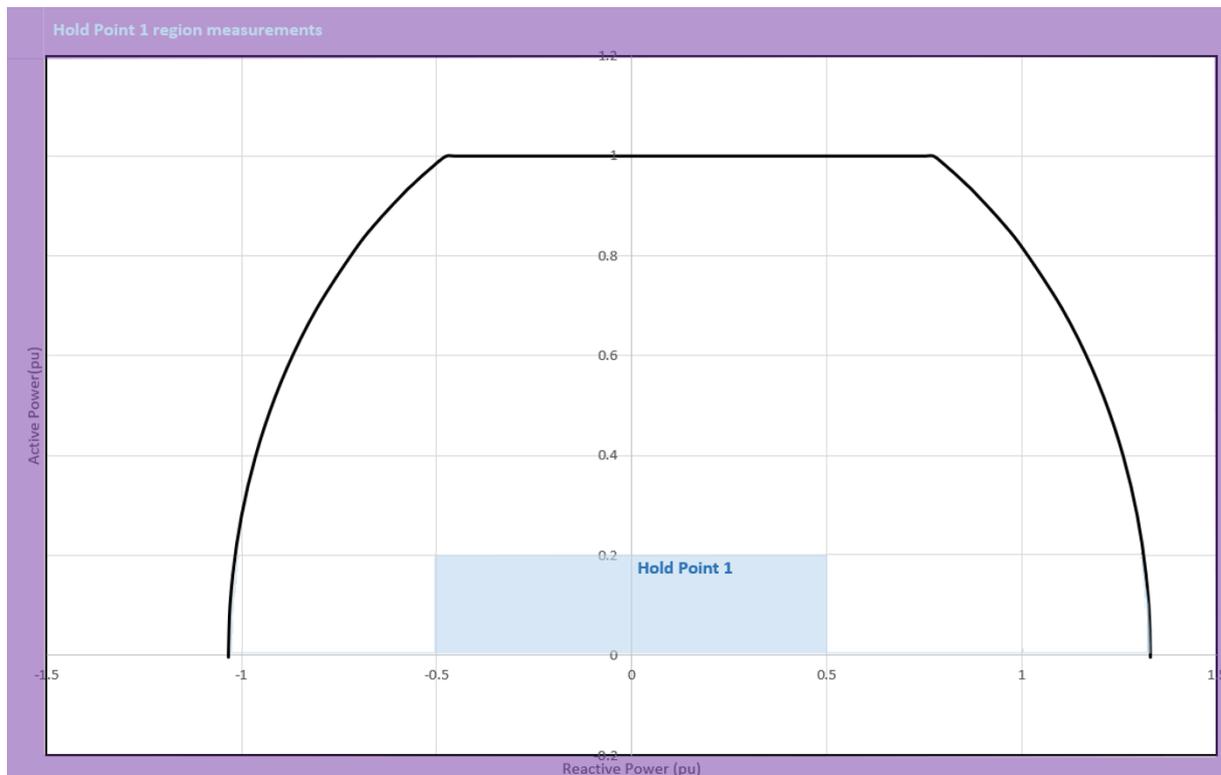
[Follow the test data naming convention and file format in section 3.2.2 of this procedure]

#### **Acceptance criteria**

[Acceptance criteria must include all relevant performance as described in the Generating System's Registered Generator Performance Standard.]

- *The Generating System can continuously run for 10-15 minutes under each reactive boundary operating condition.*
- *Voltage, Active Power and Reactive Power at the Connection Point and Generating Units' terminals are stable.*
- *The Generating System's Reactive Power Capability is consistent with the Registered Generator Performance Standard.*
- *Measurement data is successfully downloaded and confirmed.*

**Figure 3 Inverter-based Generating System Generator Performance Chart and measurement conditions for HP1**



### 5.2.7. Generating System Reactive Power reference test (HP1\_RPT)

#### Purpose

- To assess compliance with Technical Requirement A12.4 with respect to Reactive Power control of the Generating System.
- To assess compliance with Technical Requirement A12.17 with respect to validation of:
  - static and dynamic reactive support control system model and parameters (if applicable).
  - the Reactive Power Control System model and parameters.

#### Pre-test conditions

- If required, pre-test simulation studies to verify the extent of changes in network voltage and Reactive Power at the Connection Point that would not adversely impact the area to which the Generating System is connected.
- Measurement systems are calibrated, tested and checked accordingly.
- Risk assessment complete and risk mitigation controls applied.
- Obtain a screenshot of the plant's HMI demonstrating the plant's operational state before and after testing.
- Maximum Generating System output is the agreed HP1 MW level.
- Total output of the Generating Units is above 80%<sup>20</sup> of HP1 MW level.
- Generating units are under park dispatch control in Active Power and Reactive Power control mode.

<sup>20</sup> Specific minimum generation level at each hold point must be agreed with AEMO and Western Power.

- All reactive support plants are off-line.
- The Generating System step-up transformer automatic voltage regulator is enabled.

#### Methodology and procedure

- Communicate and confirm test with AEMO and Western Power's Control Centre.
- Confirm measurement systems are ready to record data.
- Confirm measurement systems are calibrated, tested and checked accordingly, and ready to record data.
- Pre-test conditions are confirmed.
- The reactive reference ( $Q_{ref}$ ) is set to 0 MVAR, i.e. the Generating Unit generates 0 MVAR at its terminals.
- Apply a small positive Reactive Power step to the Reactive Power reference setpoint  $Q_{ref}$ .
- Typically, 25% of possible Reactive Power available.
- Wait until the response settles.
- Allow at least 10 seconds pre-triggered recording and at least 60 seconds recording time after the response has settled at its steady-state value before the next test (step) commences.
- Return the  $Q_{ref}$  to 0 MVAR.
- Wait until the response settles.
- Allow at least 10 seconds pre-triggered recording and at least 60 seconds recording time after the response has settled at its steady-state value before the next test (step) commences.
- Confirm the Generating Units are still above 60% of rated output.
- Repeat the test with a -25% step,  $\pm 50\%$  steps and  $\pm 75\%$  steps starting from multiple levels of initial Reactive Power output.
- View test data file to ensure it has been successfully saved.

#### Signals to be measured and plotted

[Provide a table of signals to be measured and plotted for this test. Table 18 shows an example of all signals available for measurement and highlights those that need to be plotted and compared against the respective simulated response.]

#### Measurement data file name and format

[Follow the test data naming convention and file format in section 3.2.2 of this procedure]

#### Acceptance criteria

[Acceptance criteria must include all relevant performance as described in the Generating System's Registered Generator Performance Standard.]

- The Reactive Power Control System follows the Reactive Power reference correctly.
- The Reactive Power setpoint to be continuously controllable across the range of the Generator Performance Chart.
- The Generating System is able to switch between control modes in accordance with the Registered Generator Performance Standard.
- There are no unplanned trips.
- The Reactive Power Control System is able to regulate the Reactive Power at the Connection Point within 2% of the Nameplate Rating (in MVA) of the Generating System (expressed in MVAR).
- The Reactive Power Control System is Adequately Damped.

- *Measurement data is successfully downloaded and confirmed.*
- *Overlays of measured and simulated responses of the Generating System Reactive Power setpoint test are submitted as part of Hold Point reports. To assess compliance,  $\pm 10\%$  accuracy bands are superimposed on the graphs in accordance with the Generator and Load Model Guidelines.*

### 5.2.8. Generating System voltage reference step test (HP1\_VCT)

#### Purpose

- *To assess compliance with Technical Requirement A12.4 with respect to voltage control capability.*
- *To assess response of coordinated voltage control strategy of the Generating System and validate associated simulation models (if applicable).*
- *To assess compliance with Technical Requirement A12.17 with respect to validation of:*
  - *static and dynamic reactive support control system model and parameters (if applicable).*
  - *the voltage Control System model and parameters.*

#### Pre-test conditions

- *If required, pre-test simulation studies to verify the extent of changes in network voltage and Reactive Power at the Connection Point that would not adversely impact the area to which the Generating System is connected.*
- *Measurement systems are calibrated, tested and checked accordingly.*
- *Confirm with Western Power the target voltage and droop at the Connection Point.*
- *Risk assessment complete and risk mitigation controls applied.*
- *Obtain a screenshot of the plant's HMI demonstrating the plant's operational state before and after testing.*
- *Maximum Generating System output is at the agreed HP1 MW level.*
- *Total output of the generating units is above  $80\%^{21}$  of HP1 MW level.*
- *Generating units are under park dispatch control.*
- *The Generating System is in voltage control mode.*
- *The Generating System step-up transformer automatic voltage regulator is enabled.*

#### Methodology and procedure

- *Communicate and confirm test with AEMO and Western Power's Control Centre.*
- *Confirm measurement systems are ready to record data.*
- *Configure the Generating System control to local control mode.*
- *Apply a  $\pm 2.5\%$  step to Vref.*
- *Apply a  $\pm 2.5\%$  return step to Vref.*
- *Apply a  $\pm 5\%$  step to Vref.*
- *Apply a  $\pm 5\%$  return step to Vref.*
- *Allow at least 10 seconds pre-triggered recording and at least 60 seconds recording time after the response has settled at its steady-state value before the next test (step) commences.*
- *View test data file to ensure it has been successfully saved.*
- *Repeat the test starting from multiple levels of initial Reactive Power output.*

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<sup>21</sup> Specific minimum generation level at each hold point must be agreed with AEMO and Western Power.

### Signals to be measured and plotted

[Provide a table of signals to be measured and plotted for this test. Table 18 shows an example of all signals available for measurement and highlights those that need to be plotted and compared against the respective simulated response.]

### Measurement data file name and format

[Follow the test data naming convention and file format in section 3.2.2 of this procedure]

### Acceptance criteria

[Acceptance criteria must include all relevant performance as described in the Generating System's Registered Generator Performance Standard.]

- *The Generating System's voltage Control System regulates voltage at the Connection Point to within 0.5% of the setpoint, where that setpoint is adjusted based on 4% voltage droop.*
- *The Generating System is able to switch between control modes in accordance with the Registered Generator Performance Standard.*
- *The Generating System is able to return to stable operation after each step.*
- *There are no unplanned trips.*
- *The voltage and Reactive Power Rise Time following a 5% step change in the voltage Control System reference meets the Registered GPS.*
- *The Settling Time of Active Power, Reactive Power and voltage response following a 5% voltage step change meets the Registered GPS.*
- *The voltage Control System outputs are Adequately Damped.*
- *Measurement data is successfully downloaded and confirmed.*
- *Overlays of measured and simulated responses of the Generating System voltage reference step tests are submitted as part of Hold Point reports. To assess compliance,  $\pm 10\%$  accuracy bands are superimposed on the graphs in accordance with the Generator and Load Model Guidelines.*

## 5.2.9. Generating System Power Factor reference step test (HP1\_PFT)

### Purpose

- *To assess compliance with Technical Requirements A12.4 with respect to Power Factor Control System.*
- *To assess compliance with Technical Requirement A12.17 with respect to validation of:*
  - *static and dynamic reactive support control system model and parameters (if applicable).*
  - *the Power Factor Control System model and parameters.*

### Pre-test conditions

- *If required, pre-test simulation studies to verify the extent of changes in network voltage and Reactive Power at the Connection Point that would not adversely impact the area to which the Generating System is connected.*
- *Measurement systems are calibrated, tested and checked accordingly.*
- *Risk assessment complete and risk mitigation controls applied.*
- *Obtain a screenshot of the plant's HMI demonstrating the plant's operational state before and after testing.*
- *Maximum Generating System output is at the agreed HP1 MW level.*

- Total output of the generating units is above 80%<sup>22</sup> of HP1 MW level.
- Generating units are under park dispatch control.
- The Generating System is in Power Factor control mode and the Power Factor reference (PFref) is set to unity.
- The Generating System step-up transformer automatic voltage regulator is enabled.

#### Methodology and procedure

- Communicate and confirm test with AEMO and Western Power's Control Centre.
- Confirm measurement systems are ready to record data.
- Configure the Generating System control to local control mode.
- Set Pfref to 0.99 capacitive.
- Set Pfref back to unity.
- Set Pfref to 0.99 inductive.
- Set Pfref back to unity.
- Set Pfref to 0.95 (or plant GPS limit) capacitive.
- Set Pfref back to unity.
- Set Pfref to 0.95 (or plant GPS limit) inductive.
- Set Pfref back to unity.
- Allow at least 10 seconds pre-triggered recording and at least 60 seconds recording time after the response has settled at its steady-state value before the next test (step) commences.
- View test data file to ensure it has been successfully saved.
- Repeat the test starting from multiple levels of initial Reactive Power output.

#### Signals to be measured and plotted

[Provide a table of signals to be measured and plotted for this test. Table 18 shows an example of all signals available for measurement and highlights those that need to be plotted and compared against the respective simulated response.]

#### Measurement data file name and format

[Follow the test data naming convention and file format in section 3.2.2 of this procedure]

#### Acceptance criteria

[Acceptance criteria must include all relevant performance as described in the Generating System's Registered Generator Performance Standard.]

- The Generating System is able to return to stable operation after each step.
- The Reactive Power Control System outputs are Adequately Damped.
- Measurement data is successfully downloaded and confirmed.
- Power factor setpoint is continuously controllable across the Generator Performance Chart in the Registered Generator Performance Standard.
- The Power Factor Control System can regulate the Power Factor at the Connection Point within the tolerance band in the Registered Generator Performance Standard.
- Overlays of measured and simulated responses of the Generating System Power Factor setpoint tests are submitted as part of Hold Point reports. To assess compliance,  $\pm 10\%$

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<sup>22</sup> Specific minimum generation level at each hold point must be agreed with AEMO and Western Power.

*accuracy bands are superimposed on the graphs in accordance with the Generator and Load Model Guidelines.*

### 5.2.10. Generating System transformer manual tap position change test (HP1\_TXT)

#### Purpose

- *To assess compliance with Technical Requirement A12.4 and A12.8 with respect to the Generating System and Generating units' response to small voltage disturbances caused by transformer tap changes.*
- *To assess compliance with Technical Requirement A12.17 with respect to validation of dynamic model and parameters of the:*
  - *Generating Units.*
  - *Transformer tap changer (if applicable).*
  - *Central park level controller.*
  - *Generating System Control System.*
  - *Coordinated voltage control scheme (if applicable).*
- *To assess compliance with Technical Requirement A12.14 and A12.16 with respect to confirmation of:*
  - *SCADA feedback signals.*
  - *Communication equipment.*

#### Pre-test conditions

- *If required, pre-test simulation studies to verify the extent of changes in network voltage and Reactive Power at the Connection Point that would not adversely impact the area to which the Generating System is connected.*
- *Measurement systems are calibrated, tested and checked accordingly.*
- *Maximum Generating System output is at the agreed HP1 MW level.*
- *Total output of the generating units is above 80%<sup>23</sup> of HP1 MW level.*
- *Generating units are under park dispatch control.*
- *The Generating System is in voltage control mode.*
- *The Generating System transformer is under manual control (fixed tap).*

#### Methodology and procedure

- *Confirm measurement systems are calibrated, tested and checked accordingly, and ready to record data.*
- *Configure the Generating System control to local control mode.*
- *Vary Generating System's transformer tap position with the range identified from the pre-test simulation with one tap position at each step.*
- *Monitor closely the voltage at the Connection Point, MV collection grid, and LV terminals of generating units and reactive support devices to make sure that all voltages are within  $\pm 10\%$  of nominal all the time.*
- *Allow at least 60 seconds recording time after the response settled at steady state before the next test (step) commences.*
- *View test data file to ensure it has been successfully saved.*

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<sup>23</sup> Specific minimum generation level at each HP must be agreed with AEMO and Western Power.

### Signals to be measured and plotted

[Provide a table of signals to be measured and plotted for this test. Table 18 shows an example of all signals available for measurement and highlights those that need to be plotted and compared against the respective simulated response.]

### Measurement data file name and format

[Follow the test data naming convention and file format in section 3.2.2 of this procedure]

### Acceptance criteria

[Acceptance criteria must include all relevant performance as described in the Generating System's Registered Generator Performance Standard.]

- *The Generating System is able to return to stable operation after each step.*
- *Measurement data is successfully downloaded and confirmed.*
- *Overlays of measured and simulated responses of the Generating System transformer manual tap position change test are submitted as part of Hold Point reports. To assess compliance,  $\pm 10\%$  accuracy bands are superimposed on the graphs in accordance with the Generator and Load Model Guidelines.*

### 5.2.11. Generating System voltage, Reactive Power and Power Factor remote control mode test (HP1\_VRC)

#### Purpose

- *To assess compliance with Technical Requirement A12.4 for the procedure when the Generating System switches between control modes as per the Registered Generator Performance Standard.*
- *To assess compliance with Technical Requirement A12.14, A12.15 and A12.16 with respect to:*
  - SCADA feedback signals.
  - Remote monitoring and control of the Generating System's voltage, Reactive Power and Power Factor control modes.
  - Communication paths.

#### Pre-test conditions

- *If required, pre-test simulation studies to verify the extent of changes in network voltage and Reactive Power at the Connection Point that would not adversely impact the area to which the Generating System is connected.*
- *Measurement systems are calibrated, tested and checked accordingly.*
- *Confirm with Western Power the target voltage and droop at the Connection Point.*
- *Risk assessment complete and risk mitigation controls applied.*
- *Obtain a screenshot of the plant's HMI demonstrating the plant's operational state before and after testing.*
- *Maximum Generating System output is at the agreed HP1 MW level.*
- *Total output of the generating units is above 80%<sup>24</sup> of HP1 MW level.*
- *Generating units are under park dispatch control.*
- *The Generating System is in voltage control mode.*

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<sup>24</sup> Specific minimum generation level at each hold point must be agreed with AEMO and Western Power.

- The Generating System step-up transformer automatic voltage regulator is enabled.

#### Methodology and procedure

- Communicate and confirm test with AEMO and Western Power's Control Centre.
- Confirm measurement systems are ready to record data.
- Configure the Generating System control to remote control mode.

The following steps are initiated by Western Power Control Centre and conducted via the Energy Management System (EMS) interface:

#### **Test A – Change voltage setpoint in voltage control mode**

- Check the Generating System is in voltage control mode.
- Set voltage setpoint to the voltage monitored at the Connection Point.
- Decrease the voltage by 0.02pu (or another value as appropriate).
- Wait until the voltage step-change at the Connection Point is verified in the EMS.
- Increase the voltage by 0.02pu (or another value as appropriate).
- Wait until the voltage step-change at the Connection Point is verified in the EMS.

#### **Test B – Change Reactive Power setpoint in Reactive Power control mode**

- Set Reactive Power setpoint to 2 Mvar less than the current Reactive Power output at the Connection Point.
- Set the Generating System to Reactive Power mode.
- Check that the Reactive Power at the Connection Point remains the same (for Control Systems that support bumpless transfer)
- Set the Reactive Power setpoint to 3 Mvar absorb (or another absorb value as appropriate).
- Wait until the Reactive Power step-change at the Connection Point is verified in the EMS.
- Set the Mvar setpoint to 3 Mvar supply (or another supply value as appropriate).
- Wait until the Reactive Power step-change at the Connection Point is verified in the EMS.

#### **Test C – Change Power Factor setpoint in Power Factor control mode**

- Set Power Factor setpoint to the current Power Factor at the Connection Point.
- Enable power factor control mode
- Set the power factor setpoint to 0.99 capacitive (or other capacitive value as appropriate).
- Wait until the power factor step-change at the Connection Point is verified in the EMS.
- Set the power factor setpoint to 0.99 inductive (or other inductive value as appropriate).
- Wait until the power factor step-change at the Connection Point is verified in the EMS.

#### **Test D - Return to normal operation**

- Set the Generating System to voltage control mode and in normal operation.

#### Signals to be measured and plotted

[Provide a table of signals to be measured and plotted for this test. Table 18 shows an example of all signals available for measurement and highlights those that need to be plotted and compared against the respective simulated response.]

#### Measurement data file name and format

[Follow the test data naming convention and file format in section 3.2.2 of this procedure]

## Acceptance criteria

[Acceptance criteria must include all relevant performance as described in the Generating System's Registered Generator Performance Standard.]

- *The Generating System is able to return to stable operation after each step.*
- *The voltage, Reactive Power and Power Factor Control System is Adequately Damped.*
- *Measurement data is successfully downloaded and confirmed.*
- *The voltage, Reactive Power and Power Factor at the Connection Point follows the setpoint reference correctly in Western Power's EMS.*
- *The switching between control mode is consistent with the switching procedure as agreed with WP and AEMO.*

### 5.2.12. Generating System frequency control test (HP1\_FCT)

#### Purpose

- *To assess compliance with Technical Requirement A12.6 with respect to frequency control.*
- *To validate dynamic model and associated parameters of the frequency control function in central park level controller.*
- *To assess compliance with Technical Requirement A12.14 with respect to confirmation of:*
  - SCADA feedback signals.
  - Communication equipment.
- *To assess compliance with Technical Requirement A12.17 with respect to validation of dynamic model and parameters of the:*
  - Generating Units.
  - Central park level controller.
  - Generating System Control System.

#### Pre-test conditions

- *If required, pre-test simulation studies to verify the extent of changes in Active Power at the Connection Point that would not adversely impact the area to which the Generating System is connected.*
- *Measurement systems are calibrated, tested and checked accordingly.*
- *Total output of the Generating System is above 90% of HP1 MW.*
- *Total output of the Generating System is above 90% of HP1 MW level (for over-frequency tests).*
- *Total output of the Generating System is above 90% of HP1 MW level but curtailed to 50% of HP1 (for under-frequency tests).*
- *Generating units are under park dispatch control and configured to frequency control mode.*
- *The Generating System is in default control mode.*
- *The Generating System step-up transformer automatic voltage regulator is enabled.*

#### Methodology and procedure

- *Communicate and confirm test with AEMO and Western Power's Control Centre.*
- *Confirm measurement systems are ready to record data.*
- *Configure the Generating System control to local control mode.*
- *Inject frequency step signal in the range of 0 to  $\pm 0.05$  Hz to assess the Generating System's Frequency Dead Band.*

- *Inject a frequency step signal into the frequency controller summing junction. Typical step sizes are  $\pm 0.1$  Hz,  $\pm 0.25$  Hz,  $\pm 1$  Hz and  $\pm 2.0$  Hz<sup>25</sup>.*
- *Allow at least 10 seconds pre-triggered recording and at least 60 seconds recording time after the response has settled at its steady-state value before the next test (step) commences.*

[Include tests with a sequence of frequency step signals to assess the Generating System's capability to:

- respond with larger Active Power changes following a larger frequency deviation within 10 seconds of the initial frequency disturbance.
- where applicable, to sustain an Active Power response beyond the timeframe specified in clause A12.6.2.1(d).
- return to Active Power control as required in Part A12.5 after having met the relevant requirements for Part A12.6.

For Generating Systems that has Electricity Storage such as a battery energy storage system that has charge and discharge mode of operation, include frequency step signals to test the transition from Active Power generation to charging mode and vice-versa.]

#### Signals to be measured and plotted

[Provide a table of signals to be measured and plotted for this test. Table 18 shows an example of all signals available for measurement and highlights those that need to be plotted and compared against the respective simulated response.]

#### Measurement data file name and format

[Follow the test data naming convention and file format in section 3.2.2 of this procedure]

#### Acceptance criteria

[Acceptance criteria must include all relevant performance as described in the Generating System's Registered Generator Performance Standard.]

- *The Generating System returns to stable operation after each test.*
- *There are no unplanned trips.*
- *The Active Power response complies with the frequency control requirements in the Registered Generator Performance Standard.*
- *Measurement data is successfully downloaded and confirmed.*
- *Overlays of measured and simulated responses of the Generating System frequency control tests are submitted as part of Hold Point reports. To assess compliance,  $\pm 10\%$  accuracy bands are superimposed on the graphs in accordance with the Generator and Load Model Guidelines.*

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<sup>25</sup> Step sizes and hold times for *frequency* injection signal must be agreed with AEMO and Western Power.

### 5.2.13. Generating System communication fail test (HP1\_CFT)

#### Purpose

- To assess compliance with Technical Requirement A12.5 with respect to maintaining its Active Power output consistent with its last received dispatch level in the event RME, RCE or Communications are unavailable.
- To assess compliance with Technical Requirement A12.16 to:
  - Verify that the response of the Generating System to a communication failure does not pose any risk to the power system security.
  - Verify the communication failsafe mechanism of the Generating System for communication failures between central park controller and each Generating Unit and central park level controller and measurement equipment.

#### Pre-test conditions

- Measurement systems are calibrated, tested and checked accordingly.
- Communication failsafe mechanism document agreed with Western Power and AEMO.
- Risk assessment complete and risk mitigation controls applied.
- Obtain a screenshot of the plant's HMI demonstrating its operational state before and after testing.
- Record pre-test local limit (Active Power).
- Maximum Generating System output is at the agreed HP2 MW level.
- Total output of the Generating Units is above 80% of HP2 MW level.
- Generating units are under park dispatch control.
- The Generating System is in voltage control mode.

#### Methodology and procedure

- Confirm measurement systems are ready to record data.
- Communicate and confirm test with AEMO and Western Power's Control Centre.
- Allow at least 10 seconds pre-triggered recording and at least 60 seconds recording time after the response has settled at its steady-state value before the next test (step) commences.
- View test data file to ensure it has been successfully saved before the next test (step) commences.
- Record responses for communication failure and communication restoration.
- Record local limit (Active Power) and its last received dispatch level before the next test (step) commence.
- Test A – Initiate a communication failure to one Generating Unit.
- Restore communication link and Generating Unit back online from standby mode before Test B commences.
- Test B – Initiate a communication failure between central plant controller and Generating Units communication.
- Restore communication link and all Generating Units back online from standby mode before Test C commences.
- Test C - Initiate a communication failure between central plant controller and plant controller meters.
- Restore communication link and all Generating Units back online from standby mode.

- *Tests E – Initiate a communication failure between central plant controller and the Network Operator’s Control Centre. This will be coordinated with Western Power’s commissioning support engineer (WP\_CSE)*
- *Restore communication link and the Generating System.*
- *Tests D – If redundant central plant controller available, demonstrate primary plant controller communication failure and redundant plant controller control take over.*

#### Signals to be measured and plotted

[Provide a table of signals to be measured and plotted for this test. Table 18 shows an example of all signals available for measurement and highlights those that need to be plotted and compared against the respective simulated response.]

#### Measurement data file name and format

[Follow the test data naming convention and file format in section 3.2.2 of this procedure.]

#### Acceptance Criteria

[Acceptance criteria must include all relevant performance as described in the Generating System’s Registered Generator Performance Standard.]

- *Pre- and post-local limit (Active Power) calculation accuracy based on Generating Units in service confirmed.*
- *The Generating System and each Generating Unit’s operation is consistent with the communication failsafe mechanisms in the Registered Generator Performance Standard.*
- *Measurement data is successfully downloaded and confirmed.*

### 5.3. Hold Point 2 tests

#### 5.3.1. Generating System Active Power control test (HP2\_LOC, HP2\_DIS)

[This test shall follow the same principles as HP1\_LOC and HP1\_DIS. Please refer to the tests for guidance]

#### 5.3.2. Generating System Reactive Power capability test (HP2\_RPC)

[This test shall follow the same principles as HP1\_RPC. Please refer to the test for guidance. Figure 3 depicts an example test region.]

**Figure 4 Inverter-based Generating System Generator Performance Chart and measurement conditions for HP2**



- 5.3.3. Generating System Reactive Power reference test (HP2\_RPT)  
 [This test shall follow the same principles as HP1\_RPT. Please refer to the test for guidance]
- 5.3.4. Generating System voltage reference step test (HP2\_VCT)  
 [This test shall follow the same principles as HP1\_VCT. Please refer to the test for guidance]
- 5.3.5. Generating System power factor reference step test (HP2\_PFT)  
 [This test shall follow the same principles as HP1\_PFT. Please refer to the test for guidance]
- 5.3.6. Generating System transformer manual tap position change test (HP2\_TXT)  
 [This test shall follow the same principles as HP1\_TXT. Please refer to the test for guidance]
- 5.3.7. Generating System voltage, Reactive Power and Power Factor remote control mode test (HP2\_VRC)  
 [This test shall follow the same principles as HP1\_VRC. Please refer to the test for guidance]
- 5.3.8. Generating System frequency control test (HP2\_FCT)  
 [This test shall follow the same principles as HP1\_FCT. Please refer to the test for guidance]
- 5.3.9. Generating System communication fail test (HP2\_CFT)  
 [This test shall follow the same principles as HP1\_CFT. Please refer to the test for guidance]

### Signals to be measured and plotted

[Provide a table of signals to be measured and plotted for this test. Table 18 shows an example of all signals available for measurement and highlights those that need to be plotted and compared against the respective simulated response.]

### Measurement data file name and format

[Follow the test data naming convention and file format in section 3.2.2 of this procedure.]

### Acceptance Criteria

[Acceptance criteria must include all relevant performance as described in the Generating System's Registered Generator Performance Standard.]

- *Pre- and post-local limit (Active Power) calculation accuracy based on Generating Units in service confirmed.*
- *The Generating System and each Generating Unit's operation is consistent with the communication failsafe mechanisms in the Registered Generator Performance Standard.*
- *Measurement data is successfully downloaded and confirmed.*

### 5.3.10. Partial Generating System trip test (HP2\_PTT)

#### Purpose

- *To assess compliance with Technical Requirements A12.4 and A12.8 with respect to the Generating System and each of its operating Generating Units to remain in Continuous Uninterrupted Operation.*
- *To validate dynamic model of Generating Units, Generating System and all associated Control Systems.*
- *To validate the local limit (Active Power) calculation based on number of Generating Units in service.*

#### Pre-test conditions

- *If required, pre-test simulation studies to verify the extent of changes in network voltage, Active Power and Reactive Power at the Connection Point that would not adversely impact the area to which the Generating System is connected.*
- *Confirm the measurement systems are ready.*
- *Risk assessment complete and risk mitigation controls applied.*
- *Obtain a screenshot of the plant's HMI demonstrating the plant's operational state before and after testing.*
- *Maximum Generating System output is at the agreed HP2 MW level.*
- *Total output of the Generating System is above 90%<sup>26</sup> of HP2 MW level (for over-frequency tests).*
- *Generating units are under park dispatch control.*
- *The Generating System is in default control mode, e.g. voltage control mode.*
- *The Generating System step-up transformer automatic voltage regulator is enabled.*

#### Methodology and procedure

- *Record pre-test local limit (Active Power).*

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<sup>26</sup> Specific minimum generation level at each Hold Point must be agreed with AEMO and Western Power.

- *Communicate and confirm test with AEMO and Western Power's Control Centre.*
- *Confirm measurement systems are ready.*
- *Trip part of the Generating System by either:*
  - *Opening one of feeder circuit breakers to trip the Generating Units connected to that feeder; or*
  - *Opening a main grid transformer circuit breaker for a Generating System with two or more grid transformers.*
- *Allow at least 10 seconds pre-triggered recording and at least 60 seconds recording time after the response has settled at its steady-state value before the next test (step) commences.*
- *Record post-test local limit (Active Power).*

#### Signals to be measured and plotted

[Provide a table of signals to be measured and plotted for this test. Table 18 shows an example of all signals available for measurement and highlights those that need to be plotted and compared against the respective simulated response.]

#### Measurement data file name and format

[Follow the test data naming convention and file format in section 3.2.2 of this procedure]

#### Acceptance criteria

[Acceptance criteria must include all relevant performance as described in the Generating System's Registered Generator Performance Standard.]

- *Generating units not subject to tripping and capable of maintaining Continuous Uninterrupted Operation after partial tripping concludes.*
- *Pre- and post-local limit (Active Power) calculation accuracy based on Generating Units in service confirmed.*
- *Measurement data is successfully downloaded and confirmed.*
- *Overlays of measured and simulated responses of the Generating System partial trip test are submitted as part of Hold Point reports. To assess compliance,  $\pm 10\%$  accuracy bands are superimposed on the graphs in accordance with the Generator and Load Model Guidelines.*

## 5.4. Hold Point 3 tests

### 5.4.1. Power quality test (HP3\_PQT)

[HP3\_PQT shall follow the same principles as HP1\_PQT. Please refer to HP1\_PQT for guidance. A special consideration for HP3\_PQT is to include a variety of Active Power output levels from Minimum Rated Active Power to at least 90% of Rated Maximum Active Power or as specified for HP3 Active Power Levels in section 3.3]

### 5.4.2. Generating System Active Power control test (HP3\_LOC, HP3\_DIS)

[This test shall follow the same principles as HP1\_LOC and HP1\_DIS. Please refer to the test for guidance]

5.4.3. Generating System Reactive Power capability test (HP3\_RPC)

[This test shall follow the same principles as HP1\_RPC. Please refer to the test for guidance. Figure 4 depicts a sample test region.]

**Figure 5 Inverter-based Generating System Generator Performance Chart and measurement conditions for HP3**



5.4.4. Generating System Reactive Power reference test (HP3\_RPT)

[This test shall follow the same principles as HP1\_RPT. Please refer to the test for guidance]

5.4.5. Generating System voltage reference step test (HP3\_VCT)

[This test shall follow the same principles as HP1\_VCT. Please refer to the test for guidance]

5.4.6. Generating System power factor reference step test (HP3\_PFT)

[This test shall follow the same principles as HP1\_PFT. Please refer to the test for guidance]

5.4.7. Generating System transformer manual tap position change test (HP3\_TXT)

[This test shall follow the same principles as HP1\_TXT. Please refer to the test for guidance]

5.4.8. Generating System voltage, Reactive Power and power factor remote control mode test (HP3\_VRC)

[This test shall follow the same principles as HP1\_VRC. Please refer to the test for guidance]

#### 5.4.9. Generating System frequency control test (HP3\_FCT)

[This test shall follow the same principles as HP2\_ FCT. Please refer to the test for guidance]

#### 5.4.10. Low energy source availability tests (HP3\_LES)

##### Purpose

*To assess stability of the voltage Control System under low wind conditions.*

##### Pre-test conditions

- *Measurement systems are calibrated, tested and checked accordingly.*
- *Risk assessment complete and risk mitigation controls applied.*
- *Obtain a screenshot of the plant's HMI demonstrating the plant's operational state before and after testing.*
- *Wind speed is around the speed for minimum Active Power output.*
- *Generating units are under park dispatch control.*
- *The Generating System is in voltage control mode.*
- *The Generating System step-up transformer automatic voltage regulator is enabled.*

##### Methodology and procedure

[The methodology and procedure are the same as those in section 5.2.5, 5.2.8 and 5.2.11 of this procedure]

##### Acceptance criteria

[The acceptance criteria are the same as those in section 5.2.5, 5.2.8 and 5.2.11 of this procedure]

#### 5.4.11. Frequency control at variable energy source availability (HP3\_FVE)

##### Purpose

- *To assess compliance with Technical Requirement A12.6 with respect to stability of Control Systems and the Generating System for a frequency event during intermittent energy source availability.*
- *To assess compliance with Technical Requirement A12.17 with respect to validation of dynamic model and parameters of the:*
  - *Generating Units.*
  - *Central park level controller.*
  - *Generating System Control Systems.*

##### Pre-test conditions

- *Measurement systems are calibrated, tested and checked accordingly.*
- *Risk assessment complete and risk mitigation controls applied.*
- *Obtain a screenshot of the plant's HMI demonstrating the plant's operational state before and after testing.*
- *Active Power dispatch is not constrained, i.e. Active Power generation reflects energy source availability and Active Power output is:*
  - *for test 1 (HP3\_FVE\_Test1), at minimum 85% of Rated Maximum Active Power;*
  - *for test 2 (HP3\_FVE\_Test2), between 5% and 20% of Rated Maximum Active Power;*

- *Energy source availability is forecasted to change during the time of testing (e.g. sudden drop in solar irradiance, dynamic change in wind conditions, battery reaching maximum or minimum State of Charge).*
- *Generating units are under park dispatch control.*
- *The Generating System is in voltage control mode.*
- *The Generating System step-up transformer automatic voltage regulator is enabled.*

#### **Methodology and procedure**

[The methodology and procedure shall be the same as for HP1\_FCT, HP2\_FCT and HP3\_FCT with additional consideration as follows:

- It is not necessary to test frequency Dead Band;
- for HP3\_FVE\_Test1, the energy source availability must go down for testing control system response for under-frequency event;
- for HP3\_FVE\_Test2, the energy source availability must go up for testing control system response for over-frequency event.]

#### **Acceptance criteria**

[The acceptance criteria are the same as those in section 5.2.11 of this procedure.]

#### 5.4.12. Generating System communication fail test (HP3\_CFT)

[This test shall follow the same principles as HP1\_CFT. Please refer to the test for guidance]

#### 5.4.13. Partial Generating System trip test (HP3\_PTT)

[This test shall follow the same principles as HP1\_PTT. Please refer to the test for guidance]

#### 5.4.14. Generating System trip or runback scheme test (HP3\_STT, HP3\_RBK) (if applicable)

#### **Purpose**

- *To assess implementation and compliance of trip or runback scheme with Registered Generator Performance Standard Technical Requirement A12.13 and any relevant disconnection settings in Registered Generator Performance Standard Technical Requirement A12.5, A12.6, A12.8, A12.9.*
- *To assess compliance with Technical Requirement A12.17 with respect to validation of dynamic model and parameters of the:*
  - *Generating Units.*
  - *Central park level controller.*
  - *Generating System protection settings.*
- *To assess compliance with Technical Requirement A12.14, A12.15 and A12.16 with respect to confirmation of:*
  - *SCADA feedback signals.*
  - *Communication equipment.*

### Pre-test conditions

- *If required, pre-test simulation studies to verify the extent of changes in network voltage, Active Power and Reactive Power at the Connection Point that would not adversely impact the area to which the Generating System is connected.*
- *Measurement systems are calibrated, tested and checked accordingly.*
- *Risk assessment complete and risk mitigation controls applied.*
- *Obtain a screenshot of the plant's HMI demonstrating the plant's operational state before and after testing.*
- *Generating units are under park dispatch control.*
- *Total output of the Generating System is above 90% of HP3 MW level.*
- *All Generating System protection systems in service with normal settings.*
- *The Generating System is in default control mode, e.g. voltage control mode.*
- *The Generating System step-up transformer automatic voltage regulator is enabled.*

### Methodology and procedure

- *Communicate and confirm test with AEMO and Western Power's Control Centre.*
- *Confirm the measurement systems are ready.*
- *Trip or runback full/part of the Generating System by either:*
  - *Coordinating with Western Power Control Centre to simulate trip or runback signal; or*
  - *Simulate a trip or runback signal from the Generating System receiving end.*
- *Allow at least 10 seconds pre-triggered recording and at least 60 seconds recording time after the response has settled at its steady-state value before the next test (step) commences.*

### Signals to be measured and plotted

[Provide a table of signals to be measured and plotted for this test. Table 18 shows an example of all signals available for measurement and highlights those that need to be plotted and compared against the respective simulated response.]

### Measurement data file name and format

[Follow the test data naming convention and file format in section 3.2.2 of this procedure.]

### Acceptance criteria

- *The Generating System is able to return to stable operation after runback and/or trip.*
- *Trip or runback scheme operation comply with the requirements in the Registered Generator Performance Standard Technical Requirement A12.13 and A12.6.*
- *Measurement data is successfully downloaded and confirmed.*
- *Overlays of measured and simulated responses of the Generating System trip or runback scheme test are submitted as part of Hold Point reports. To assess compliance,  $\pm 10\%$  accuracy bands are superimposed on the graphs in accordance with the Generator and Load Model Guidelines.*

## 5.5. Other Hold Point tests

[This section lists the special system tests that may be requested by Western Power or AEMO at the during or immediately after Hold Point tests:

- *Network MVar switching tests such as switching on/off a network capacitor and/or reactor.*

- Low energy source availability tests such as Low irradiance/low wind speed tests.
- Temperature dependent Active Power local limit test.
- N-1 system outage tests i.e. Lines, transformers.
- Battery charge and discharge tests.
- Wind farm daytime tests.
- Solar farm night-time voltage control tests.
- Frequency Co-optimised Essential System Services tests.
- Non-Co-optimised Essential System Services tests.

#### 5.5.1. Network reactor bank/capacitor bank switching test (HP3\_RST, HP3\_CST)

Western Power, in cooperation with AEMO, will determine the availability of switching the network reactor and capacitor bank. The following must be considered while planning these tests:

- The test dates must be proposed to Western Power and AEMO in sufficient time to allow co-ordination of the planned network switching.
- The Market Participant must plan the test to be completed within the switching period.
- The Market Participant must provide a Commissioning Test Plan in consultation with Western Power and AEMO.

#### Purpose

- *To assess compliance with Technical Requirement A12.4 with respect to voltage and Reactive Power control of the Generating System.*
- *To assess compliance with Technical Requirement A12.8 with respect to Continuous Uninterrupted Operation of the Generating System and each of its operating Generating Units.*
- *To assess compliance with Technical Requirement A12.11 with respect to the requirement for the Generating System and each of its operating Generating Units to remain connected in the event of a disturbance to Quality of Supply.*
- *To assess response of the Generating System and Generating Units to voltage disturbances caused by capacitor or reactor switching.*
- *To assess compliance with Technical Requirement A12.17 with respect to validation of dynamic model and parameters of the coordinated voltage control scheme.*

#### Pre-test conditions

- *Measurement systems are calibrated, tested and checked accordingly.*
- *Output of the Generating Units is above 90% of Hold Point MW level.*
- *Generating units are under park dispatch control.*
- *The Generating System is in default control mode, e.g. voltage control mode.*
- *The Generating System step-up transformer automatic voltage regulator is enabled.*
- *Obtain a screenshot of the plant's HMI demonstrating the plant's operational state before and after testing.*
- *Communicate and confirm test with AEMO and Western Power's Control Centre.*

### Methodology and procedure

- *Confirm measurement systems are ready to record.*
- *Configure the Generating System control to local control mode.*
- *Inform Western Power's Control Centre to switch out the reactive device.*
- *Wait until the response settles.*
- *Inform Western Power to switch the reactor in.*
- *Allow at least 60 seconds recording time after the response settled at steady state before the next test (step) commences.*
- *View test data file to ensure it has been successfully saved.*

### Signals to be measured and plotted

[Provide a table of signals to be measured and plotted for this test. Table 18 shows an example of all signals available for measurement and highlights those that need to be plotted and compared against the respective simulated response.]

### Measurement data file name and format

[Follow the test data naming convention and file format in section 3.2.2 of this procedure.]

### Acceptance criteria

- *Generating System is able to return to stable operation after each switching action.*
- *The Settling Time of voltage, Reactive Power and Active Power response for the switching action complies with the requirements of Technical Requirement A12.4.*
- *The Generating System and each of its operating Generating Units are capable of Continuous Uninterrupted Operation while the Connection Point voltage remains within the Registered Generator Performance Standard.*
- *Measurement data is successfully downloaded and confirmed.*
- *Overlays of measured and simulated responses of the reactor switching test are submitted as part of Hold Point reports. To assess compliance,  $\pm 10\%$  accuracy bands are superimposed on the graphs in accordance with the Generator and Load Model Guidelines.*

## 5.5.2. Temperature Dependent Local Active Power Limit Test (HP3\_TDP)

### Purpose

- *To assess compliance with the Registered Generator Performance Standard Technical Requirement A12.3 with respect to Temperature Dependency Data.*

### Pre-test conditions

- *Measurement systems are calibrated, tested and checked accordingly.*
- *Pre assessment complete to verify the local limit calculation accuracy;*
  - Monitor all inputs to and output from the local limit calculation, trending with 1 second resolution in SCADA;
  - Trend inputs and output of local limit calculation for at least 4 hours to allow temperature to vary in a broader range;
  - Calculate the value of the local limit from the inputs (temperature, number of Generating Units in service etc);
  - Compare output of local limit with calculated value of local limit;
- *Total output of the Generating System is above 90% of HP MW.*

- *Generating units are under park dispatch control.*
- *Frequency control is disabled in park dispatch control;*
- *The Generating System is in the default control mode; e.g. voltage control mode.*
- *The Generating System step-up transformer automatic voltage regulator is enabled; and*
- *Obtain a screenshot of the plant's HMI demonstrating the plant's operational state before testing.*
- *Record the configuration and number of inverters operating.*

#### **Methodology and procedure**

- *Communicate and confirm test with AEMO and Western Power's Control Centre.*
- *Confirm measurement systems are ready to record data.*
- *The record of ambient temperature*
- *Enable the ambient temperature simulator in the SCADA.*
- *Adjust the Pdsp at max Hold Point level, considering the relation between temperature and Active Power limit represented in Reactive Power capability curve.*
- *Adjust ambient temperature setpoint (Tsp) at 25°C*
- *Apply +5°C step to Tsp in ambient temperature simulator and wait for 60 sec.*
- *Repeat the step above until 40°C*
- *Apply +2.5°C step to Tsp in ambient temperature simulator and wait for 60 sec.*
- *Repeat the step above until 50°C*
- *Return Tsp to 25°.*
- *Apply -2.5°C step to Tsp in ambient temperature simulator and wait for 60 sec.*
- *Repeat the steps above until 20°C*
- *Disable the ambient temperature simulator in the SCADA.*
- *View test data file to ensure it has been successfully saved.*
- *Re-enabled frequency control once all tests are completed.*

#### **Measured signals**

[Provide a table of signals to be measured and plotted for this test. Table 18 shows an example of all signals available for measurement and highlights those that need to be plotted and compared against the respective simulated response.]

#### **Measurement data file name and format**

[Follow the test data naming convention and file format in section 3.2.2 of this procedure.]

#### **Acceptance Criteria**

- *There are no unplanned trips during tests;*
- *Measurement data is successfully downloaded and confirmed; and*
- *Generating System responds to the derating with the variation in temperature consistent with the Temperature Dependency Data.*

#### **5.5.3. System outage tests (HP3\_SOT)**

[Western Power in consultation with AEMO may request Hold Point tests for a planned N-1 system outage that have been identified as a low system strength condition during the connection assessment. The following Technical Requirements will be assessed for compliance under the N-1 system outage:

- Technical Requirement A12.3 with respect to Reactive Power Capability.
- Technical Requirement A12.4 with respect to voltage Control System requirements.

AEMO and Western Power will determine the outages for the tests. The following must be considered while planning these tests:

- The test dates must be proposed to Western Power and AEMO in sufficient time to allow the co-ordination of planned outages on the applicable transmission line or distribution line. If no planned outage is available, Western Power and AEMO may organise the line outage as required.
- The Market Participant must plan the test to be completed within the outage period.
- The Market Participant must provide a Commissioning Test Plan in consultation with Western Power and AEMO.
- The same methodology should be used to test the Generating System Reactive Power capability (HP3\_RPC) and voltage Control System (HP3\_VCT).

#### 5.5.4. Battery charge and discharge mode tests (HP3\_BCD)

AEMO and Western Power may request additional battery charge and discharge mode tests. Hold Point Tests in section 5.4 of this procedure may be repeated for all battery modes of operation and at various State of Charges (SoC). For example:

- Battery operating as a load (charge mode) drawing 25%, 50% and 100% of its full charging capability and with state of charges at minimum, 50% and maximum.
- Battery operating as a generator (discharge mode) with state of charges at minimum, 50% and maximum.
- Dynamic behaviour of battery discharging/charging when approaching minimum SoC or maximum SoC.

#### 5.5.5. Wind Farm daytime tests (HP3\_WFD)

AEMO and Western Power may request additional commissioning tests during daytime while other solar farms in operation.

#### 5.5.6. Solar Farm night-time voltage control tests (HP3\_SFN)

AEMO and Western Power may request additional commissioning tests from solar farms to provide voltage control during night-time.

#### 5.5.7. Frequency Co-optimised Essential System Services tests (HP3\_FCESS)

AEMO and Western Power may request additional frequency control tests for Generating Systems that are seeking accreditation of Frequency Co-optimised Essential System Services (FCESS). This may include:

- Regulation Raise.
- Regulation Lower.
- Contingency Reserve Raise.
- Contingency Reserve Lower.

- Rate of Change of Frequency (RoCoF) Control Service.

FCESS testing requirements are outlined in the “Frequency Co optimised Essential System Services Testing Guideline” available on AEMO’s website.

#### 5.5.8. Non-Co-optimised Essential System Services tests (HP3\_NCESS)

AEMO and Western Power may request tests for Generating Systems that are seeking accreditation of Non-Co-optimised Essential System Services (NCESS). This may include System Restart Services tests.

#### 5.5.9. AGC tuning tests (HP3\_AGCT)

AGC tuning is required prior to dispatching and integrating the Generating System into the Market. It is recommended that Market Participants allocate 2 days, although tuning can take less than a day if power system, weather, and fuel conditions permits.

AGC tuning involves movement of approximately 30 MW withdrawal and injection, and AEMO’s modelling team will use the dispatch quantities to finetune the signal scaling from the AGC.

The tests are conducted and run by AEMO’s Grid Modelling team with supervision of a SCADA engineer on site. Market Participants should include AGC tuning in their CTP.

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## 6. Typical Tests for Synchronous Generating System and Units

### 6.1. Hold Point 0 tests

[The off-line tests provided in this section (to assess performance and model parameters for the synchronous machine, excitation system and turbine-governor) are for illustrative purposes. A Market Participant is expected to validate all relevant performances and parameters in their Registered Generator Performance Standard]

#### 6.1.1. Background power quality measurements (HPO\_PQT)

[Power quality tests are conducted to determine background power quality signature of the grid before the Generating System is connected. When compared with the corresponding post-connection power quality signature of the Generating System, these measurements allow demonstrating compliance with Technical Requirement A12.12.

Measurements conducted include:

- Voltage flicker.
- Harmonic voltage distortion.
- Voltage unbalance (negative sequence component).

Continuous measurement must be captured at the Connection Point for a suitable period.

See section 5.1.1 of this procedure for an example of this test.]

#### 6.1.2. Generating Unit off-line voltage step response tests (HPO\_VSR)

##### Purpose

- To assess the response of voltage Control System and step response characteristics of voltage and Reactive Power in accordance with the Registered Generator Performance Standard Technical Requirement A12.4.
- To validate/identify the machine and excitation system model parameters including:
  - Direct axis open circuit transient time constant,  $T'd0$ .
  - Saturation characteristic, as determined in HPO\_OCT.
  - AVR control gains, time constants and limits.
  - Exciter characteristics (if applicable).
  - Any other parameters validated by this test.

##### Pre-test conditions

- Confirm measurement systems are calibrated, tested and checked accordingly.
- The Generating Unit is disconnected from the network and runs at rated speed with AVR in automatic operation mode.
- Machine terminal voltage is 1.0 per unit (pu).
- Determine machine rotor and stator winding temperature.

##### Methodology and procedure

- Confirm the measurement system is ready.

- Apply +/- 2.5% steps to the voltage control setpoint initially and ensure step responses are stable.
- Apply +/- 5% steps to the voltage control setpoint and ensure step responses are stable.
- Adjust machine terminal voltage to 0.95 and 1.05 per unit.
- Repeat the +5% and -5% voltage setpoint step tests respectively.
- Download and check the measurement data.
- At least 10 seconds pre-triggered recording required and allow at least 60 seconds recording time after the terminal voltage reached new steady-state conditions before the next test (step) commences.
- Perform the tests with both AVR channels (i.e. Channel A and Channel B).

**Measured signals**

[Provide a table of signals to be measured and plotted for this test. Table 19 shows an example of typical signals available for measurement and highlights those that need to be plotted and compared against the respective simulated response.

Tests shall be repeated in both Channel A and Channel B of the monitoring equipment to confirm identical performance]

**Table 19 List of measurement signals - example**

| Signals to be measured                           | Signals for model overlay | Sampling rate   | Record time window  |
|--|---------------------------|---|---|
| Voltage at Connection Point                      |                           | Min. sampling rate of 100 Hz for steady state tests and 2 kHz for dynamic tests | Allow at least 10 seconds pre-triggered recording and at least 60 seconds recording time after the response has settled at its steady-state value |
| Active power at Connection Point                 |                           |   |   |
| Reactive power at Connection Point               |                           |   |   |
| Step-up transformer on-load tap changer position |                           |   |   |
| Active power at generator terminals              |                           |   |   |
| Reactive power at generator terminals            |                           |   |   |
| Stator voltage                                   | ✓                         |   |   |
| Key variables for AVR/OEL/UEL/SCL/PSS/ V/Hz      | ✓                         |   |   |
| Main field voltage                               | ✓                         |   |   |
| Main field current                               | ✓                         |   |   |
| Exciter field voltage                            | ✓                         |   |   |
| Exciter field current                            | ✓                         |   |   |
| Armature current                                 |                           |   |   |
| Generator speed                                  | ✓                         |   |   |
| Valve/gate position setpoint                     |                           |   |   |
| Valve/gate position feedback                     |                           |   |   |
| Speed reference                                  |                           |   |   |
| Dispatch target                                  |                           |   |   |
| Load (rotor) angle                               |                           |   |   |
| Frequency  |                           |   |   |

| Signals to be measured   | Signals for model overlay | Sampling rate | Record time window |
|--|---------------------------|---------------|--------------------|
| Ambient Temperature  |                           |               |                    |
| Internal control variables   |                           |               |                    |
| Other signals as agreed in the Registered Generator Performance Standard |                           |               |                    |

**Measurement data file name and format**

[Follow the test data naming convention and file format in section 3.2.2 of this procedure]

**Acceptance Criteria**

- *Overlays of measured and simulated responses for the off-line voltage setpoint test will be submitted as part of the Hold Point test report.*
- *To assess conformance with Generator and Load Model Guidelines , +/- 10% accuracy bands needs to be superimposed on the graphs which include overlays of measured and simulated responses.*
- *The machine is able to return to stable operation after each step change.*
- *Settling time for a 5% step response complies with the Technical Requirement A12.4 in the Registered Generator Performance Standard*
- *Signals and scaling factors documented.*
- *Measurement data is successfully downloaded and confirmed.*

6.1.3. Generating Unit open circuit characteristics tests (HP0\_OCT)

**Purpose**

- *To determine synchronous machine saturation characteristics and validate/identify associated model delivered in accordance with Technical Requirement A12.17 of the Registered Generator Performance Standard.*

**Pre-test conditions**

- *Measurement systems are calibrated, tested and checked accordingly.*
- *The Generating Unit is disconnected from the network and runs at rated speed with AVR in manual operation mode.*

**Methodology and procedure**

- *Confirm the measurement system is ready.*
- *Increase terminal voltage over a wide range (e.g. from 0 pu to 1.2 pu) in steps of 0.05 pu.*
- *Ensure terminal voltage has reached steady-state conditions before the next step commences.*
- *Download and check the measurement data.*

**Measured signals**

[Provide a table of signals to be measured and plotted for this test. Table 19 shows an example of all signals available for measurement and highlights those that need to be plotted and compared against the respective simulated response.]

**Measurement data file name and format**

[Follow the test data naming convention and file format in section 3.2.2 of this procedure]

## Acceptance Criteria

- *Signals and scaling factors documented and successfully downloaded.*
- *Measurement data is successfully downloaded and confirmed.*
- *Overlays of measured and simulated responses of the open circuit characteristics tests are submitted as part of Hold Point reports.*

### 6.1.4. Generating Unit short circuit characteristic tests (HPO\_SCT)

#### Purpose

- *To confirm machine's short circuit characteristic.*
- *To confirm machine's synchronous impedance,  $X_d$ .*
- *The test setup and procedure provided below is for illustrative purposes. Detail test setup and procedure should be developed in consultation with the synchronous machine manufacturer.*
- *To validate the generation system model in accordance with Technical Requirement A12.17 of the Registered Generator Performance Standard*

#### Pre-test conditions

- *Machine terminals are shorted.*
- *Machine is off-line and runs at rated speed.*

#### Methodology and procedure

- *Measurement systems are calibrated, tested and checked accordingly.*
- *Energise excitation system.*
- *Confirm the measurement system is ready.*
- *Vary field current to achieve armature current of 0 to the maximum testing current as per the synchronous machine manufacturer.*
- *Ensure armature current has reached steady-state conditions before the next step commences.*
- *Download and check the measurement data.*

#### Measured signals

[Provide a table of signals to be measured and plotted for this test. Table 19 shows an example of all signals available for measurement and highlights those that need to be plotted and compared against the respective simulated response.]

#### Measurement data file name and format

[Follow the test data naming convention and file format in section 3.2.2 of this procedure]

#### Acceptance Criteria

- *Signals and scaling factors are documented and successfully downloaded.*
- *Measurement data is successfully downloaded and confirmed.*
- *Overlays of measured and simulated responses of the short circuit characteristics tests are submitted as part of Hold Point reports.*

### 6.1.5. Generating Unit speed response tests (HP0\_SRT)

#### Purpose

- To validate the R2 data specified in the Connection Application (Prime Mover and Governor) and the generation system model in accordance with Technical Requirement A12.17 of the Registered Generator Performance Standard.
- To validate turbine-governor model parameters such as:
  - Governor gains.
  - Valve/gate control characteristics.
  - Turbine characteristics.

[This governor model parameter list is provided for illustrative purposes. A Market Participant must list all relevant turbine and governor model parameters verified by this test.]

#### Pre-test conditions

- Measurement systems are calibrated, tested and checked accordingly.
- Machine is off-line and runs at rated speed.

#### Methodology and procedure

- Confirm the measurement system is ready.
- Apply a positive step to the governor speed reference setpoint.

[Market Participant to propose the size of the step change.]

- Wait until the response settles.
- Return the speed reference setpoint to pre-test value.
- Wait until the response settles.
- Download and check the measurement data.
- Repeat the test with a negative step.

#### Measured signals

[Provide a table of signals to be measured and plotted for this test. Table 19 shows an example of all signals available for measurement and highlights those that need to be plotted and compared against the respective simulated response.]

#### Measurement data file name and format

[Follow the test data naming convention and file format in section 3.2.2 of this procedure.]

#### Acceptance Criteria

- Machine's speed correctly follows the speed reference.
- The machine is able to return to stable operation after each step change.
- Signals and scaling factors are documented.
- Measurement data is successfully downloaded and confirmed.
- Overlays of measured and simulated speed response tests are submitted as part of Hold Point reports.

### 6.1.6. Generating Unit standstill valve response tests (HPO\_VRT)

#### Purpose

- To validate the governor parameters related to valve/gate control of the prime mover for the generation system model in accordance with Technical Requirement A12.17 of the Registered Generator Performance Standard.

#### Pre-test conditions

- Measurement systems are calibrated, tested and checked accordingly.
- Machine is at standstill with valve/gate positioning enabled.

#### Methodology and procedure

- Confirm the measurement system is ready.
- Position the valve/gate according to Table 20.
- Apply an appropriate step to the valve/gate position reference.

[Market Participant to propose the size of the step change.]

- Ensure the valve/gate has reached steady state before applying the next step.
- Download and check the measurement data.

[As appropriate, a range of step changes in valve reference should be performed with the generator shutdown to validate time constants and rate limits associated with the control and intercept valve(s) (where present)]

#### Measured signals

[Provide a table of signals to be measured and plotted for this test. Table 19 shows an example of all signals available for measurement and highlights those that need to be plotted and compared against the respective simulated response.]

#### Measurement data file name and format

[Follow the test data naming convention and file format in section 3.2.2 of this procedure]

#### Acceptance Criteria

- Valve follows the setpoint command.
- Response is Adequately Damped.
- Signals and scaling factors are documented.
- Measurement data is successfully downloaded and is confirmed.

Table 20 Operating conditions for Hold Point standstill valve response tests - example

| Test   | Valve/gate position | Step size | Data file name | Comments |
|--------|---------------------|-----------|----------------|----------|
| 1      |                     |           |                |          |
| 2      |                     |           |                |          |
| 3      |                     |           |                |          |
| 4      |                     |           |                |          |
| 5      |                     |           |                |          |
| Others |                     |           |                |          |

### 6.1.7. Generating Unit V/Hz limiter tests (HPO\_VHT)

#### Purpose

- *To confirm the performance of the V/Hz limiter.*
- *To validate R2 data specified in the Connection Application and the generation system model in accordance with Technical Requirement A12.17 of the Registered Generator Performance Standard.*

#### Pre-test conditions

- *Measurement systems are calibrated, tested and checked accordingly.*
- *Machine is off-line and runs at rated speed. Terminal voltage is 1 pu.*

#### Methodology and procedure

- *Pre-test conditions are confirmed.*
- *Confirm the measurement system is ready.*
- *Gradually reduce machine speed until the V/Hz limiter operates. Depending on the type of synchronous machine under test, a voltage step reference change can also be applied to activate and demonstrate stable operation of the V/Hz limiter.*
- *Perform tests with both AVR channels.*
- *Return to rated machine speed after tests are complete.*
- *Signals and scaling factors are documented.*
- *Download and check measurement data.*

#### Measured signals

[Provide a table of signals to be measured and plotted for this test. Table 19 shows an example of all signals available for measurement and highlights those that need to be plotted and compared against the respective simulated response.]

#### Measurement data file name and format

[Follow the test data naming convention and file format in section 3.2.2 of this procedure]

#### Acceptance Criteria

- *The V/Hz limiter responds according to expected design characteristics.*
- *Response is Adequately Damped.*
- *V/Hz protection does not operate.*
- *Machine capability does not reduce compared to that before activation of the V/Hz limiter while maintains Continuous Uninterrupted Operation.*
- *Signals and scaling factors are documented.*
- *Measurement data is successfully downloaded and confirmed.*
- *Overlays of measured and simulated responses for the off-line V/Hz test will be submitted as part of the Hold Point test report. To assess compliance,  $\pm 10\%$  accuracy bands are superimposed on the graphs in accordance with the Generator and Load Model Guidelines.*

### 6.1.8. Generating Unit frequency sweep tests (HPO\_FSW)

#### Purpose

- *To validate the transfer function block diagram of the AVR and PSS loops in the generation system model in accordance with Technical Requirement A12.17 of the Registered Generator Performance Standard.*

#### Pre-test condition

- *Machine is off-line.*
- *Excitation system is off-line.*
- *Measurement systems are calibrated, tested and checked accordingly.*

#### Methodology and procedure

- *Confirm the measurement system is ready.*
- *Frequency response of the excitation system is assessed over a frequency bandwidth of at least 0.01 – 10.0 Hz by injecting sinusoidal signals with the specific bandwidth into the control blocks. The gain and phase variations with frequency of each measured transfer function are then compared with those obtained from the model.*
- *Ensure the following steps per bandwidth:*
  - 0.01– 0.09 Hz in 9 steps.
  - 0.1 – 1 Hz in 19 steps.
  - 1 – 2 Hz in 11 steps.
  - 2.5 – 10 Hz in 16 steps.

*Each point shall be configured so the calculation is performed over four cycles averaging per measurement point.*

#### Measured signals

[Provide a table of signals to be measured and plotted for this test. Table 19 shows an example of all signals available for measurement and highlights those that need to be plotted and compared against the respective simulated response.]

#### Measurement data file name and format

[Follow the test data naming convention and file format in section 3.2.2 of this procedure]

#### Acceptance Criteria

- *Signals and frequency responses are documented.*
- *Measurement data is successfully downloaded and confirmed.*
- *Overlays of measured and simulated frequency sweep tests are submitted as part of Hold Point reports.*

### 6.1.9. Other off-line tests

[Apart from the negative-sequence impedance tests outlined below, all other tests highlighted in this section are commonly carried out before all other off-line tests described in section 6.1 of this procedure]

#### 6.1.10. Generating Unit standstill frequency response tests (HPO\_SFR)

[This is an alternative test to identify synchronous machine model parameters. The machine must be shut down, off-turning gear and electrically isolated. The machine rotor is required to turn to a precise position before the tests. IEEE Std 115 provides details about typical testing conditions, required measurements, typical test setups, and a step-by-step test procedure.]

#### 6.1.11. Generating Unit negative sequence impedance tests (HPO\_NSI)

[There are five methods to measure synchronous machine negative sequence impedance as presented in reference IEEE Std 115: Single-Phase Line-to-Line Sustained Short Circuit Test, which is the most commonly method implemented for on-site testing. The machine needs to run at the rated speed with a sustained single-phase short-circuit between two of the armature line terminals and excited at reduced field current. This standard also provides details about typical testing conditions, required measurements, typical test setups, and a step-by-step test procedure.]

### 6.2. Hold Point 1 tests

[The online tests provided in this section (to assess the synchronous machine, excitation system and turbine-governor performance and model parameters) are for illustrative purposes. Market Participants are expected to validate all relevant performances and parameters in their Registered Generator Performance Standard.

For power stations with multiple conventional Generating Units, as agreed with AEMO and Western Power, other Generating Units not under tests, may be dispatched so that any changes induced to the grid by the tests can be compensated.]

#### 6.2.1. Generating Unit online characteristic values tests (HP1\_CVT)

[In reference to IEEE Std 115, there are number of methods that can be conducted to determine transient and sub-transient parameters which may involve sudden changes to any or all the three-phase circuits at or electrically near the machine armature or the machine armature terminals]

#### Purpose

- To validate/identify R2 parameters of the synchronous machine, excitation system and turbine- governor control system specified in the Connection Application and the generation system model in accordance with Technical Requirement A12.17 of the Registered Generator Performance Standard. This includes:
  - Stator leakage reactance ( $X_L$ ).
  - Direct axis unsaturated synchronous reactance ( $X_D$ ).
  - Direct axis unsaturated transient reactance ( $X_D'$ ).
  - Direct axis unsaturated sub-transient reactance ( $X_D''$ ).
  - Direct axis open circuit transient time constant ( $T_{DO}'$ ).
  - Direct axis open circuit sub-transient time constant ( $T_{DO}''$ ).
  - Quadrature axis unsaturated synchronous reactance ( $X_Q$ ).
  - Quadrature axis unsaturated transient reactance ( $X_Q'$ ).
  - Quadrature axis unsaturated sub-transient reactance ( $X_Q''$ ).
  - Quadrature axis open circuit transient time constant ( $T_{QO}'$ ).

- Quadrature axis open circuit sub-transient time constant ( $T_{QO}$ ’).
- Synchronous machine model and parameters, such as
  - Saturation characteristic and parameters (e.g.  $S1.0$ ,  $S1.2$ ).
  - Combined inertia constant of the synchronous machine and prime mover ( $H$ ).
- (i) Excitation system model and parameters, such as:
  - AVR control gains, time constants and limits.
  - Exciter characteristics (if applicable).
- (ii) Governor and turbine model parameters including:
  - Governor gains.
  - Valve or gate characteristics.
  - Turbine characteristics.

### Pre-test conditions

- If required, pre-test simulation studies to verify the extent of changes in network voltage, Active Power and Reactive Power at the Connection Point that would not adversely impact the area to which the Generating System is connected.
- Confirm measurement systems are calibrated, tested and ready to record data.
- The Generating Unit is connected to the network and under partial load conditions specified in Table 21.
- Rotor angle can be measured.

### Methodology and procedure

- Communicate and confirm test with AEMO and Western Power’s Control Centre.
- Confirm the measurement system is ready.
- Place the machine into manual control mode.
- Start recorders just before the circuit breaker is opened.
- Reject load by tripping the machine circuit breaker manually.
- Record until after the terminal voltage and generator speed have settled in steady state.
- After each load rejection, view the test data file to ensure it has been successfully saved before conducting the next load rejection.
- Re-synchronise the machine to the power system.
- Repeat the process for all operating conditions stated in Table 21.

[Power plant substation HV bus voltage will be impacted by Reactive Power rejection. AEMO/Western Power control centre must be consulted before the test so that mitigation measures can be implemented if necessary.]

### Measured signals

[Provide a table of signals to be measured and plotted for this test. Table 19 shows an example of all signals available for measurement and highlights those that need to be plotted and compared against the respective simulated response.]

### Measurement data file name and format

[Follow the test data naming convention and file format in section 3.2.2 of this procedure]

### Acceptance Criteria

- The synchronous machine must be returned to a stable pre-test operating condition after load rejection.
- Signals and scaling factors are documented.
- Measurement data is successfully downloaded and confirmed.
- Overlays of measured and simulated online characteristic values tests are submitted as part of Hold Point reports.

**Table 21 Operating conditions for Hold Point online characteristic values tests - example**

| Test   | Initial MW | Initial MVar | Excitation control mode | Data file name |
|--------|------------|--------------|-------------------------|----------------|
| 1      |            |              |                         |                |
| 2      |            |              |                         |                |
| 3      |            |              |                         |                |
| 4      |            |              |                         |                |
| 5      |            |              |                         |                |
| Others |            |              |                         |                |

### 6.2.2. Generator Capability tests (HP1\_GCT)

#### Purpose

- To partially validate the Generator Performance Chart in accordance with Technical Requirement A12.3.
- To validate R2 parameters in the Connection Application and generation system model in accordance with Technical Requirement A12.17 of the Registered Generator Performance Standard. This includes:
  - Stator leakage reactance ( $X_L$ ).
  - Direct axis unsaturated synchronous reactance ( $X_D$ ).
  - Quadrature axis unsaturated synchronous reactance ( $X_Q$ ).
  - Saturation characteristic and parameters.

#### Pre-test conditions

- If required, pre-test simulation studies to verify the extent of changes in network voltage and Reactive Power at the Connection Point that would not adversely impact the area to which the Generating System is connected.
- Measurement systems are calibrated, tested and checked accordingly.
- The Generating Unit is connected to the network and the active and Reactive Power outputs are consistent to those specified in Table 22.

#### Methodology and procedure

- Communicate and confirm test with AEMO and Western Power’s Control Centre.
- Confirm the measurement system is ready.
- Load the machine according to the operating conditions specified in Table 22.
- If required, change the tap position on the generator transformer and/or upstream transformer (coordination with Western Power is necessary).
- Modify terminal voltage.
- Wait until the response settles.

- Record the signals specified in Table 22 and record the rotor temperature.
- Ensure the recording system continues for at least 60 seconds after the response has reached new steady-state conditions.
- Allow the machine to run continuously for 10-15 minutes at each operating point.
- View the test data file to ensure it has been successfully saved before moving forward to the next operating condition.

**Measured signals**

[Provide a table of signals to be measured and plotted for this test. Table 19 shows an example of all signals available for measurement and highlights those that need to be plotted and compared against the respective simulated response.]

**Measurement data file name and format**

[Follow the test data naming convention and file format in section 3.2.2 of this procedure]

**Acceptance Criteria**

- The machine operates stably at each specified operating condition.
- Signals and scaling factors are documented.
- Measurement data is successfully downloaded and confirmed.
- Overlays of measured and simulated Generator Capability tests are submitted as part of Hold Point reports.

[The initial MW levels shown in Table 22 are required to have a minimum of three reactive values at each MW level: 0 MVAR and at the boundaries of the Generator Performance Chart in the Registered Generator Performance Standard.]

**Table 22 Operating conditions for Hold Point Generator capability tests - example**

| Test   | Terminal voltage (pu) | Initial MW* | Initial MVAR* | Data file name | Comments |
|--------|-----------------------|-------------|---------------|----------------|----------|
| 1      |                       |             |               |                |          |
| 2      |                       |             |               |                |          |
| 3      |                       |             |               |                |          |
| 4      |                       |             |               |                |          |
| 5      |                       |             |               |                |          |
| Others |                       |             |               |                |          |

### 5.1.1 Generating Unit voltage step response tests (HP1\_VSR)

#### Purpose

- *To assess compliance with Technical Requirement A12.4 with respect to performance characteristics including:*
  - Regulated voltage is maintained within the tolerance specified in the Registered Generator Performance Standard.
  - Allow the voltage setpoint to be continuously controllable in the range specified in the Registered Generator Performance Standard.
  - Rise Times and Settling Times for voltage and Reactive Power for a 5% voltage step are within the levels specified in the Registered Generator Performance Standard.
  - Control System is Adequately Damped.
- *To validate the generation system model in accordance with Technical Requirement A12.17 of the Registered Generator Performance Standard including:*
  - AVR control characteristics, such as control gains, time constants and AVR limits.
  - Exciter characteristics (if applicable).
  - Confirm the inputs signals, the washout filters for each of the inputs and transfer functions of the PSS.
- *To confirm the stability and performance of the PSS.*

#### Pre-test conditions

- *If required, pre-test simulation studies to verify the extent of changes in network voltage and Reactive Power at the Connection Point that would not adversely impact the area to which the Generating System is connected.*
- *Measurement systems are calibrated, tested and checked accordingly.*
- *The Generating Unit is connected to the network with an initial terminal voltage of 1 pu and a rated speed of 1 pu.*
- *Initial levels of active and Reactive Power are consistent with those specified in Table 23.*

#### Methodology and procedure

- *Communicate and confirm test with AEMO and Western Power's Control Centre.*
- *Confirm the measurement system is ready.*
- *Load the machine according to the operating conditions specified in Table 23.*
- *Ensure PSS is on with AVR in automatic operation mode.*
- *Confirm the terminal voltage, active and Reactive Power are in steady-state conditions.*
- *Apply +/- 2.5% steps to the voltage control setpoint initially and ensure step responses are stable.*
- *Allow the terminal voltage, active and Reactive Power to reach steady state conditions.*
- *Step the voltage setpoint back to its original value.*
- *Confirm the terminal voltage, active and Reactive Power have reached steady-state conditions*
- *Apply +/- 5% steps to the voltage control setpoint in the same manner as the +/- 2.5% steps.*
- *Repeat the +/- 5% voltage setpoint step tests.*
- *Download and check measurement data.*
- *At least 10 seconds pre-triggered recording required and allow at least 60 seconds recording time after the terminal voltage reached new steady-state conditions before the next test (step) commences.*

- Repeat the above tests with PSS off.
- Perform the tests with both AVR channels.

**Measured signals**

[Provide a table of signals to be measured and plotted for this test. Table 19 shows an example of all signals available for measurement and highlights those that need to be plotted and compared against the respective simulated response.]

**Measurement data file name and format**

[Follow the test data naming convention and file format in section 3.2.2 of this procedure]

**Acceptance Criteria**

- Overlays of measured and simulated responses for the online voltage setpoint test will be submitted as part of the Hold Point test report. To assess compliance,  $\pm 10\%$  accuracy bands are superimposed on the graphs in accordance with the Generator and Load Model Guidelines.
- The machine is able to return to stable operation after each step change.
- The machine can be run continuously within the voltage range between 95% and 105% of normal voltage.
- Response is Adequately Damped.
- Rise Time and Settling Time of the voltage response for a 5% voltage step complies with the Registered Generator Performance Standard.
- Signals and scaling factors are documented.
- Measurement data is successfully downloaded and confirmed.

**Table 23 Operating conditions for Hold Point online voltage step response tests - example**

| Test   | Terminal voltage (pu) | Initial P | Initial Q | PSS Status | Step Size | Data file name | Comments |
|--------|-----------------------|-----------|-----------|------------|-----------|----------------|----------|
| 1      |                       |           |           |            |           |                |          |
| 2      |                       |           |           |            |           |                |          |
| 3      |                       |           |           |            |           |                |          |
| 4      |                       |           |           |            |           |                |          |
| Others |                       |           |           |            |           |                |          |

## 5.1.2 Generating Unit OEL tests (HP1\_OEL)

### Purpose

- To assess compliance with Technical Requirement A12.4 with respect to the performance characteristics required for AC exciter, rotating rectifier and Static Excitation Systems.
- To partially validate the Generator Performance Chart in accordance with Technical Requirement A12.3.
- Obtain suitable online data for validation of the machine and excitation system (including OEL) model parameters including:
  - AVR control characteristics, such as control gains, time constants and AVR limits.
  - Exciter characteristics (if applicable).
  - OEL control gains and limits.
  - Time delays and time constants of the OEL control.

### Pre-test conditions

- If required, pre-test simulation studies to verify the extent of changes in network voltage and Reactive Power at the Connection Point that would not adversely impact the area to which the Generating System is connected.
- Measurement systems are calibrated, tested and checked accordingly.
- The Generating Unit is connected to the network, and the initial level of active and Reactive Power is according to Table 24.

### Methodology and procedure

- The test will be executed in two stages. In the first stage, the OEL functionality is validated with altered settings to allow for safe operating margin should the OEL malfunction. In the second stage, the test is executed with final OEL settings in accordance with Registered Generator Performance Standard. The procedure is as follows: Communicate and confirm test with AEMO and Western Power's Control Centre.
- Confirm the measurement system is ready.
- Prepare Stage 1 of the test:
  - Temporarily alter OEL settings.

#### [Market Participant to propose specific OEL settings and consult with WP/AEMO]

- Load the machine according to the operating conditions specified in Table 24 such that the voltage setpoint applied allows the machine to marginally operate on the OEL limit.
- Record the status of PSS.
- Confirm the terminal voltage, active and Reactive Power have reached steady-state conditions.
- Confirm OEL is enabled.
- Execute Stage 1 of the test:
  - Reduce the voltage reference setpoint by 2.5%.
  - If required, change the tap position on generator transformer and/or upstream transformer (coordination with Western Power is necessary).

- Confirm the terminal voltage, active and Reactive Power have reached steady-state conditions.
- Apply a positive 2.5% step to the voltage reference setpoint.
- Confirm OEL operation (OEL should be marginally activated).
- Confirm the terminal voltage, active and Reactive Power have reached new steady-state conditions.
- Apply a negative 2.5% step to the voltage reference setpoint.
- Confirm the terminal voltage, active and Reactive Power have reached new steady state conditions.
- Apply a positive 5.0% step to the voltage reference setpoint.
- Confirm operation of the OEL.
- Prepare Stage 2 of the test:
  - Revert to the original OEL settings in accordance with Registered Generator Performance Standard.
  - Repeat all remaining steps from Stage 1 preparation.
- Execute Stage 2 of the test:
  - Repeat all steps from Stage 1 execution.

### Measured signals

[Provide a table of signals to be measured and plotted for this test. Table 19 shows an example of all signals available for measurement and highlights those that need to be plotted and compared against the respective simulated response.]

### Measurement data file name and format

[Follow the test data naming convention and file format in section 3.2.2 of this procedure]

### Acceptance Criteria

- Overlays of measured and simulated responses for the OEL setpoint test will be submitted as part of the Hold Point test report. To assess compliance,  $\pm 10\%$  accuracy bands are superimposed on the graphs in accordance with the Generator and Load Model Guidelines.
- Confirm operation and performance of the OEL:
  - OEL is activated for a 2.5% voltage step applied.
  - Settling time of Reactive Power for a 5% voltage step in respect to OEL operation complies with the Registered Generator Performance Standard.
  - Response is Adequately Damped.
  - The generator/exciter field current and Reactive Power output are limited to the predicted values.
- Over-excitation (V/Hz) relay does not operate.
- Signals and scaling factors are documented.
- Measurement data is successfully downloaded and is confirmed.

**Table 24 Operating conditions for Hold Point OEL tests**

| Test   | Terminal voltage (pu) | Initial P | Initial Q | PSS Status | Step Size | Data file name | Comments |
|--------|-----------------------|-----------|-----------|------------|-----------|----------------|----------|
| 1      |                       |           |           |            |           |                |          |
| 2      |                       |           |           |            |           |                |          |
| 3      |                       |           |           |            |           |                |          |
| 4      |                       |           |           |            |           |                |          |
| Others |                       |           |           |            |           |                |          |

### 5.1.3 Generating Unit UEL tests (HP1\_UEL)

#### Purpose

- To assess compliance with Technical Requirement A12.4 with respect to the performance characteristics required for AC exciter, rotating rectifier and Static Excitation Systems.
- To partially validate the Generator Performance Chart in accordance with Technical Requirement A12.3.
- Obtain suitable online data for validation of the machine and excitation system (including UEL) model parameters including:
  - AVR control characteristics, such as control gains, time constants and limits.
  - Exciter characteristics (if applicable).
  - UEL control gains and limits.
  - Time delays and time constants of the UEL control.

#### Pre-test conditions

- If required, pre-test simulation studies to verify the extent of changes in network voltage and Reactive Power at the Connection Point that would not adversely impact the area to which the Generating System is connected.
- Measurement systems are calibrated, tested and checked accordingly.
- The Generating Unit is connected to the network and the initial level of active and Reactive Power is in accordance with Table 25.

#### Methodology and procedure

The test will be executed in two stages. In the first stage, the UEL functionality is validated with altered settings to allow for safe operating margin should the UEL malfunction. In the second stage, the test is executed with final UEL settings in accordance with Registered Generator Performance Standard. The procedure is as follows:

- Communicate and confirm test with AEMO and Western Power’s Control Centre.
- Confirm the measurement system is ready.
- Prepare Stage 1 of the test:
  - Temporarily alter UEL settings.

[Market Participant to propose specific UEL settings and consult with WP/AEMO]

- Load the machine according to the operating conditions specified in Table 25, such that the voltage setpoint applied allows the machine to marginally operate on the UEL limit (use tap changing transformer if necessary).
- Record the status of PSS.
- Confirm the terminal voltage, active and Reactive Power have reached steady-state conditions.
- Confirm UEL is enabled.
- Execute Stage 1 of the test:
  - Increase the voltage reference setpoint by 2.5%.
  - Confirm the terminal voltage, active and Reactive Power have reached steady-state conditions.
  - Apply a negative 2.5% step to the voltage reference setpoint.
  - Confirm UEL operation (UEL should be marginally activated).
  - Confirm the terminal voltage, active and Reactive Power have reached new steady-state conditions.
  - Apply a positive 2.5% step to the voltage reference setpoint.
  - Confirm the terminal voltage, active and Reactive Power have reached steady-state conditions.
  - Apply a negative 5.0% step to the voltage reference setpoint.
  - Confirm UEL operation.
  - Confirm the terminal voltage, active and Reactive Power have reached steady-state conditions.
  - Step the voltage setpoint back to its pre-test value.
  - Perform the tests with both AVR channels.
  - At least 10 seconds pre-triggered recording required and allow at least 60 seconds recording time after the terminal voltage reached new steady-state conditions before the next test (step) commences.
  - View the test data file to ensure it has been successfully saved.
- Prepare Stage 2 of the test:
  - Revert to the original UEL settings in accordance with Registered Generator Performance Standard.
  - Repeat all remaining steps from Stage 1 preparation.
- Execute Stage 2 of the test:
  - Repeat all steps from Stage 1 execution.

### Measured signals

[Provide a table of signals to be measured and plotted for this test. Table 19 shows an example of all signals available for measurement and highlights those that need to be plotted and compared against the respective simulated response.]

### Measurement data file name and format

[Follow the test data naming convention and file format in section 3.2.2 of this procedure]

### Acceptance Criteria

- *Overlays of measured and simulated responses for the UEL setpoint test will be submitted as part of the Hold Point test report. To assess compliance, ±10% accuracy bands are superimposed on the graphs in accordance with the Generator and Load Model Guidelines.*
  - *Confirm operation and performance of the UEL.*
  - *UEL is activated for a 2.5% voltage step applied.*
  - *Settling time of voltage, active and reactive for a 5% voltage step in respect of the UEL complies with the Registered Generator Performance Standard.*
  - *Response is Adequately Damped.*
  - *Reactive power output and terminal voltage are limited to the predicted values.*
- *Loss-of-excitation and out-of-step (pole slip) relays do not operate.*
- *Signals and scaling factors are documented.*
- *Measurement data is successfully downloaded and confirmed.*

**Table 25** Operating conditions for Hold Point UEL tests

| Test   | Terminal voltage (pu) | Initial P | Initial Q | PSS Status | Step Size | Data file name | Comments |
|--------|-----------------------|-----------|-----------|------------|-----------|----------------|----------|
| 1      |                       |           |           |            |           |                |          |
| 2      |                       |           |           |            |           |                |          |
| 3      |                       |           |           |            |           |                |          |
| 4      |                       |           |           |            |           |                |          |
| Others |                       |           |           |            |           |                |          |

### 5.1.4 Generating System frequency step tests (HP1\_FST)

#### Purpose

- *To assess compliance with Technical Requirement A12.6 with respect to frequency control.*
- *To validate the R2 data specified in the Connection Application (Prime Mover and Primary Mechanical Control Systems).*
- *To validate the turbine and governor model parameters including:*
  - *Dead Band.*
  - *Governor droop.*
  - *Governor gains.*
  - *Valve or gate characteristics.*
  - *Turbine characteristic.*

#### Pre-test conditions

- *If required, pre-test simulation studies to verify the extent of changes in network voltage and Reactive Power at the Connection Point that would not adversely impact the area to which the Generating System is connected.*
- *Communicate and confirm test with AEMO and Western Power’s Control Centre.*
- *Measurement systems are calibrated, tested and checked accordingly.*

- *The Generating Unit is connected to the network and operates as per the operating conditions specified in Table 26.*
- *Low Reactive Power output.*
- *No ramp rate limits introduced into the input step signal when applying the test sequence.*

#### **Methodology and procedure**

- *Confirm the measurement system is ready.*
- *Load the machine according to the operating conditions specified in Table 26.*
- *Apply an appropriate step/ramp to the speed/frequency setpoint or feedback signal which is the actual measurement signal, such as speed, angle or frequency to be fed into the Governor control.*
- *Wait until the response reaches new steady-state conditions.*
- *Return the speed/frequency setpoint or feedback to pre-test value.*
- *Wait until the response reaches new steady-state conditions.*
- *Download and view the test data file to ensure it has been successfully saved.*

#### **Measured signals**

[Provide a table of signals to be measured and plotted for this test. Table 19 shows an example of all signals available for measurement and highlights those that need to be plotted and compared against the respective simulated response.]

#### **Measurement data file name and format**

[Follow the test data naming convention and file format in section 3.2.2 of this procedure]

#### **Acceptance Criteria**

- *Overlays of measured and simulated responses for the frequency step test will be submitted as part of the Hold Point test report. To assess compliance,  $\pm 10\%$  accuracy bands are superimposed on the graphs in accordance with the Generator and Load Model Guidelines.*
- *The steady-state change in Active Power complies with the Registered Generator Performance Standard.*
- *Response is Adequately Damped.*
- *Measurement data is successfully downloaded and confirmed.*
- *Signals and scaling factors are documented.*

**Table 26** Operating conditions for Hold Point frequency step tests - example

| Test   | Initial MW | Frequency deviation | Deviation shape (step or ramp) | Data file name | Comments |
|--------|------------|---------------------|--------------------------------|----------------|----------|
| 1      |            |                     |                                |                |          |
| 2      |            |                     |                                |                |          |
| 3      |            |                     |                                |                |          |
| 4      |            |                     |                                |                |          |
| Others |            |                     |                                |                |          |

### 5.1.5 Generating System Active Power tests (HP1\_APT)

#### Purpose

- *To assess compliance with Technical Requirement A12.5 with respect to Active Power control.*

#### Pre-test conditions

- *If required, pre-test simulation studies to verify the extent of changes in network frequency and Active Power at the Connection Point that would not adversely impact the area to which the Generating System is connected.*
- *Measurement systems are calibrated, tested and checked accordingly.*
- *The Generating Unit is connected to the network, and output is at Rated Minimum Active Power.*
- *Low Reactive Power output.*
- *No ramp rate limits are introduced into the input step signal when applying the test sequence.*

#### Methodology and procedure

- *Communicate and confirm test with AEMO and Western Power’s Control Centre.*
- *Confirm the measurement system is ready.*
- *Load the machine according to the operating conditions specified in Table 27.*
- *Apply the step/ramp, specified in Table 27 to the generator’s dispatch target (ensuring the control system for normal dispatch is used).*
- *Wait until the next dispatch interval before applying the next step/ramp.*
- *Ensure that at least one dispatch target is held for 10 minutes.*
- *Download and view the test data file to ensure it has been successfully saved.*

#### Measured signals

*[Provide a table of signals to be measured and plotted for this test. Table 19 shows an example of all signals available for measurement and highlights those that need to be plotted and compared against the respective simulated response.]*

#### Measurement data file name and format

*[Follow the test data naming convention and file format in section 3.2.2 of this procedure]*

### Acceptance Criteria

- *Overlays of measured and simulated responses for the Active Power test will be submitted as part of the Hold Point test report. To assess compliance,  $\pm 10\%$  accuracy bands are superimposed on the graphs in accordance with the Generator and Load Model Guidelines.*
- *The Generating System complies with the Dispatch Systems Requirements.*
- *Generating unit achieves and maintains the intended dispatch target.*
- *The Generating Unit ramps linearly from one dispatch target to another.*
- *Response is Adequately Damped.*
- *Signals and scaling factors are documented.*
- *Measurement data is successfully downloaded and confirmed before the next test commences.*

**Table 27** Operating conditions for Hold Point Active Power control tests - example

| Test   | Initial dispatch target | Final dispatch target | Ramp rate | Data file name | Comments |
|--------|-------------------------|-----------------------|-----------|----------------|----------|
| 1      |                         |                       |           |                |          |
| 2      |                         |                       |           |                |          |
| 3      |                         |                       |           |                |          |
| 4      |                         |                       |           |                |          |
| Others |                         |                       |           |                |          |

#### 5.1.6 Generating Unit stator current limiter tests (HP1\_SCL)

##### Purpose

- *To assess compliance with Technical Requirement A12.4 with respect to the voltage and Reactive Power control accounting for the action of the Stator Current Limiter (SCL).*

##### Pre-test conditions

- *If required, pre-test simulation studies to verify the extent of changes in network voltage and Reactive Power at the Connection Point that would not adversely impact the area to which the Generating System is connected.*
- *Measurement systems are calibrated, tested and checked accordingly.*
- *The Generating Unit is connected to the network and operates such that stator current limiter is active.*

##### Methodology and procedure

- *Communicate and confirm test with AEMO and Western Power's Control Centre.*
- *Confirm the measurement system is ready.*
- *Load the machine according to the operating condition specified in Table 28, such that the voltage set point enables the generator to marginally operate on the stator current limit.*
- *Record the status of the PSS.*
- *Confirm the terminal voltage, active and Reactive Power have reached steady-state conditions.*
- *Confirm stator current limiter is enabled.*

- Reduce voltage reference set point by 2.5%
- Confirm the terminal voltage, active and Reactive Power have reached steady-state conditions.
- Apply a positive 2.5% step to the voltage reference set point.
- Confirm operation of the stator current limiter.
- Confirm the terminal voltage, active and Reactive Power have reached steady-state conditions.
- Apply a negative 2.5% step to the voltage reference set point.
- Confirm the terminal voltage, active and Reactive Power have reached steady-state conditions.
- Apply a positive 5.0% step to the voltage reference set point.
- Increase the step size by increments of 1% if the initial 5% step is not adequate to engage the SCL.
- Confirm operation of the stator current limiter.
- Confirm the terminal voltage, active and Reactive Power have reached steady-state conditions.
- Step the voltage set point back to its pre-test value.
- View the test data file to ensure it has been successfully saved.
- Perform the test with both AVR channels.
- Repeat the above tests with opposite step sizes if SCL applies to under-excited as well as the over-excited operating range.

#### Measured signals

[Provide a table of signals to be measured and plotted for this test. Table 19 shows an example of all signals available for measurement and highlights those that need to be plotted and compared against the respective simulated response.]

#### Measurement data file name and format

[Follow the test data naming convention and file format in section 3.2.2 of this procedure]

#### Acceptance Criteria

- Confirm operation and performance of the stator current limiter with respect to:
  - Operation of the stator current limiter with 2.5% voltage step applied.
  - Settling time of voltage and reactive for a 5% voltage step in respect to stator current limiter operation complies with the Registered Generator Performance Standard.
- Response is Adequately Damped.
- Stator current is limited to the predicted values.
- No protective function operates.
- Signals and scaling factors are documented.
- Measurement data is successfully downloaded and confirmed.

**Table 28** Operating conditions for Hold Point Active Power control tests - example

| Test   | Terminal voltage (pu) | Initial P | Initial Q | PSS Status | Step size | Data file name | Comments |
|--------|-----------------------|-----------|-----------|------------|-----------|----------------|----------|
| 1      |                       |           |           |            |           |                |          |
| 2      |                       |           |           |            |           |                |          |
| 3      |                       |           |           |            |           |                |          |
| 4      |                       |           |           |            |           |                |          |
| Others |                       |           |           |            |           |                |          |

### 6.3. Hold Point 2 tests

#### 5.1.7 Power quality tests (HP2\_PQT)

[This test follows the same methodology as HP0\_PQT, but with power quality measurements recorded while the Generating System is connected and exporting to the grid. The measurements should cover various operating conditions, including maximum and minimum Active Power output. By comparing these results with background power quality measurements, compliance with Registered Generator Performance Standard Technical Requirement A12.12 can be demonstrated.]

#### 5.1.8 Generator Capability tests (HP2\_GCT)

[This test shall follow the same principles as HP1\_GCC. Please refer to the test for guidance]

#### 5.1.9 Generating Unit voltage step response tests (HP2\_VSR)

[This test shall follow the same principles as HP1\_VSR. Please refer to the test for guidance]

#### 5.1.10 Generating Unit OEL tests (HP2\_OEL)

[This test shall follow the same principles as HP1\_OEL. Please refer to the test for guidance]

#### 5.1.11 Generating Unit UEL tests (HP2\_UEL)

[This test shall follow the same principles as HP1\_UEL. Please refer to the test for guidance]

#### 5.1.12 Generating Unit field voltage ceiling tests (HP2\_FVC)

##### Purpose

- To assess compliance with Technical Requirement A12.4 with respect to the excitation ceiling voltage with the following characteristics, at least:
  - For a Static Excitation System, 2.3 times; or
  - For other Excitation Control Systems, 1.5 times,
 the excitation required to achieve generation at the Nameplate Rating for rated Power Factor, rated speed and nominal voltage;

- The excitation system can rise from rated field voltage to excitation ceiling voltage in no more than:
  - 0.05 seconds for a Static Excitation System; or
  - 0.5 seconds for other Excitation Control Systems.

#### Pre-test conditions

- If required, pre-test simulation studies to verify the extent of changes in network voltage and Reactive Power at the Connection Point that would not adversely impact the area to which the Generating System is connected.
- Measurement systems are calibrated, tested and checked accordingly.
- The Generating Unit is connected to the network and at its nameplate rated conditions.

#### Methodology and procedure

- Communicate and confirm test with AEMO and Western Power's Control Centre.
- Confirm the measurement system is ready
- Confirm the terminal voltage, active and Reactive Power have reached steady-state conditions
- Apply an impulse to the voltage reference set point sufficiently large, e.g. 10%, to reach the excitation ceiling
- Check the test data to ensure field voltage has successfully reached ceiling
- Save the measurement data before moving on to the next test
- Record the signals and record the rotor temperature if possible.
- Perform the test with both AVR channels.

#### Measured signals

[Provide a table of signals to be measured and plotted for this test. Table 19 shows an example of all signals available for measurement and highlights those that need to be plotted and compared against the respective simulated response.]

#### Measurement data file name and format

[Follow the test data naming convention and file format in section 3.2.2 of this procedure]

#### Acceptance Criteria

- Overlays of measured and simulated responses for the ceiling field voltage test will be submitted as part of the Hold Point test report. To assess compliance,  $\pm 10\%$  accuracy bands are superimposed on the graphs in accordance with the Generator and Load Model Guidelines.
- The ceiling field voltage complies with the Excitation Control System performance characteristics specified in the Registered Generator Performance Standard.
- The machine is able to return to stable operation after the step change.
- Signals and scaling factors are documented.
- Measurement data is successfully downloaded and confirmed.

#### 6.3.1. Generating Unit frequency step tests (HP2\_FST)

[This test shall follow the same principles as HP1\_FST. Please refer to the test for guidance]

### 6.3.2. Generating Unit Active Power tests (HP2\_APT)

[This test shall follow the same principles as HP1\_APT. Please refer to the test for guidance]

### 6.3.3. Generating Unit stator current limiter tests (HP2\_SCL)

[This test shall follow the same principles as HP1\_SCL. Please refer to the test for guidance]

## 6.4. Hold Point 3 tests

[Online tests required for Hold Point 3 are identical to those described for Hold Point 2.]

## 6.5. Other Hold Point tests

[This section lists the special system tests that may be requested by Western Power or AEMO at the same time or immediately after the Hold Point tests:

- Network reactive compensation switching tests such as switching on/off a network capacitor and/or reactor. See HP3\_RST and HP3\_CST in this procedure.
- Temperature dependent Active Power local limit test. See HP3\_TDP in this procedure
- N-1 system outage tests. See HP3\_SOT in this form
- Frequency Co-optimised Essential System Services tests. See HP3\_FCESS in this procedure
- Non-Co-optimised Essential System Services tests. See HP3\_NCESS in this procedure
- AGC tuning tests (HP3\_AGCT)]

## 7. Network events prior to Approval to Generate (for all Generating Systems)

[Any power system disturbance(s) captured by continuous monitoring systems (and/or by metering equipment installed for the purpose of commissioning) which occurred between commencement of commissioning and an Approval to Generate Notification will be used for GPS compliance assessment and model validation.

AEMO and Western Power will provide information of the power system disturbance, such as fault location, fault clearing time, nature of the fault, post-fault power system condition, power system model information representing the snapshot of the power system prior to occurrence of the power system disturbance and relevant system model information and files.

Generating System measurement equipment should be able to trigger, record and save high speed data automatically for power system events and the measurement equipment specifications are in accordance with Appendix B.5 of the WEM Procedure: Communications and Control Systems. The recorded data must be made available to AEMO and Western Power.

The Market Participant must capture network events and assess compliance of the Generating System with relevant GPS Technical Requirements and validate accuracy of the model with the measured responses. The compliance assessment includes:

- Generating System response to frequency disturbances under Technical Requirement A12.6 and A12.7.
- Generating System response to voltage disturbances under Technical Requirement A12.4 and A12.8.
- Generating System response to disturbances following contingency events under Technical Requirement A12.9.
- Generating System response to a partial load rejection under Technical Requirement A12.10.
- Generating System response to a quality of supply disturbance under Technical Requirement A12.11.
- Generating System protection response to power system disturbances under Technical Requirement A12.13