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| GPS Compliance Assessment and R2 Model Validation Test Plan Template |

February 2020

For Inverter-based Generation Technologies

Important notice

PURPOSE

AEMO has prepared this document to provide information to assist Generators in their preparation of GPS compliance assessment and R2 model validation test plans for inverter-based generation technologies, such as wind, solar and battery, as at the date of publication.

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Version Control

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| --- | --- | --- |
| Version | Release date | Changes |
| 1.0 | Sep 2016 | First issue |
| 2.0 | Feb 2020 | Revised and updated general requirements , tests and report requirements |

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# Introduction

## Purpose and scope

Under the National Electricity Rules (NER), Generators are required to:

* Prepare commissioning programs for new or replacement equipment (see clause 5.8.4).
* Provide a commissioning program to the connecting *Network Service Provider* (**NSP**) and AEMO not less than 3 months prior to commencement of commissioning for a *connection* to a transmission *network* and not less than 1 month prior to commencement of commissioning for a *connection* to a *distribution network* (see clause 5.8.4(b)).
* Prepare test plans to demonstrate that their *generating systems* comply with their performance standards (GPS) and *connection agreements* (see clause 5.7.3).
* Demonstrate that any *system strength remediation scheme* provided by their *facilities* meets the requirements specified in their *connection agreements* (see clause 5.7.3A).
* Notify AEMO and the NSP of any test to their equipment, or *generating units*, that requires a change to normal operation (see clause 5.7.5, or 5.7.6, respectively).
* Develop a routine compliance test program for their *plant* (see clause 4.15(b)).

This document has been prepared to assist Generators to prepare a commissioning program or test plan for inverter-based *generation* to meet any of the purposes detailed above for:

* New and upgraded *plant* and equipment.
* Inverter-based generation technologies, primarily wind, solar photovoltaic (PV), and battery.
* Tests to validate compliance with GPS and *connection agreements* when carrying out:
  + Temporary changes to *control system* settings; and
  + Temporary changes to *plant* operating modes.

The document does not cover every conceivable variation to *generating system* design. Minor modifications will be acceptable when submitting test plans to AEMO and NSP in those circumstances.

This document does not apply to changes to *plant protection systems* to any detailed test procedure (also known as an ‘Inspection and Test Procedure’ or ‘ITP’) for test engineers for on-site testing.

## Definitions and interpretation

### Glossary

Terms defined in the *National Electricity Law* and the NER have the same meanings in this document.

Terms defined in the NER are intended to be identified in this document by italicising them, but failure to italicise a defined term does not affect its meaning.

The words, phrases and abbreviations in the table below have the meanings set out opposite them when used in this document.

|  |  |
| --- | --- |
| Term | Definition |
| AGC | Automatic Generation Control |
| COMTRADE | Common format for Transient Data Exchange for power systems |
| CSV | Comma-separated values |
| DI | Dispatch Interval |
| FAT | Factory acceptance test |
| FCAS | Frequency control ancillary services |
| Generators | *Generators* and those intending to register as *Generators* following the construction and *connection* of new *generating plant*. |
| GPS | *Performance standard*, as it applies to *generating systems*. |
| GPS S5.2.X.X | The *performance standard* applicable to the *generating system* being tested. The reference to “S5.2.5.X” refers to the clause in Schedule 5.2 of the NER from which the applicable performance standard is drawn. |
| GPS Compliance Assessment and R2 Validation Test Plan | The plan submitted for the purposes of clause 5.8.4 of the NER. |
| HIL | Hardware in the Loop |
| HMI | Human Machine Interface |
| HP | Hold Point |
| HV | High voltage |
| Hz | hertz |
| kHz | kilohertz |
| LV | Low voltage |
| MAT | Model acceptance test |
| MMS | AEMO’s Market Management Systems |
| MV | Medium voltage |
| MVA | megavolt amperes |
| MVAr | megavolt ampere reactive |
| MW | megawatt |
| DRD | Asynchronous dynamic reactive support device |
| NEM | National Electricity Market |
| NER | National Electricity Rules |
| NSP | The *Network Service Provider* who has *connected* the *generating system* to the *network*. |
| OEM | Original equipment manufacturer |
| PF | Power factor |
| PSCADTM/EMTDCTM | Power Systems Computer Aided Design / Electromagnetic Transient with Direct Current |
| PSS®E | Power System Simulator for Engineering. |
| PU | Per unit |
| PV | Photovoltaic |
| RMS | Root mean square |
| RUG | *Releasable user guide* |
| SCADA | Supervisory control and data acquisition |
| SDRD | Synchronous dynamic reactive support device |
| SI | Solar inverter |
| SMIB | Single machine infinite bus |
| STATCOM | Static synchronous compensator |
| UPS | Uninterruptible power supply |
| WTG | Wind turbine generator |

### Interpretation

This document is subject to the principles of interpretation set out in Schedule 2 of the *National Electricity Law*.

* 1. Related documents

|  |  |
| --- | --- |
| Title | Location |
| Commissioning Requirements for Generating Systems | [https://aemo.com.au/-/media/Files/PDF/Commissioning\_Requirements\_‌for\_‌Generating\_Systems-pdf.pdf](https://aemo.com.au/-/media/Files/PDF/Commissioning_Requirements_for_Generating_Systems-pdf.pdf) |
| Dispatch Procedure SO\_OP\_3705 | [https://www.aemo.com.au/-/media/Files/Electricity/NEM/Security\_and\_Reliability/‌Power\_System\_Ops/Procedures/SO\_OP\_3705---Dispatch.pdf](https://www.aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/Power_System_Ops/Procedures/SO_OP_3705---Dispatch.pdf) |
| GPS Compliance Assessment and R2 Model Validation Test Plan Template for Conventional Synchronous Machines | [https://aemo.com.au/-/media/Files/Electricity/NEM/Network\_Connections/‌Transmission-and-Distribution/Generating-System-Test-Plan-Template-for-Conventional-Synchronous-Machines.pdf](https://aemo.com.au/-/media/Files/Electricity/NEM/Network_Connections/Transmission-and-Distribution/Generating-System-Test-Plan-Template-for-Conventional-Synchronous-Machines.pdf) |
| Outage Assessment SO\_OP\_3718 | [https://www.aemo.com.au/-/media/Files/Electricity/NEM/Security\_and\_Reliability/ Power\_System\_Ops/Procedures/SO\_OP\_3718---Outage-Assessment.pdf](https://www.aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/%20Power_System_Ops/Procedures/SO_OP_3718---Outage-Assessment.pdf) |
| Power System Design Data Sheets and Power System Settings Data Sheets | [https://aemo.com.au/-/media/Files/Electricity/NEM/Security\_and\_Reliability/‌System-Security-Market-Frameworks-Review/2018/Power\_System\_Design\_and\_‌Setting\_Data\_Sheets\_PUBLISHED.xlsx](https://aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/System-Security-Market-Frameworks-Review/2018/Power_System_Design_and_Setting_Data_Sheets_PUBLISHED.xlsx) |
| Power System Model Guidelines | [https://aemo.com.au/-/media/Files/Electricity/NEM/Security\_and\_Reliability/‌System-Security-Market-Frameworks-Review/2018/Power\_Systems\_Model\_‌Guidelines\_PUBLISHED.pdf](https://aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/System-Security-Market-Frameworks-Review/2018/Power_Systems_Model_Guidelines_PUBLISHED.pdf) |
| Power System Security Guidelines SO\_OP\_3715 | [https://www.aemo.com.au/-/media/Files/Electricity/NEM/Security\_and\_Reliability/‌Power\_System\_Ops/Procedures/SO\_OP\_3715---Power-System-Security-Guidelines.pdf](https://www.aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/Power_System_Ops/Procedures/SO_OP_3715---Power-System-Security-Guidelines.pdf) |
| R2 Testing Guideline | <https://aemo.com.au/-/media/Files/PDF/R2_Testing_Guideline.pdf> |

# General requirements

## Pre-requisites for GPS Compliance and R2 Model Validation Testing

The following are required before compliance or R2 model validation testing can begin:

* Generator’s application for registration as a *Generator* is approved by AEMO.
* GPS are included in the relevant *connection agreement* and notified to AEMO under clause 5.3.7 of the NER.
* SCADA signals of good quality are received by AEMO.
* All *protection systems* are in service.
* All trip, runback scheme and other *control systems* are in service.
* The following documents have been submitted to AEMO and the NSP:
  + Final connection study reports.
  + R1 *Power System Design Data Sheets* and *Power System Setting Data Sheets*.
  + R1 model package:
    - *Generating unit* model and aggregation method used.
    - *Generating system central dispatch* control model.
    - Static and dynamic reactive support devices model (if applicable).
    - *System strength remediation scheme* facilities model (if applicable).
    - Coordinated *generating system control system* model (if applicable).
  + R1 block diagrams for the above models.
  + R1 model source codes.
  + R1 model parameters.
  + R1 *releasable user guide* (**RUG**).
  + Model acceptance test report (**MAT**)
  + Final, as-built single line diagrams.
  + An agreed GPS Compliance and R2 Validation Test Plan as required by clause 5.8.4 of the NER.
  + Voltage control strategy report.
  + Trip, runback scheme and other *control system* reports (if applicable).
  + Start-up and shut-down procedure.
  + Communication failsafe mechanism (central park controller to *generating units* and central park controller to measurement meters) document.
  + Physical setting downloads of the controllers.
  + Setting summary table comparing physical settings downloaded from controllers on site with the R1 PSS®ETM and PSCADTM/EMTDC™ model settings.
  + Valid calibration certificates of measurement equipment.
  + Test schedule and *generation* profiles.
  + 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*.
  + *Generating system* layout, including location of the closest NSP *substation*, *generating unit* and *generating system transformers*, *transmission line*/cable arrangement, other static and dynamic reactive support devices (if available).
  + All pre-energisation checks/tests (e.g. protection tests) complete and confirmation that safe to energise.
  + Type test, factory acceptance test (**FAT**) and any relevant off-site test reports.
  + Photos of *nameplate ratings* of major *plant* installed on site (e.g. *transformers*, solar inverter (SI)/wind turbine generator (WTG)) 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 and GPS compliance and R2 validation tests.
  + Confirmation of compliance with all workplace health and safety requirements.
  + Any other compliance evidence to the agreed GPS.
* Operational communication facilities functional.
* Bids and intermittent generation section of the Market Management System (MMS) portal complete.
* AEMO and the NSP have approved *plant* to commence commissioning tests.

## Main point of contacts

A commissioning test plan includes contact details of the key personnel involved in commissioning activities. The Generator must keep the main contact list up to date. *Plant* operator contacts should be available on a 24-hour basis for AEMO and NSP control room staff to contact. Refer to Appendix A1.1 for a recommended contact list template.

## Key plant information

A commissioning test plan includes key *plant* information consistent with the GPS, RUG and *Power System Data Sheets*. Refer to Appendix A1.2 for a recommended key plant list template.

## Communication protocol

The commissioning test plan includes the relevant communication protocols for:

* Commissioning test schedule and *generation* profile updates.
  + Submit updated commissioning test schedule and daily *generation* profiles to AEMO and the NSP at least one week prior to each hold point (**HP**) commencement.
  + Refer to Appendices A1.5 and A1.6 for a recommended test schedule and *generation* profile template.
* Bids and MMS portal updates.
  + Submit bids (‘Availability’ and ‘Rate of Change’) reflecting the test requirements and follow *dispatch* targets and rate of change requirements, as required by the System Security Protocol for Generating Unit Commissioning or Testing in the Power System Security Guidelines SO\_OP\_3715.
  + Update MMS portal *intermittent generation* section consistent with the commissioning test schedule and *plant* availability.
* Update to operational contacts.
  + Any changes to operational contact details must be communicated to AEMO and the NSP by email to National Electricity Market Real Time Operations (NEM RTO) at [CROCS@aemo.com.au](mailto:CROCS@aemo.com.au), NSP operational contact, AEMO Commissioning support contact and NSP commissioning support contact.
* Physical controller settings downloads.
  + AEMO, the NSP and Generator must agree on required controllers, format, frequency of the controller settings download submissions prior to commencement of HP tests.
* HP approval.
  + AEMO and NSP commissioning support engineers must approve the current HP report before the next HP tests commence.
* Commissioning test approval.
  + Before proceeding with each commissioning test, seek approval from the NSP control room and AEMO control room.
* Constraints in MMS.
  + AEMO will invoke and revoke constraint equations in MMS based on the HP level and NSP and Generator advice on commissioning testing. Any change to *plant* operating levels or updates to constraint equation expiry date should be communicated to the AEMO commissioning support engineer so that AEMO can update the relevant constraint equation.
* Submission of HP reports.
  + Commissioning schedules include the HP reports submission dates. Any change to a previously agreed HP completion date or HP report submission date must be communicated to the AEMO and NSP commissioning support engineers for their approval.
* Semi-dispatch cap.
  + *Semi-scheduled generating systems* must always follow their *dispatch* target during a *semi-dispatch* *interval* during commissioning tests. *Dispatch* targets can be below the HP level based on the binding constraint equation. Each *semi-scheduled generating system* is expected to ramp linearly from its initial *active power* output to its semi-dispatch cap applying at the end of a *semi-dispatch interval*, subject to energy availability[[1]](#footnote-1). Any non-conformance to the *dispatch* target while a semi‑dispatch cap applies must be communicated to the AEMO control room.
* Plant monitoring.
  + *Plant* should be monitored constantly. Processes should be in place, and met, to report any non-compliance to the AEMO/NSP control rooms and commissioning support engineers immediately.
* Changes to the commissioning test methodology and procedures.
  + The Generator must seek advice from AEMO and the NSP if changes are required to the agreed test methodology and procedures before proceeding with the commissioning tests.
* Update on test progress.
  + The Generator test coordinator must update the AEMO and NSP commissioning support engineers on progress of the commissioning tests on a daily or weekly basis, as required.

## Risk assessment

The commissioning and GPS compliance testing program must identify potential risks arising from carrying out each test and describe the applied risk mitigation controls. The Generator’s test lead/manager must sign-off on each risk control before each test commences. Refer to Appendix A1.7 for a recommended risk assessment template.

## Commissioning test schedule

A commissioning test schedule includes all planned activities from the pre-energisation phase to bringing the *generating system* to commercial operation. Refer to Appendix A1.5 for a recommended commissioning test template.

The following information is generally included:

* *Active power* and *reactive power* output expected for each test at each HP.
* A list of all GPS Compliance Assessment and R2 Model Validation Tests conducted, including:
  + Offline tests.
  + Online tests for all HPs.
* *Generation* profiles for each day of testing must be submitted two *business days* before testing. Refer to Appendix A1.6 for a preferred template.

Ensure that all tests specified in the commissioning schedule are accurately represented in the daily *generation* profiles. If any inconsistency is identified, the Generator must immediately update these documents with the latest commissioning information and provide them to AEMO and the NSP.

## Hold Points

When commissioning new or upgraded *plant* for the first time or making a change to *control system* settings or mode of operation HPs are generally required, whereby the *generating system’s* overall output is constrained to a pre-defined megawatt (MW) level, which increases following successful completion of each level. At each HP, a report must be submitted to AEMO and the NSP for review and approval before progressing further with commissioning.

This process allows for the staged release of capacity subject to:

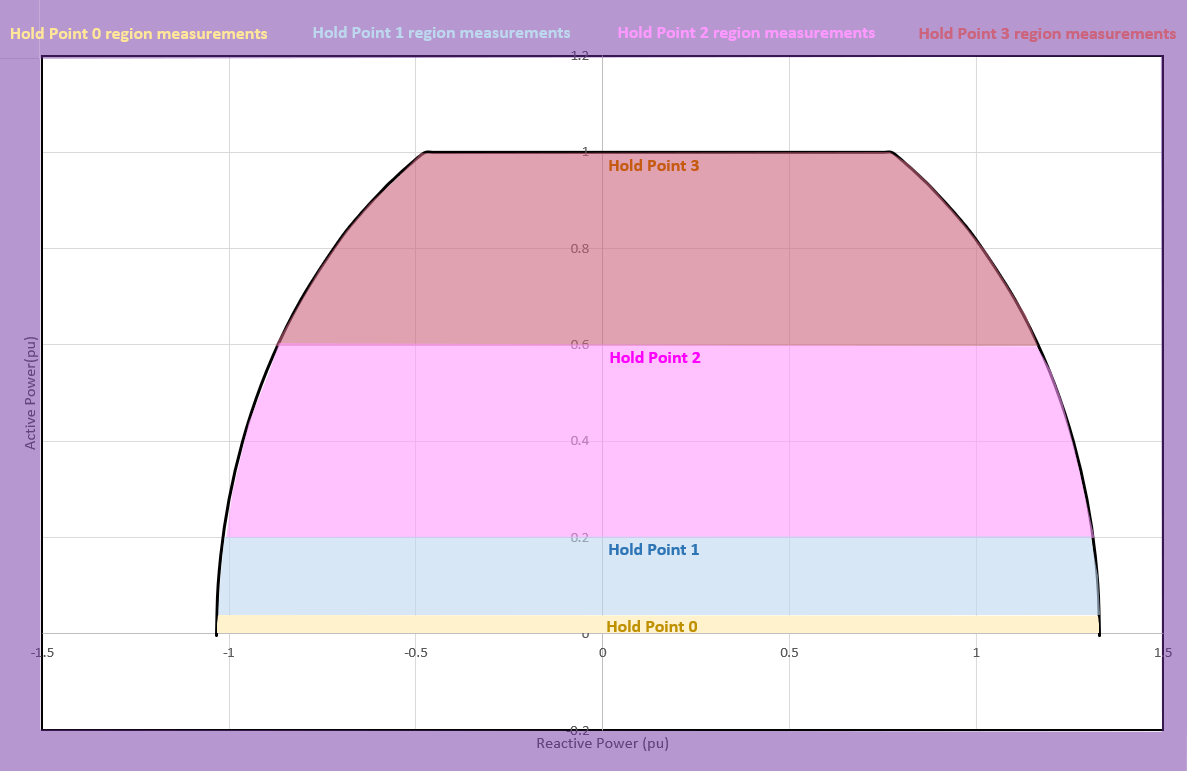
* Successful demonstration of applicable GPS.
* Confirmation of simulation model(s) against measured responses for all tests that can be replicated by performing dynamic simulation.

The number of HPs could vary depending on the size of the *generating system* and its impact on the *power system*. Typical HPs, as shown in Figure 1 for illustrative purposes, include:

* HP 0 – Prior to energisation of *generating units*.
* HP 1 – At least 20% of *plant* maximum capacity with at least 1/3 of *generating units* in service.
* HP 2 – At least 60% of *plant* maximum capacity with all *generating units* in service.
* HP 3 – At least 90% of *plant* maximum capacity with all *generating units* in service.

Refer to Appendix A1.3 for a recommended HP table template.

1. Typical Hold Point regions and measurements



This document assumes that three HPs are required. In practice, AEMO or the NSP can request more than three based on the location, number of *generating units* available for tests and size of the *generating system*.

HPs 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 HPs may be introduced if HP testing show there is no reasonable correlation between measured and simulated responses.

The minimum *generation* level and number of *generating units* online must be agreed with AEMO and the NSP for each HP in the commissioning test plan.

AEMO and the NSP release HP capacity for commissioning testing only. *Plant* is not expected to operate for an extended period without tests being undertaken. If HP tests are not completed or HP reports are not submitted to AEMO and the NSP within the agreed timeframes, AEMO will constrain *generating system* output to the previously approved HP level. If HP tests cannot be completed due to primary energy source availability, interim HPs may be tested subject to agreement with AEMO and the NSP.

AEMO and the NSP will confirm the following items are complete before final HP approval for unconstrained operation:

* All HP reports have been approved.
* All non-compliances during the commissioning period have been resolved.
* All control schemes, including *system strength remediation schemes,* are in operation and agreed parameters implemented.
* Operational communications are functional.
* *Energy conversion model* (**ECM**) is accurate and all SCADA signals are of good quality.
* Bids are updated accurately.
* *Plant* follows dispatch targets from AEMO as in accordance with the Dispatch Procedure SO\_OP\_3705.
* *Plant* is continuously monitored by the Generator’s control room, and processes are in place to identify and notify any non-conformance to the AEMO and NSP control rooms.
* The Generator’s control room operators have been trained to follow verbal instructions from the AEMO and NSP control rooms (e.g. switching operation, *voltage* set point change).
* Non-compliance reporting process is in place.

## Measurement equipment

Information that needs to be provided to AEMO and the NSP on the measurement equipment and its location is as follows:

* Manufacturer, model and serial number of the equipment.
* Type of equipment[[2]](#footnote-2):
  + Continuous monitoring, or event triggering, manual triggering or others.
  + Measurement equipment should be permanent to allow for compliance with clauses 4.15(b) and 5.7.3(g) of the NER.
  + It is recommended Generators use instrument *transformers* with a higher accuracy class to minimise the errors.
* Location of measurement equipment marked on a single line diagram:
  + Inverter-based *generation* technologies, such as wind and solar farms, generally consist of several *generating units* and reactive support devices. Measurement equipment must, therefore, be provided at various locations within the *generating system* including:
    - *Connection point* or HV terminals of *plant transformers* (T1 HV) (See Figure 7).
    - MV collector bus to which the *generating units* are *connected*.
    - *Generating units*:
* 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.
* 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.
  + - Some of the 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 such technologies are expected to cover both LV terminals.
    - Each type of dynamic reactive support device, such as STATCOMs and *synchronous condensors* (if applicable).
    - Central park level controller.
* Sampling rate and time window available for configuration.
* Inverter-based *generation* technologies generally employ fast acting power electronic converter controls. High speed measurement equipment is, therefore, required to capture the dynamic response adequately. Typical sampling rate of such measurement equipment is over 10 kHz.
* Format of measurement data (CSV or COMTRADE).
* The following data and information should be made available to AEMO and the NSP:
  + 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 measurement equipment.
* Valid and up-to-date calibration certificates of measurement equipment.
* Signals to be measured at each measurement location.
* Where many recorders are to be used, details on how measurement results will be synchronised to GPS clock.
* *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), per-phase RMS.
* 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.

## Test data file names

The following naming convention is required for all test data files captured:

PlantName\_SectionName\_HPNo\_TestName\_TNo.CSV



For example:

**Wind Farm X\_South section\_HP2\_VSR\_2\_B.CSV**

refers to a test carried out at Wind Farm X, South section, Hold Point 2, Voltage Step Response (VSR) test, test number 2.

Note that for *generating unit* testing, “Section name” is replaced with “Unit number”.

## GPS Compliance Assessment and R2 Model Validation Test Plan requirements

The Generator is expected to submit a GPS Compliance Assessment and R2 Model Validation Test Plan for approval from AEMO and the NSP before test commencement. Section 3 presents a list of typical tests and associated test procedures for inverter-based *generation* technologies. The commissioning test plan should be updated during commissioning and resubmitted to AEMO and the NSP if material changes are required.

The following information is generally included in a GPS Compliance Assessment and R2 Model Validation Test Plan:

* Introduction, test objective and scope of the test plan.
* Pre-requisites to commence.
* Key *plant* information (refer Section 2.3 and sample format in Appendix A1.2).
* Main contacts (refer Section 2.2 and sample format in Appendix A1.1).
* Communication protocol (refer Section 2.4).
* HP details (refer Section 2.7 and sample format in Appendix A1.3).
* Overview of GPS Compliance Assessment and R2 Model Validation Tests.
* Measuring equipment details and location (refer Section 2.8).
* Test data file names format (refer Section 2.9).
* HP test details (see Section 3).
  + Pre-requisites for HP tests commencement.
  + Risk assessment for each test (see sample format in Appendix A1.7).
  + Purpose, pre-test conditions, methodology and procedure, signals to be measured and plotted, measurement data file name and format, and acceptance criteria.
  + Simulation software for overlays agreed for each test (PSS®ETM or PSCADTM/EMTDCTM).
* Single line diagram.
* *Reactive power* capability curve.
* Measurement point layout (see Appendix A1.10).

## Hold point test report requirements

The purpose of HP reports is to demonstrate that the tested *plant* can meet its GPS and that the *plant* model is reasonably representative of its performance. Therefore, the results should be presented so that compliance can be assessed.

As a guide, the following information is generally included in a HP test report:

* Background.
* Summary of HP tests.
* Applicable controller firmware and simulation models (PSS®ETM and PSCADTM/EMTDC™) version summary.
* Test results:
  + Details of the test record, which includes 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. Refer to Appendix A1.8, Table 12 for a template.
  + File name summary, which includes test, time stamp and file name. Refer to Appendix A1.8, Table 12, for a template.
  + Screenshots of the human machine interface (HMI), as required under pre-test conditions.
  + Plot all signals agreed in the signals to measured and plotted section under each test.
  + Overlays of measured and simulated results including ±10% accuracy bands for simulated response under the acceptance criteria.
  + Summary of test results to confirm compliance for each test.
  + Conclusion section clearly analysing the test compliance with the agreed acceptance criteria.
* Summary of HP test results showing compliance with the relevant GPS. Refer to Appendix A1.9 for a template.
* Any plotted result should be on an appropriate scale and include any relevant analysis to allow AEMO and the NSP to confirm compliance with the relevant GPS.
* If relevant, the setpoint value that is being modified should be included in the results and on any plots.
* Information needed to replicate the simulated results, including the case type used (NEM or SMIB). If relevant, the value used for the grid impedance and the method of deriving the grid impedance should 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).
* HP test measured date files consistent with format, resolution and naming convention as detailed under Sections 2.8 and 2.9.
* Applicable setting summary table comparing physical settings downloaded from actual controllers on site with the R1 PSS®ETM and PSCADTM/EMTDC™ model settings as an appendix.

# Typical tests for inverter-based generation technologies

Typical tests for inverter-based *generation* technologies, and the information sought from Generators for each test, is detailed below. Some aspects of the *generating system* GPS and R2 models cannot be fully demonstrated/validated through staged tests. In these circumstances, the Generator must specify an alternative assessment methodology.

## Hold Point 0 Tests

### Synchronous dynamic reactive and/or system strength support device (SDRD) control test – HP0\_SDR test (if applicable)

The operation of synchronous dynamic reactive and/or system strength support devices, commonly referred to as *synchronous condensors*, is identical to that of *synchronous* *generating systems* with an *excitation control system*. Tests conducted on a *synchronous condensor* are, therefore, similar to those for a *synchronous generating system*, except that a *synchronous condensor* 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 the GPS Compliance Assessment and R2 Model Validation Test Plan Template for Conventional Synchronous Machines.

### Asynchronous dynamic/static reactive support device (DRD) control system test – HP0 DRD test (if applicable)

##### Purpose

* To assess the response of *voltage control system* and step response characteristics of *voltage* and *reactive power.*
* 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*, tap changer control logic.

[Note: The asynchronous dynamic reactive support device *control system* model parameters listed above are provided for illustrative purposes. The Generator must specify all model parameters being validated].

#### Pre-test conditions

* All *generating units* are offline.
* *Generating systems’ connection point* is energised.
* All other reactive support devices are offline.
* Pre-test simulation studies report is submitted by the Generator to AEMO and the NSP to verify the extent of changes in *network voltage* and *reactive power*.
* *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 NSP control rooms.

#### Reactive power capability test (HP0 NDR Test A)

##### Methodology and procedure

* Pre-test conditions are confirmed.
* Confirm the measurement systems are ready.
* Configure the *control system* to *reactive power* control and set Qref to 0 MVAr.
* Increase Qref to positive limit in steps (step size can be determined from pre-test simulation studies and need to be agreed with the NSP and AEMO. Typical sizes are 2 to 5 MVAr).
* Return Qref to 0 MVAr in steps (2 to 5 MVAr step).
* Decrease Qref to negative limit in steps (2 to 5 MVAr step).
* Return Qref to 0 MVAr in steps (2 to 5 MVAr step).
* Allow the device to run continuously for 10-15 minutes at each operating point above with at least 60 seconds recording time after the response has settled at its steady-state value.
* View test data file to ensure it has been successfully saved.
* Reconfigure the *control system* to default control mode.

##### Signals to be measured and plotted

Table 1 shows the typical signals to be measured for the HP1\_NDR Test A, and highlights those that need to be plotted and compared against the respective simulated response.

1. Typical signals to be measured for asynchronous dynamic reactive support device control system tests

|  |  |  |  |
| --- | --- | --- | --- |
| Signals to be measured | Signals for model overlay | Sampling rate | Record time window |
| Voltage at connection point |  | Minimum 2 kHz sampling rate | Minimum 10 minutes for test A and 60 seconds for test B after reaching steady-state conditions |
| Active power at connection point |  |
| Reactive power 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 T1MV |  |
| Active power at T1MV |  |
| Reactive power at T1MV |  |
| Voltage at T2MV |  |
| Active power at T2MV |  |
| Reactive power at T2MV |  |
| Voltage at reactive plant feeder | ✓ |
| Active power at reactive plant feeder |  |
| Reactive power at reactive plant feeder | ✓ |
| DRD terminal voltage | ✓ |
| DRD reactive power output | ✓ |
| NDRD control signals from control system |  |
| Status of reactive support devices before and after the test |  |
| Vref of the DRD control system | ✓ |
| Qref of the DRD control system | ✓ |
| PFref of the DRD control system |  |
| **Any other applicable command signals** |  |  |  |

Include signals that are plotted and compared against the respective simulated response in the GPS Compliance Assessment and R2 Model Validation Test Plan.

##### Measurement data file name and format

PlantName\_UnitNo\_HP0\_NDR\_T01.CSV.

##### Acceptance criteria

* *Reactive power* output follows the reference set point 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.

#### Voltage control test (HP0 NDR Test B)

##### Methodology and procedure

* Pre-test conditions are confirmed.
* Confirm the measurement systems are ready.
* Configure the *control system* to *voltage* control and set Vref to measured target *voltage*.
* Increase Vref to Vref\_max in steps (0.1 per unit (pu) step).
* Return Vref to pre-test level in steps (0.1 pu step).
* Decrease Vref to Vref\_min in steps (0.1 pu step).
* Return Vref to pre-test level steps (0.1 pu step).
* Apply a +5% step to Vref.
* Apply a -5% 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.
* Reconfigure the *control system* to default control mode.

##### Signals to be measured and plotted

Table 1 shows typical signals that need to be measured for the HP0\_NDR Test B, and highlights those that need to be plotted and compared against the respective simulated response. Refer to Figure 7 for location of measured signals.

##### Measurement data file name and format

PlantName\_UnitNo\_HP0\_NDR\_T02.CSV.

##### Acceptance criteria

* Model overlays of the *reactive power* responses for the *voltage* step test are submitted as part of HP reports.
* To assess compliance with the *Power System Model Guidelines*, ±10% accuracy band is superimposed on the graphs, including overlays of measured and simulated responses.
* *Reactive power* response able to return to stable operation after each step.
* *Voltage*, *active power* and *reactive power* *settling time* for a 5% step response complies with GPS S5.2.5.13, i.e. a *settling time* of five seconds or less for the *voltage* step response.
* *Reactive power* *rise time* for a 5% step response complies with GPS S5.2.5.13, i.e. a *rise time* of two seconds or less for the *voltage* step response.
* Measurement data is successfully downloaded and confirmed.

#### Switching logic test (HP0 NDR Test C)

##### Methodology and procedure

* Pre-test conditions are confirmed.
* Confirm the measurement systems are ready.
* *Reactive power* support devices are isolated from the *control system*.
* The *generating system* is in default control mode.
* Qref, Pref signals are injected to reactive support *control system* in steps until reactive power support device switching is triggered.
* Repeat the test for each *reactive power* support device switching threshold.

##### Signals to be measured and plotted

Table 1 shows the typical signals to be measured for the HP0\_NDR Test C, and highlights those that need to be compared against the respective simulated response.

##### Measurement data file name and format

PlantName\_UnitNo\_HP0\_NDR\_T03.CSV.

##### Acceptance criteria

* Confirm capacitors switching logic threshold, hysteresis, deadband, and delay consistent with *voltage* control strategy document.
* Measurement signal data is successfully downloaded and confirmed.

#### Transformer tap changer logic test (HP0 NDR Test D)

##### Methodology and procedure

* Pre-test conditions are confirmed.
* The *generating system* is in default control mode.
* Vref, Qref signals are injected to signals to *transformer* automatic *voltage* regulation *control system* in steps until *transformer* tap changer is triggered.
* Repeat the test for each tap changer threshold.

##### Signals to be measured and plotted

Table 1 shows the typical signals to be measured for the HP1\_NDR Test D, and highlights those that need to be plotted and compared against the respective simulated response.

##### Measurement data file name and format

PlantName\_UnitNo\_HP0\_NDR\_T04.CSV.

##### Acceptance criteria

* Confirm tap changer logic threshold, hysteresis, deadband, and delay consistent with *voltage* control strategy document.
* Measurement signal data is successfully downloaded and confirmed.

### Background power quality measurements (HP0\_WFPQT/HP0\_SFPQT)

##### Purpose

* To determine background power quality signature at the *connection point* before *connection* of the *generating system*.

##### Pre-test conditions

* Confirm measurement systems are ready.
* *Generating system’s connection point* is energised.
* All *generating units* and balance of *plant* components are *disconnected*.

##### Signals to be measured

The typical signals to be measured for the HP0\_ WFPQT/HP01\_SFPQT test are as follows:

* Phase to neutral *voltages* of each phase.
* Fundamental *frequency.*
* Harmonics voltages up to the 50th (including THD).
* Flicker levels (including pst and plt levels).
* *Voltage* unbalance levels (positive sequence *voltage*, negative sequence *voltage* and negative sequence unbalance *voltage*).

##### Methodology and procedure

* Background measurement (HP0\_WFPQT/HP0\_SFPQT).
* It is generally expected that the background power quality data is available from the NSP. If not, a background power quality test (HP0\_WFPQT) at the *connection point* should be performed by the Generator before commissioning begins. Steady-state continuous measurements must be conducted at the *connection point* for at least one week using the method described in AS/NZS 61000.4.7:2012 and AS/NZS 61000.4.15:2012.

#### Acceptance criteria

Measurement data is successfully downloaded and confirmed.

### Generating unit signal injection tests (HP0\_WFSI/HP0\_SFSI)

#### Purpose

* To confirm *voltage* and *frequency* protection settings of the *generating units* consistent with GPS S5.2.5.8.
* To validate *voltage* and *frequency* protection settings implemented in dynamic models of *generating units*.

#### Pre-test conditions

* Confirm measurement systems are ready.
* Confirm all *generating unit* protection settings consistent with GPS.
* All *generating unit* protection settings uploaded and in service.

#### Methodology and procedure

* 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.

#### Acceptance criteria

* Measurement data is successfully downloaded and confirmed.
* Confirm *generating units* trip and delay consistent with the applied settings and GPS.

### End to end communication delay test (HP0\_WFCD/HP0\_SFCD)

#### Purpose

* To validate communication delays implemented in dynamic simulation models of *generating units*.
* To confirm functions of communication equipment and feedback signals.

##### Pre-test conditions

* Confirm measurement systems are ready.
* 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.

##### Acceptance criteria

* Measurement data is successfully downloaded and confirmed.
* Confirm measured communication delays consistent with the dynamic simulation models time delays.

## Hold Point 1 Tests

### Power quality test (HP1\_WFPQT/HP11SFPQT)

##### Purpose

To partially assess compliance with GPS S5.5.5.2 and GPS S5.2.5.6.

##### Pre-test conditions

* Confirm measurement systems are ready.
* *Generating system’s connection point* is energised.
* *Generating units* and balance of *plant* components as agreed in the commissioning plan are *connected*.

#### Signals to be measured and plotted

Table 2 shows the typical signals to be measured for the HP1\_WFPQT/HP1\_SFPQT.

#### Methodology and procedure

Continuous measurement must be captured at the *connection point* (measurement window must be agreed with the NSP and AEMO) as described in AS/NZS 61000.4.7:2012 and AS/NZS 61000.4.15:2012. This is to ensure that the final power quality assessment based on IEC TR 61000.3.6:2012 and IEC TR 61000.3.7:2012 meets the agreed GPS limits.

Measurements include high (80% of HP1 MW level) and low *generation* conditions where practically possible. The final compliance assessment will be conducted by comparing results obtained from the background measurements before and after *connection* of the *generating system*. Measurements used in the final report should include one week of continuous measurements for each pre- and post-*connection*.

#### Acceptance criteria

* Measurement data is successfully downloaded and confirmed.
* Assessment is conducted by comparing results obtained from the background measurements (HP1\_WFPQT/HP1\_SFPQT) and during the HP 2 testing period.
* The quality of the electricity generated (harmonics, flicker and voltage unbalance) is within the agreed limits under GPS S5.2.5.2.

### Generating unit and park dispatch control test

#### Purpose

* To validate *reactive power* capability, *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.

#### Generating unit reactive power capability test (HP1 WTG Test A/ HP1 SI Test A)

##### Pre-test conditions

* Confirm measurement systems are ready.
* Monitor and record the ambient temperature before, during and after the test.
* *Generating units* under test are operated with the park dispatch control enabled.
* The park dispatch controller is in *active power* and *reactive power* control mode.
* All reactive support and energy storage devices are offline.
* The *generating system transformers* are in manual control (fixed tap).

##### Methodology and procedure

* *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 HP, and boundaries of *reactive power generation* 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

* *Generating unit* terminal *voltage*.
* *Generating unit* terminal *active power*.
* *Generating unit* terminal *reactive power*.

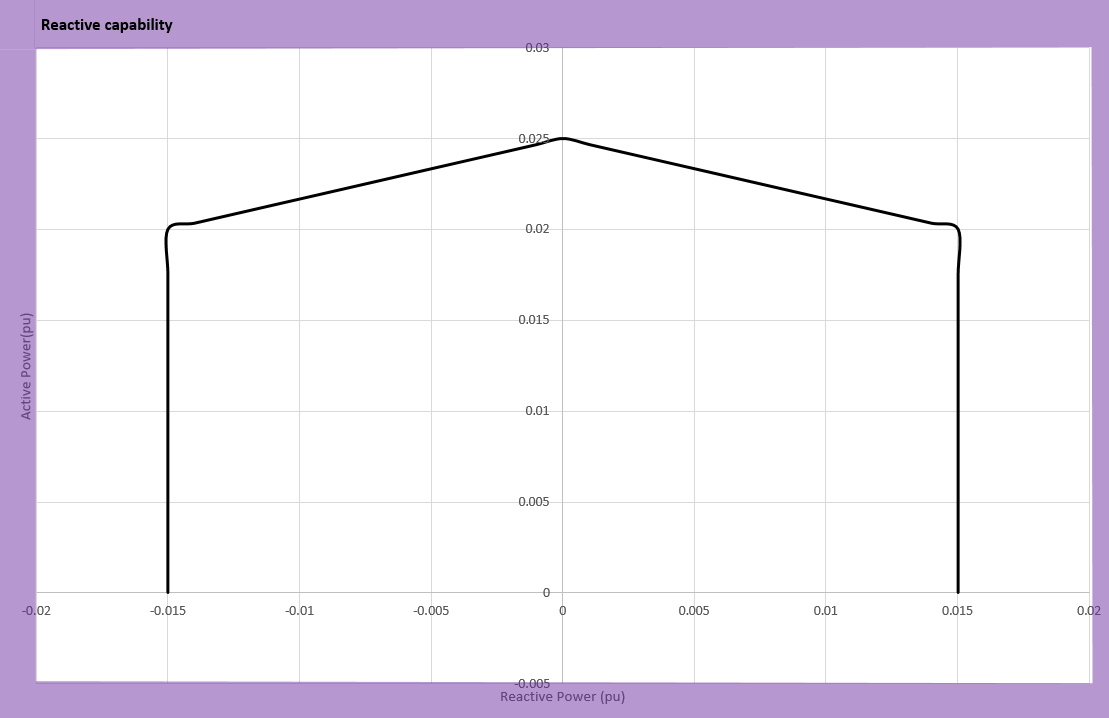
##### Measurement data file name and format

PlantName\_UnitNo\_HP1\_WTG\_RCT.CSV.

##### 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.

1. Typical reactive power capability of a solar inverter generating unit



#### Generating unit active power dispatch test (HP1\_WTG Test B / HP1\_SI Test B)

##### 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 offline.
* The *generating system transformers* are in manual control (fixed tap).
* The *generating units* are operating at above 80% of rated *active power* output.

##### Methodology and procedure

* Pre-test conditions are confirmed.
* Confirm measurement systems are ready.
* Apply a -20% step to the *active power dispatch* set point (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

Table 2 summarises typical signals to be measured for the *generating unit active power dispatch* test, and highlights those that need to be plotted and compared against the respective simulated response.

##### Measurement data file name and format

PlantName\_UnitNo\_HP1\_WTG\_APT.CSV.

##### Acceptance criteria

* The *active power* response follows the reference correctly.
* *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.
* Model overlays for the *active power dispatch* test are submitted as part of HP reports.
* To assess compliance with the *Power System Model Guidelines*, ±10% accuracy bands need to be superimposed on the graphs, which include overlays of measured and simulated responses.
* Measurement data is successfully downloaded and confirmed.

#### Generating unit reactive power dispatch test (HP1 WTG Test C / HP1 SI Test C)

##### Pre-test conditions

* Confirm measurement systems are ready.
* *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 offline.
* *Generating system transformers* are in manual control (fixed tap).
* *Generating units* are operating at above 80% of rated *active power* output.

##### 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* set point Qdsp (typically 25%).
* 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 -25% step, ±50% steps and ±75% steps.
* View test data file to ensure it has been successfully saved.

##### Signals to be measured and plotted

Table 2 summarises typical signals to be measured for the *generating unit reactive power dispatch* test and highlights those signals that need to be compared against the respective simulated response.

##### Measurement data file name and format

PlantName\_UnitNo\_HP1\_WTG\_RPT.CSV.

##### Acceptance criteria

* The *reactive power* response follows the reference correctly.
* The *generating unit* is able to return to stable operation after each step.
* Model overlays for the *reactive power dispatch* test are submitted as part of HP reports.
* To assess compliance with the *Power System Model Guidelines*, ±10% accuracy bands need to be superimposed on the graphs, which include overlays of measured and simulated responses.
* Measurement data is successfully downloaded and confirmed.

1. Typical signals to be measured for generating unit and park dispatch control tests

|  |  |  |  |
| --- | --- | --- | --- |
| 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 |  |
| 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 set point reference | ✓ |
| Frequency control set point reference | ✓ |
| **Any other applicable command signal** |  |  |  |

### Generating system reactive power capability test (HP1\_WFRCT/HP1\_SFRCT)

##### Purpose

* To assess compliance with GPS S5.2.5.1 with respect to *reactive power* capability of the *generating system*.
* To assess compliance with GPS S5.2.6.1 and clause 4.11.1 of the NER with respect to confirmation of:
  + SCADA feedback signals.
  + Communication equipment.

##### Pre-test conditions

* Confirm measurement systems are ready.
* Communicate and confirm test with NSP and AEMO control rooms.
* 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.
* The *generating units* are in park dispatch control.
* The *generating system* is in default control mode, e.g. *voltage* 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

The *generating system* is operated at a wide range of operating conditions including *reactive power* *generation* and absorption boundaries. Figure 3 shows a typical *reactive power* capability of inverter-based *generating system* with minimum operating points that are required to be captured during an HP1 test.

* Pre-test simulation studies report is submitted by the Generator 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*.
* 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 3.
* Wait until the response settles.
* 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

Table 2 summarises typical signals to be measured for the test and highlights those signals that need to be compared against the respective simulated response.

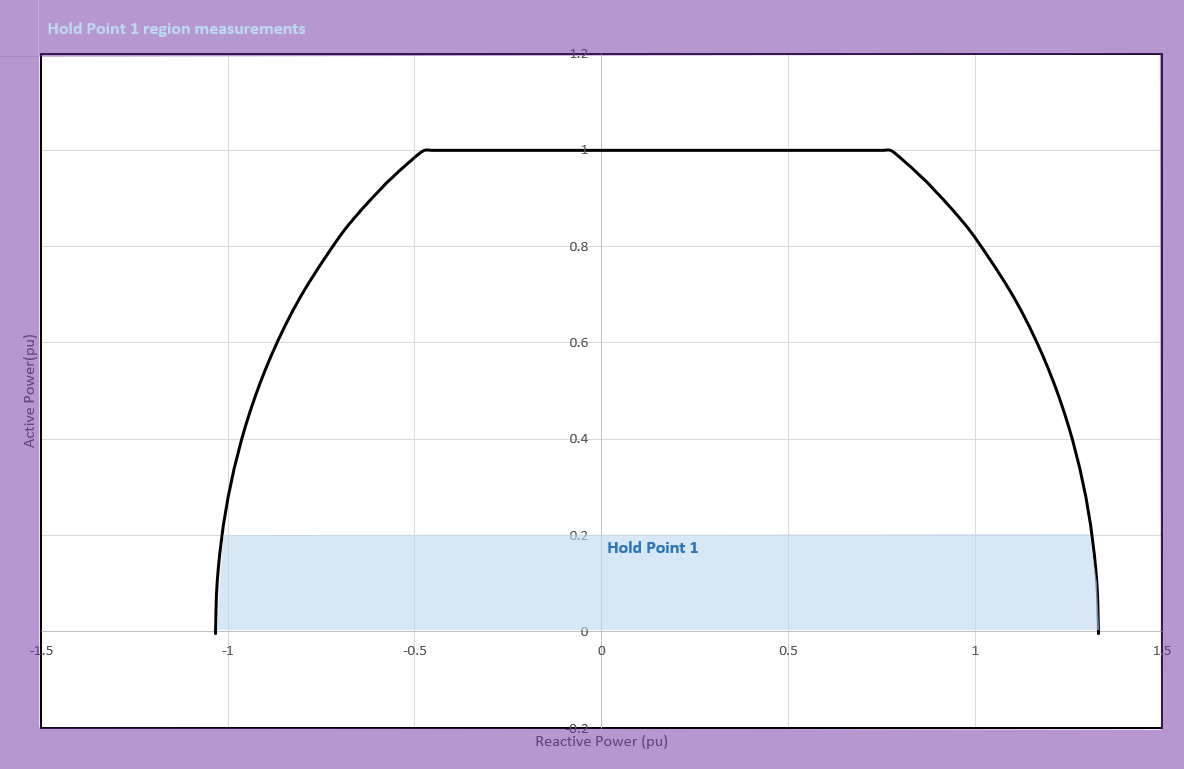
#### Measurement data file name and format

PlantName\_SectionNo\_HP1\_WFRCT.CSV.

#### Acceptance criteria

* The *generating system* can continuously run for 10-15 minutes under each reactive boundary operating condition.
* *Voltage*, *active power* and *reactive power* at the *generating system’s connection point* and *generating units*’ terminals are stable.
* Measurement data is successfully downloaded and confirmed.

1. Typical inverter-based generating system reactive power capability and measurement conditions for HP1



### Static reactive support device manual switching test[[3]](#footnote-3) (HP1\_WFCAP/HP1\_SFCAP)

#### Purpose

* To assess compliance with GPS S5.2.5.13 with respect to *voltage* and *reactive power* control of the *generating system*.
* To assess compliance with GPS S5.2.5.4 with respect to *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 validate the dynamic reactive support *control system* model and parameters (if applicable).
* To validate the park dispatch control model and parameters.
* To assess compliance with GPS S5.2.6.1 and clause 4.11.1 with respect to confirmation of:
  + SCADA feedback signals.
  + Communication equipment.

#### Pre-test conditions

* Communicate and confirm test with the NSP and AEMO control rooms.
* 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%[[4]](#footnote-4) 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 but in local manual control.
* The *generating system transformer* is under auto control.

#### Methodology and procedure

* Pre-test simulation studies report are submitted by the Generator 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*.
* Confirm measurement systems are ready.
* 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

Table 2 summarises typical signals that need to be measured for the test, and highlights those that need to be compared against the respective simulated response.

#### Measurement data file name and format

PlantName\_SectionNo\_HP1\_WFCAP.CSV.

#### Acceptance criteria

* Model overlays for the static reactive support device manual switching test are submitted as part of HP reports.
* To assess compliance with the *Power System Model Guidelines*, ±10% accuracy bands need to be superimposed on the graphs which include overlays of measured and simulated responses.
* *Generating system* is able to return to stable operation after each switching action.
* The *settling time* of *voltage* response for the switching action complies with the requirements of GPS S5.2.5.13, e.g. 5 seconds settling required for a 5% *voltage* disturbance.
* The *settling time* of *reactive power* response for the switching action complies with the requirements of GPS S5.2.5.13, e.g. 5 seconds settling required for a 5% *voltage* disturbance.
* The *active power* and *reactive power* response for the switching action complies with the requirements of GPS S5.2.5.4. e.g. *generating system* and each of its *generating units* capable of *continuous uninterrupted operation* for a *power system* disturbance causes *voltage* at the *connection point* to vary.
* Measurement data is successfully downloaded and confirmed.

### Generating system active power control test

#### Purpose

* To assess compliance with GPS S5.2.5.14 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 room and the *generating system* local control.
* To validate ramp up and down rates (ramp rate algorithm) to a *dispatch* command from the AEMO control room (e.g. linear ramping at the end of the dispatch interval as required under Dispatch Procedure SO\_OP\_3705).
* 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 validate *active power* control loop model and parameters of the *generating units*.
* To validate the park dispatch control model and parameters.
* To assess compliance with GPS S5.2.6.1 and clause 4.11.1 with respect to confirmation of:
  + SCADA feedback signals.
  + Communication equipment.

#### Generating system active power control (local control) test (HP1\_WFAPC\_LOC/HP1\_SFAPC\_LOC)

##### Pre-test conditions

* Communicate and confirm test with NSP and AEMO control rooms.
* 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%[[5]](#footnote-5) 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 transformer* is under auto control.

##### Methodology and procedure[[6]](#footnote-6)

* Confirm measurement systems are ready.
* This test is generally conducted in two stages and carried out in HP1/HP2 and HP3, respectively.
* The first stage of the test involves *active power* control test initiated through local *generating system* park controller (HP1\_WFAPT\_LOC/HP1\_SFAPT\_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.
  + 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.
* The second stage of the test will be described in Section 3.4.4.

##### Signals to be measured and plotted

Table 2 summarises typical signals that that need to be measured for the test, and highlights those that need to be compared against the respective simulated response.

##### Measurement data file name and format

PlantName\_SectionNo\_HP1\_WFAPT\_LOC.CSV.

##### Acceptance criteria

* Model overlays of the *generating system active power dispatch* test are submitted as part of HP reports.
* To assess compliance with the *Power System Model Guidelines*, ±10% accuracy bands need to be superimposed on the graphs, which include overlays of measured and simulated responses.
* The *generating system* is able to return to stable operation after each step.
* The response time of *active power dispatch* complies with the requirements of GPS S5.2.5.14, e.g. *active power* output ramps linearly from one level of *dispatch* to another.
* Ramp up and down rate within the maximum ramp rate.
* Measurement data is successfully downloaded and confirmed.

#### Generating system active power control (dispatch) test (HP1\_WFAPC\_DIS/HP1\_SFAPC\_DIS)

This is the second stage of the *active power* control test and conducted after successful completion of *generating system* level testing. This test is initiated by an *active power dispatch* signal from the AEMO control room.

The Generator submits 30-minute bids to achieve the required *active power dispatch* levels. The *dispatch* signal from AEMO control room and subsequent *generating system* response must be monitored to confirm end-to-end communication of *active power dispatch* command from the AEMO control room through to each *generating unit*.

Typically, a minimum of two 30-minute bids are required: one for run-back *dispatch* and another for run-up *dispatch*.

#### Pre-test conditions

* Communicate and confirm test with the NSP and AEMO control rooms.
* 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 HP1 MW level.
* Total output of the *generating units* is above 80%[[7]](#footnote-7) 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 transformer* is under auto control.
* AGC tests complete during SCADA tests.

#### Methodology and procedure[[8]](#footnote-8)

* Confirm measurement systems are ready.
* This test is initiated by an *active power dispatch* signal from the AEMO control room and conducted as follows:
  + Configure the *generating system* control to remote control mode.
  + The Generator submits 30-minute bids to achieve ramp down to 50%, ramp down to 10%, ramp up to 40% and ramp up to 80% of HP1 output level.
* The *dispatch* signal from the AEMO control room and subsequent *generating system* response will be monitored to confirm end-to-end communication of *active power dispatch* command from the AEMO control room 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

Table 2 summarises typical signals that that need to be measured for the test, and highlights those that need to be compared against the respective simulated response.

#### Measurement data file name and format

PlantName\_SectionNo\_HP1\_WFAPT\_DIS.CSV.

#### Acceptance criteria

* Model overlays of the *generating system active power dispatch* test are submitted as part of HP reports.
* To assess compliance with the *Power System Model Guidelines*, ±10% accuracy bands need to be superimposed on the graphs, which include overlays of measured and simulated responses.
* The *generating system* is able to return to stable operation after each step.
* The response time of *active power dispatch* complies with the requirements of GPS S5.2.5.14, e.g. *active power* output ramps linearly at a constant rate from one level of *dispatch* to another at the end of dispatch interval.
* The *generating system* ramp rate algorithm is consistent with the Dispatch Procedure SO\_OP\_3705 requirements, e.g. the *semi-scheduled generating system* is expected to ramp linearly from its initial *active power* output to its semi-dispatch cap applying at the end of the *dispatch interval*, subject to energy availability.
* Effective ramp up and down rates consistent with the ramp rate algorithm.
* *Dispatch instruction* delivery delay time and processing time within reasonable limits (typically delivery time delay up to 10 seconds and processing time up to 30 seconds).
* Measurement data is successfully downloaded and confirmed.

### Generating system reactive power reference test (HP1\_WFRPT/HP1\_SFRPT)

#### Purpose

* To assess compliance with GPS S5.2.5.13 with respect to *voltage* and *reactive power* control of the *generating system*.
* To validate *reactive power* control loop model and parameters of the *generating units*.
* To validate the park dispatch control model and parameters.
* To assess compliance with GPS S5.2.6.1 and clause 4.11.1 with respect to confirmation of:
  + SCADA feedback signals.
  + Communication equipment.

#### Pre-test conditions

* Communicate and confirm test with the NSP and AEMO control rooms.
* 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%[[9]](#footnote-9) of HP1 MW level.
* *Generating units* are under park dispatch control in *active power* and *reactive power* control mode.
* All reactive support plants are offline.
* The *generating system transformer* is under auto control.

#### Methodology and procedure

* Confirm measurement systems are ready.
* Pre-test simulation studies report is submitted by the Generator to verify that the extent of changes in *network voltage* and *reactive power* at the *connection point* would not adversely impact the area to which the *generating system* is *connected*.
* Pre-test conditions are confirmed.
* The reactive reference (Qref) 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 set-point Qref.
* 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 Qref 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, ±50% steps and ±75% steps.
* View test data file to ensure it has been successfully saved.

#### Signals to be measured and plotted

Table 2 summarises typical signals to be measured for the test.

#### Measurement data file name and format

PlantName\_SectionNo\_HP1\_WFRPT.CSV.

#### Acceptance criteria

* The *reactive power* response follows the *reactive power* reference correctly.
* The *reactive power control system* can regulate the *reactive power* at the *connection point* and agreed location within 2% of the rating (in MVA) of the *generating system* (expressed in MVAr).
* Model overlays of *generating system reactive power dispatch* test are submitted as part of HP reports.
* To assess compliance with the *Power System Model Guidelines*, ±10% accuracy bands need to be superimposed on the graphs, which include overlays of measured and simulated responses.
* Measurement data is successfully downloaded and confirmed.

### Generating system voltage reference step test (HP1\_WFVCT/HP1\_SFVCT)

#### Purpose

* To assess compliance with GPS S5.2.5.13 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 validate static and dynamic reactive support *control system* model and parameters (if applicable).
* To validate the park *dispatch* *voltage* control model and parameters.
* To assess compliance with GPS S5.2.6.1 and clause 4.11.1 with respect to confirmation of:
  + SCADA feedback signals.
  + Communication equipment.

#### Pre-test conditions

* Communicate and confirm test with the NSP and AEMO control rooms.
* 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%[[10]](#footnote-10) 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 auto control.

#### Methodology and procedure

* Confirm measurement systems are ready.
* Pre-test simulation studies report is submitted by the Generator to verify that the extent of changes in *network voltage* and *reactive power* at the *connection point* would not adversely impact the area to which the *generating system* is *connected*.
* Configure the *generating system* control to local control mode.
* Apply a ±3% step to Vref.
* Apply a ±3% step to Vref.
* Apply a ±5% step to Vref.
* Apply a ±5% 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.

#### Signals to be measured and plotted

Table 2 summarises typical signals to be measured for the test.

#### Measurement data file name and format

PlantName\_SectionNo\_HP1\_WFVCT.CSV.

#### Acceptance criteria

* Model overlays of the *generating system voltage* reference step test are submitted as part of HP reports. The following responses need to be included:
  + *Connection point*.
  + Static and dynamic reactive support plant.
  + Central park level controller.
  + Coordinated *voltage* control scheme.
* To assess compliance with the *Power System Model Guidelines*, ±10% accuracy bands need to be superimposed on the graphs, which include overlays of measured and simulated responses.
* The *generating system* is able to return to stable operation after each step.
* The *settling time* of *active power*, *reactive power* and *voltage* response for the switching action complies with the requirements of GPS S5.2.5.13, e.g. five seconds settling time is required for a 5% *voltage* disturbance.
* The *reactive power* *rise time* for the switching action complies with the requirements of GPS S5.2.5.13, e.g. 2 seconds *reactive power rise time* is required for a 5% voltage disturbance.
* Measurement data is successfully downloaded and confirmed.

### Generating system power factor reference step test (HP1\_WFPFT/HP1\_SFPFT) (if applicable)

#### Purpose

* To assess compliance with GPS S5.2.5.13 with respect to *power factor* control capability.
* To assess response of coordinated *power factor* control strategy of the *generating system* and validate associated simulation models (if applicable).
* To validate static and dynamic reactive support *control system* model and parameters (if applicable).
* To validate the park *dispatch power factor* control model and parameters.
* To assess compliance with GPS S5.2.6.1 and clause 4.11.1 of the NER with respect to confirmation of:
  + SCADA feedback signals.
  + Communication equipment.

#### Pre-test conditions

* Communicate and confirm test with the NSP and AEMO control rooms.
* 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%[[11]](#footnote-11) 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 transformer* is under auto control.

#### Methodology and procedure

* Pre-test simulation studies report must be submitted by the Generator 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*.
* Confirm measurement systems are ready.
* 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.

#### Signals to be measured and plotted

Table 2 summarises typical signals to be measured for the test and highlights those signals that need to be compared against the respective simulated response.

#### Measurement data file name and format

PlantName\_SectionNo\_HP1\_WFPFT.CSV.

#### Acceptance criteria

* Model overlays of the *generating system voltage* reference step test are submitted as part of HP reports. The following responses needs to be included:
  + *Connection point*.
  + Static and dynamic reactive support *plant*.
  + Central park level controller.
  + Coordinated *voltage* control scheme.
* The *power factor* at the *connection point* or agreed location follows the *power factor* reference correctly.
* The *power factor control system* can regulate the *power factor* at the *connection point* and agreed location within 2% of the rating (in MVA) of the *generating system* (expressed in MVAr).
* To assess compliance with the *Power System Model Guidelines*, ±10% accuracy bands need to be superimposed on the graphs, which include overlays of measured and simulated responses.
* The *generating system* is able to return to stable operation after each step.
* *Power factor* setpoint can be continuously controllable across the *reactive power* capability range established under GPS S5.2.5.1.
* Measurement data is successfully downloaded and confirmed.

### Generating system transformer manual tap position change test (HP1\_WFTXT/HP1\_SFTXT)

#### Purpose

* To assess compliance with GPS S5.2.5.4 and GPS S5.2.5.13.
* To assess response of the *generating system* and *generating units* to small *voltage* disturbances caused by *transformer* tap changes.
* To validate 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 GPS S5.2.6.1 and clause 4.11.1 of the NER with respect to confirmation of:
  + SCADA feedback signals.
  + Communication equipment.

#### Pre-test conditions

* Maximum *generating system* output is at the agreed HP1 MW level.
* Total output of the *generating units* is above 80%[[12]](#footnote-12) 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 *generating system transformer* is under manual control (fixed tap).

#### Methodology and procedure

* Pre-test simulation studies report must be submitted by the Generator to AEMO and the NSP 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*.
* Confirm measurement systems are ready.
* Configure the *generating system* control to local control mode.
* Pre-test conditions are confirmed.
* 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 ±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.

#### Signals to be measured and plotted

Table 2 summarises typical signals to be measured for the test and highlights those signals that need to be compared against the respective simulated response.

#### Measurement data file name and format

PlantName\_SectionNo\_HP1\_WFTXT.CSV.

#### Acceptance criteria

* Model overlays of the *generating system transformer* manual tap position change test are submitted as part of HP reports. The following responses needs to be included:
  + *Connection point*.
  + Static and dynamic reactive support *plant*.
  + Central park level controller.
  + Coordinated *voltage* control scheme.
* To assess compliance with the *Power System Model Guidelines*, ±10% accuracy bands need to be superimposed on the graphs, which include overlays of measured and simulated responses.
* The *generating system* is able to return to stable operation after each step.
* Measurement data is successfully downloaded and confirmed.

## Hold Point 2 Test

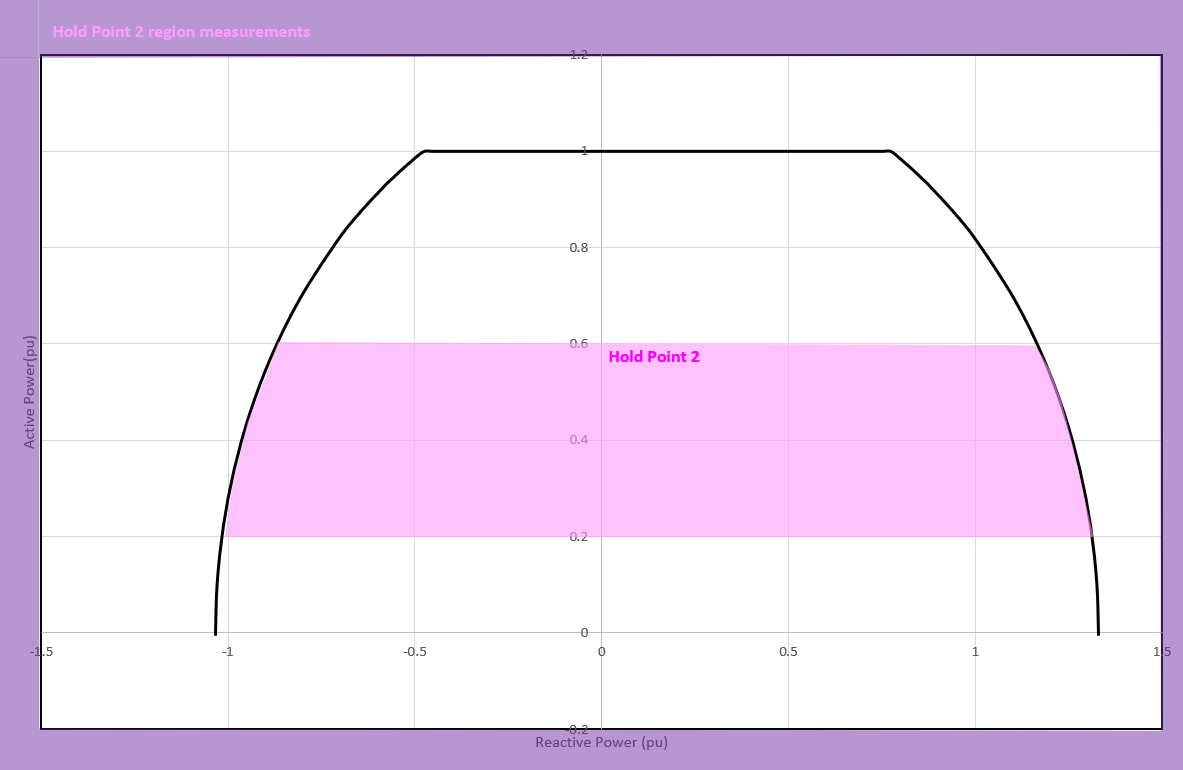
### Power quality test (HP2\_WFPQT/HP2\_SFPQT)

Refer to Section 3.2.1 as the same methodology used there is used for this test.

### Generating system reactive power capability test (HP2\_WFRCT/HP2\_SFRCT)

Refer to Section 3.2.3 as the same methodology used there is used for this test. Minimum test points are schematically shown in Figure 4.

1. Typical inverter-based generating system reactive power capability and measurement conditions for HP2



### Generating system active power control test (HP2\_WFAPT\_LOC/HP2\_SFAPT\_LOC and HP2\_WFAPT\_DIS/HP2\_SFAPT\_DIS )

Refer to Section 3.2.5 as the same methodology used there is used for this test.

### Generating system reactive power reference test (HP2\_WFRPT/HP2\_SFRPT)

Refer to Section 3.2.6 as the same methodology there is used for this test.

### Generating system voltage reference step test (HP2\_WFVCT/HP2\_SFVCT)

Refer to Section 3.2.7 as the same methodology used there is used for this test.

### Generating system power factor reference step test (HP2\_WFPFT/HP2\_SFPFT) (if applicable)

Refer to Section 3.2.8 as the same methodology used there is used for this test.

### Generating system transformer manual tap position change test (HP2\_WFTXT/HP2\_SFTXT)

Refer to Section 3.2.9 as the same methodology used there is used for this test.

### Generating system communication fail test (HP2\_WFCOMFAIL/HP2\_SFCOMFAIL)

#### Purpose

* To verify that the response of the *generating system* to a communication failure does not pose any risk to the *power system security*.
* To 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.
* To verify local limit calculation while *generating units* are offline (Test A).

#### Pre-test conditions

* Communication failsafe mechanism document agreed with the NSP and AEMO.
* Communicate and confirm test with the NSP and AEMO control rooms.
* 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%[[13]](#footnote-13) of HP2 MW level.
* *Generating units* are under park dispatch control.
* The *generating system* is in voltage control mode.
* The *generating system transformer* is under auto control.

#### Methodology and procedure

* Confirm measurement systems are ready.
* 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) before the next test (step) commence.
* Test A – Initiate a communication failure to one *generating unit*.
* Restore communication linkand *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 linkandall *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 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

Table 2 summarises typical signals to be measured for the test.

#### Measurement data file name and format

PlantName\_SectionNo\_HP2\_WFCOMFAIL\_A.CSV.

PlantName\_SectionNo\_HP2\_WFCOMFAIL\_B.CSV.

PlantName\_SectionNo\_HP2\_WFCOMFAIL\_C.CSV.

PlantName\_SectionNo\_HP2\_WFCOMFAIL\_D.CSV.

#### Acceptance criteria

* The *generating system* and each *generating unit* are able to return to stable operation/standby after each step.
* The *generating system* and each *generating unit’s* operation consistent with the communication failsafe mechanism document.
* Pre- and post-local limit (active power) calculation accuracy based on *generating units* in service confirmed.
* Measurement data is successfully downloaded and confirmed.

## Hold Point 3 Test

The *generating system* is above 90% of maximum capacity for all HP3 tests.

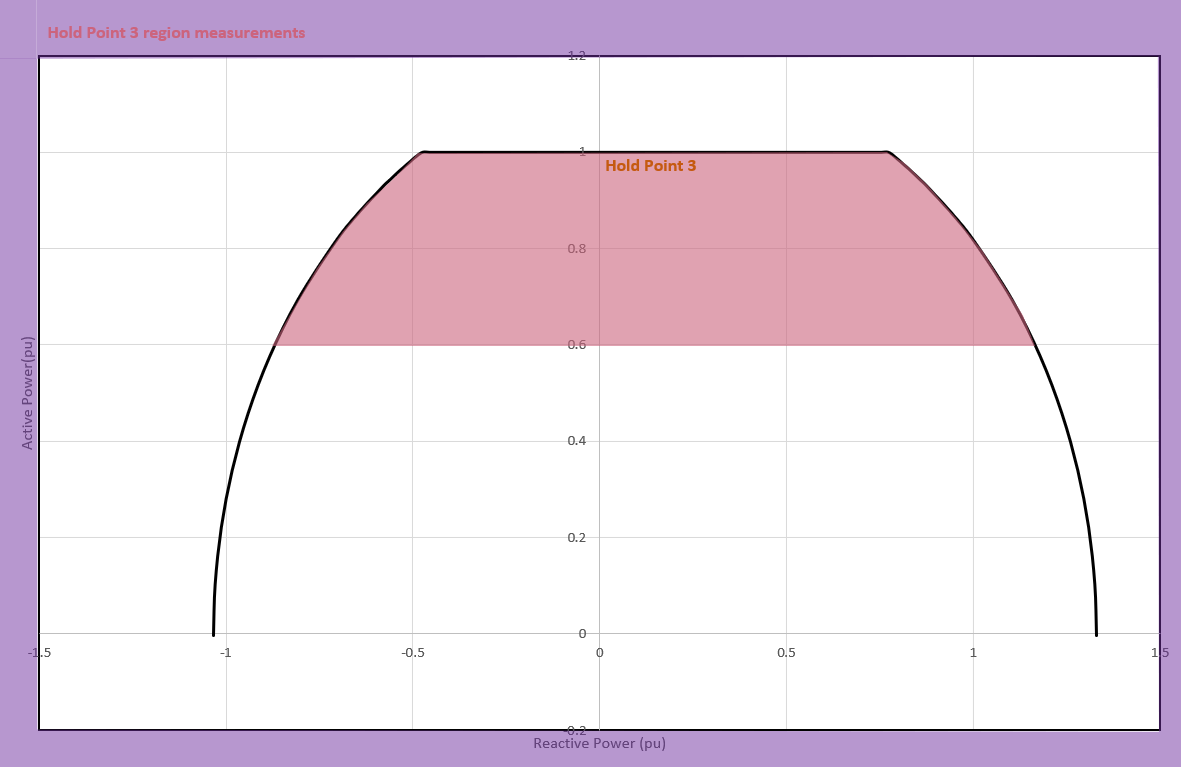
### Power quality test HP3\_WFPQT/HP3\_SFPQT

Refer to Section 3.2.1 as the same methodology used there is used for this test.

### Generating system reactive power capability test (HP3\_WFRCT/HP3\_SFRCT)

Refer to Section 3.2.3 as the same methodology used there is used for this test. Minimum test points are schematically shown in Figure 5.

1. Typical inverter-based generating system reactive power capability and measurement conditions for HP3



### Static reactive support device manual switching test (HP3\_WFCAP/HP3\_SFCAP)

Refer to Section 3.2.4 as the same methodology used there is used for this test.

### Generating system active power control test (HP3\_WFAPT\_LOC/HP3\_SFAPT\_LOC and HP3\_WFAPT\_DIS/HP3\_SFAPT\_DIS)

Refer to Section 3.2.5 as the same methodology used there is used for this test.

### Generating system reactive power reference test (HP3\_WFRPT/HP3\_SFRPT)

Refer to Section 3.2.6 as the same methodology used there is used for this test.

### Generating system voltage reference step test (HP3\_WFVCT/HP3\_SFVCT)

Refer to Section 3.2.7 as the same methodology used there is used for this test.

### Generating system power factor reference step test (HP3\_WFPFT/HP3\_SFPFT) (if applicable)

Refer to Section 3.2.8 as the same methodology used there is used for this test.

### Generating system transformer manual tap position change test (HP3\_WFTXT/HP3\_SFTXT)

Refer to Section 3.2.9 as the same methodology be used there is used for this test.

### Generating system frequency control test HP3\_WFFCT/HP3\_SFFCT

#### Purpose

* To assess compliance with GPS S5.2.5.11 with respect to *frequency* control.
* To assess compliance with GPS S5.2.5.8(a)(2) with respect to automatic rapid reduction of *generation* for a *frequency* increase.
* To assess the *generating system’s* ability to provide *primary frequency response* (**PFR**)[[14]](#footnote-14).
* To validate dynamic model and associated parameters of the *frequency* control function in central park level controller.
* To assess compliance with GPS S5.2.6.1 and clause 4.11.1 of the NER with respect to confirmation of:
  + SCADA feedback signals.
  + Communication equipment.

#### Pre-test conditions

* Total output of the *generating system* is above 90% of HP3 MW.
* Total output of the *generating system* is above 90% of HP3 MW level (for over-*frequency* tests).
* Total output of the *generating system* is above 90% of HP3 MW level but curtailed to 50% of HP3 (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, e.g. voltage control mode.
* The *generating system transformer* is under auto control.

#### Methodology and procedure

* Pre-test simulation studies report must be submitted by the Generator 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*.
* Confirm measurement systems are ready.
* Configure the *generating system* control to local control mode.
* Confirm the pre-test conditions.
* Set to default deadband and droop settings consistent with GPS S5.2.5.8(a)(2) and GPS S5.2.5.11 requirements.
* Inject a *frequency* step signal into the *frequency* controller summing junction. Typical step sizes are ±0.1 Hz, ±0.25 Hz, ±1 Hz and ±2.0 Hz[[15]](#footnote-15).
* 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.
* Repeat tests for different deadbands (range of 0 to ±1.0 Hz) and droop (range of 2% to 10%) combinations. Typical combinations are (±0.15 Hz, 2%),(±0.15 Hz, 5%),(±0.5 Hz, 2%) and (±1 Hz, 5%).

(Please note AEMO seeks to evaluate the *generating system’s* ability to adjust *generation* output automatically to arrest and stabilise *frequency*, typically in proportion to measured *frequency* deviation as required under the *primary frequency response requirements* (PFRR)[[16]](#footnote-16). The scope of this test should not be altered.)

* Repeat the tests for all proposed operating modes such as raise, lower, *frequency* sensitive mode, limited *frequency* sensitive mode, and *frequency* control *ancillary services* (FCAS).

#### Signals to be measured and plotted

Table 2 summarises typical signals that that need to be measured for the test, and highlights those that need to be compared against the respective simulated response.

#### Measurement data file name and format

PlantName\_SectionNo\_HP3\_WFFCT.CSV.

#### Acceptance criteria

* Model overlays of the *generating system frequency* control test are submitted as part of HP reports. The following responses need to be included:
  + *Connection point*.
  + Static and dynamic reactive support plant.
  + Central park level controller.
  + Coordinated *voltage* control scheme.
* To assess compliance with the *Power System Model Guidelines*, ±10% accuracy bands need to be superimposed on the graphs, which include overlays of measured and simulated responses.
* The *generating system* is able to return to stable operation after each step.
* Measurement data is successfully downloaded and confirmed.
* The *active power* response complies with the requirements of GPS S5.2.5.11, GPS S5.2.5.8(a)(2), and the PFRR.

### Partial generating system trip test (HP3\_PWFTT/HP3\_PSFTT)

#### Purpose

* To partially assess compliance with GPS S5.2.5.4, GPS S5.2.5.8 and GPS S5.2.5.13.
* 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

* Confirm the measurement systems are ready.
* Communicate and confirm test with the NSP and AEMO control rooms.
* 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 HP3 MW level.
* Total output of the *generating system* is above 90%[[17]](#footnote-17) of HP3 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 transformer is under auto control.

#### Methodology and procedure

* Pre-test conditions are confirmed.
* Record pre-test local limit (*active power*).
* 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 *generating systems* 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

Table 2 summarises typical signals to be measured for the test, and highlights those that need to be compared against the respective simulated response.

#### Measurement data file name and format

PlantName\_SectionNo\_HP3\_PWFTT.CSV.

#### Acceptance criteria

* Model overlays of partial *generating system* trip test are submitted as part of HP reports.
* To assess compliance with the *Power System Model Guidelines*, ±10% accuracy bands need to be superimposed on the graphs, which include overlays of measured and simulated responses.
* *Generating units* not subject to tripping are 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.

### Trip or runback scheme test (HP3\_WFRBK/HP3\_SFRBK)

#### Purpose

To assess implementation and compliance of trip or runback scheme with GPS S5.2.5.8 and GPS S5.2.5.12.

#### Pre-test conditions

* Confirm the measurement systems are ready.
* Communicate and confirm test with NSP and AEMO control rooms.
* 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 transformer* is under auto control.

#### Methodology and procedure

* Pre-test conditions are confirmed.
* Confirm measurement systems are ready.
* Trip or runback full/part of the *generating system* by either:
  + Coordinating with NSP control room to simulate trip or runback signal; or
  + Simulate trip or runback signal from *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

Table 2 summarises typical signals to be measured for the test, and highlights those that need to be compared against the respective simulated response.

#### Measurement data file name and format

PlantName\_SectionNo\_HP3\_SFRBK.CSV.

#### Acceptance criteria

* Model overlays of the *generating system* trip or runback test are submitted as part of HP reports.
* To assess compliance with the *Power System Model Guidelines*, ±10% accuracy bands need to be superimposed on the graphs, which include overlays of measured and simulated responses.
* Trip or runback scheme operation comply with the requirements under GPS S5.2.5.8 and GPS S5.2.5.12.
* Trip scheme – The *generating system* is able to return to stable operation and *generating units* not subject to tripping are capable of maintaining *continuous uninterrupted operation* after tripping concludes.
* Runback scheme – The *generating system* is able to return to stable operation after runback.
* Measurement data is successfully downloaded and confirmed.

## Other Hold Point 3 tests

In addition to staged HP 3 tests, the following system level tests may be initiated by AEMO or the NSP at the same time or immediately after the HP tests:

* *Network* capacitor and/or reactor switching.
* Low irradiance/wind tests.
* Temperature dependent active power local limit test.
* Fault-throwing tests.
* N-1 system outage tests.
* Battery charge and discharge tests.
* Wind farm day time tests.
* Solar farm night time voltage control tests.

### Network capacitor or reactor switching test (HP3\_WFCST/HP3\_SFCST)

#### Purpose

* To assess compliance with GPS S5.2.5.13 with respect to *voltage* and *reactive power* control of the *generating system*.
* To assess compliance with GPS S5.2.5.4 with respect to *continuous uninterrupted operation* of the *generating system*.
* To assess response of the *generating system* and *generating units* to *voltage* disturbances caused by capacitor or reactor switching.
* To validate dynamic model and parameters of the coordinated *voltage* control scheme.

#### Pre-test conditions

* Output of the *generating units* is above 90% of HP 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 transformer* is under auto control.
* 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 NSP control rooms.

#### Methodology and procedure

* Pre-test simulation studies report must be submitted by the Generator 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*.
* Confirm measurement systems are ready.
* Configure the *generating system* control to local control mode.
* Pre-test conditions are confirmed.
* Switch the capacitor (or reactor) out.
* Wait until the response settles.
* Switch the capacitor (or 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.

#### Acceptance criteria

* Model overlays for the capacitor or reactor switching test are submitted as part of HP reports.
* To assess compliance with the *Power System Model Guidelines*, ±10% accuracy bands need to be superimposed on the graphs which include overlays of measured and simulated responses.
* *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 GPS S5.2.5.13.
* The *active power* and *reactive power* response for the switching action complies with the requirements of GPS S5.2.5.4. e.g. *generating system* and each of its *generating units* capable of *continuous uninterrupted operation* for a *power system* disturbance that causes *voltage* at the *connection point* to vary.
* Measurement data is successfully downloaded and confirmed.

### Low irradiance/wind and high irradiance/wind low active power setpoint tests (HP3\_WFLIVCT/HP3\_SFLIVCT, HP3\_WFAPC\_LOC/HP3\_SFAPC\_LOC)

#### Purpose

To assess stability of the *voltage control system* under low irradiance/wind conditions.

#### Pre-test conditions

* Communicate and confirm test with NSP and AEMO control rooms.
* 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.
* For solar farms: Low irradiance level (closer to sunset, typically below 150 W/m2).
* *Generating units* are under park dispatch control.
* The *generating system* is in *voltage* control mode.
* The *generating system transformer* is under auto control.

#### Methodology and procedure

Refer to Sections 3.2.7 and 3.2.5 as the same test methodology used there is used for this test.

#### Acceptance criteria

Refer to Section 3.2.7 as the same acceptance criteria are used there.

### Temperature dependent local active power limit test (HP3\_WFLLCAL/HP3\_SFLLCAL)

#### Purpose

To assess accuracy of temperature dependent local limit calculation to meet GPS S5.2.5.1 and GPS S5.2.5.4.

#### Pre-test conditions

* Local *active power* limit calculation logic is provided to AEMO and NSP.
* 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.
* Output of the *generating units* is above 90% of HP 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 transformer* is under auto control.
* Obtain a screenshot of the *plant’s* HMI demonstrating the *plant’s* operational state before and after testing.

#### Methodology and procedure

* Confirm measurement systems are ready.
* Pre-test conditions are confirmed.
* Configure the park controller in simulation mode for temperature.
* Apply a bias to the temperature signal at the park controller to synthesise an increase the temperature to 40ºC.
* Allow 10 seconds pre-triggered recording and 120 seconds recording time after the response has settled at its steady-state value.
* Apply a bias to the temperature signal at the park controller to synthesise an increase the temperature to 50ºC.
* Allow 10 seconds pre-triggered recording and 120 seconds recording time after the response has settled at its steady-state value.
* Apply a bias to the temperature signal at the park controller to synthesise an increase the temperature to 40ºC.
* Allow 10 seconds pre-triggered recording and 120 seconds recording time after the response has settled at its steady-state value.
* Configure the park controller in normal mode.

#### Acceptance criteria

* Measurement data is successfully downloaded and confirmed.
* *Plant* responded to the expected derating with the variation in temperature as specified in GPS S5.2.5.1.

### Fault-throwing tests (HP3\_WFFTT/HP3\_SFFTT)

#### Purpose

Under special circumstances, AEMO or the NSP may consider that the fault ride through performance of a *generating system* is required to be tested by conducting a fault-throwing test. AEMO and the NSP will evaluate the risk to *power system security* and impact on other *Network* *Users* during the test.

* To validate the *generating system* response to disturbances following *contingency events* as required by GPS S5.2.5.5.

#### Pre-test conditions

* *Power system security* risk and impact on *Network* *Users* evaluated.
* Pre-test simulation studies are completed by the NSP and AEMO.
* Hardware in the loop (**HIL**) tests are completed by the Original Equipment Manufacturer (**OEM**) (AEMO and NSP to advise).
* Communicate and confirm test details with NSP and AEMO control rooms.
* The test details communicated to the other relevant *Network* *Users.*
* The testing methodology and test procedures agreed between the Generator, NSP and AEMO control rooms.
* Risk assessment complete and risk mitigation controls applied.
* Confirm the primary and secondary measurement systems are ready.

#### Methodology and procedure

The methodology and procedure should elaborate on the following:

* Fault details: Type of fault (3Ph/LLG/1Ph) and fault location in the *network*.
* Test co-ordinators from AEMO, NSP and *Generator* are identified.
* Safety procedure: Safety instructions to be followed during fault.
* Operational precautions to be followed in the event of any test failure (e.g. the relevant protection fails to clear the fault).
* Details instructions to be followed by the operations team.
* Contact details of emergency staff.

### N-1 system outage tests (HP3\_WFSOT/HP3\_SFSOT)

#### Purpose

In order to assess its performance during planned *network outage* conditions (N-1 conditions) the *generating system* will be tested during commissioning for the N-1 low system strength configurations identified during *connection* assessments. Compliance with the following GPS will be assessed during N-1 system outage tests:

* Reactive power capability test (GPS S5.2.5.1).
* Voltage reference step test (GPS S5.2.5.13).

#### Methodology and procedure

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

* The test dates must be organised with the NSP and AEMO to co-ordinate them with the planned *outages* on the *transmission line* or *distribution line* of interest. If no planned *outage* is available, the NSP and AEMO may organise the line *outage* as required by Outage Assessment SO\_OP\_3718 .
* The Generator must plan the test to be completed within the *outage* period.
* A separate N-1 test plan has to be prepared by the *Generator* in consultation with the NSP and then submitted for approval by AEMO.
* Refer to Section 3.2.3 as the same *reactive power* capability test methodology is used for this test.
* Refer to Section 3.2.7 as the same *voltage* reference step test methodology is used.

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

AEMO and the NSP may request additional battery charge and discharge mode tests that are not included in this document.

### Wind Farm day time tests (HP3\_DTWF)

AEMO and the NSP may request additional commissioning tests during daytime while other solar farms in operation that are not included in this document.

### Solar Farm night time voltage control tests (HP3\_NTSF)

AEMO and the NSP may request additional commissioning tests from solar farms provide voltage control during night time that are not included in this document.

## System event analysis

#### Purpose

Application of staged fault tests is not practicable under all circumstances. Post-processing of *network* disturbances is often used to assess compliance with GPS following a large-signal disturbance of the *generating system*, and to validate relevant parts of simulation models, including:

* *Generating system* response to frequency disturbances under GPS S5.2.5.3.
* *Generating system* response to voltage disturbances under GPS S5.2.5.4.
* *Generating system* response to disturbances following contingency events under GPS S5.2.5.5.
* Protection of *generating units* from *power system* disturbances under GPS S5.2.5.8.
* *Frequency* control under GPS S5.2.5.11.
* Impact on *network* capability under GPS S5.2.5.12.
* Fault current under GPS S5.2.8.

#### Methodology and procedure

Any *power system* disturbance captured by continuous monitoring systems during commissioning or post-commissioning will be used to conduct the GPS compliance assessment and R2 model validation. AEMO and the NSP 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 the *power system* events when *voltage* or *frequency* (or both) change outside set thresholds.

The *Generator* must capture and assess compliance of the *generating system* with relevant GPS and validate accuracy of the model with the measured responses. The recorded data must be made available to AEMO and the NSP.

1. Appendix
   1. Main points of contact
2. Key stakeholders from each party involved in commissioning and GPS compliance, and R2 tests

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Description | Abbreviation | Nominated personnel | Land line number | Mobile number | Email contact | Professional qualifications (e.g. RPEQ , CPENG and NER) |
| Generator contact | XX\_SC |  |  |  |  |  |
| Test coordinator | TC |  |  |  |  |  |
| Test lead/manager | TM |  |  |  |  |  |
| Test engineer | TE |  |  |  |  |  |
| Plant operator (24-hour contact) | PO | Primary contact |  |  |  |  |
| Secondary contact |  |  |  |  |
| Trading room | TR | Primary contact |  |  |  |  |
| Secondary contact |  |  |  |  |
| AEMO control room | AEMO\_SC | Duty Operator |  |  |  |  |
| NSP control room | NSP\_SC | Duty Operator |  |  |  |  |
| AEMO commissioning support and approval engineer | AEMO\_CSE | Primary contact |  |  |  |  |
| Secondary contact |  |  |  |  |
| NSP commissioning support and approval engineer | NSP\_CSE | Primary contact |  |  |  |  |
| Secondary contact |  |  |  |  |

* 1. Key plant information

1. Registered plant information

|  |  |  |
| --- | --- | --- |
|  | Details | Remarks |
| Generating system name |  |  |
| Nameplate rating |  |  |
| Maximum capacity |  |  |
| Number of generating units |  |  |
| Connection Point |  |  |
| Reticulation system voltage |  |  |
| Model and type of generating units |  |  |
| R1 simulation model versions (PSS®ETM and PSCADTM/EMTDCTM) |  |  |
| Controller firmware versions |  |  |
| Rated voltage |  |  |
| **Rated current** |  |  |

* 1. Hold point table

1. Example hold point table for a generating system with 100 MW maximum capacity (name plate rating 125 MVA) and 45 generating units.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| HP and maximum active power (MW) | Number of generating units in service | HP maximum active power (MW) test level\* | HP minimum active power (MW) test level\* | Maximum and minimum and reactive power (MVar) \* | Reactive plant and/or system strength support device status (if any) | Harmonic filter bank status (if any) |
| HP0 (0-5[[18]](#footnote-18) MW) | 0-2 | 5 | 0 | ±2 | Off | Off |
| HP1 (20 MW) | 15 | 20 | 16 | ±10 | On | On |
| HP2 (60 MW) | 45 | 60 | 48 | ±24 | On | On |
| **HP2 (100 MW)** | 45 | 100 | 90 | ±40 | On | On |

\* all values nominated at the *connection point*

\*\* minimum active power level for testing and number of units online need to be agreed with NSP and AEMO for each hold point

* 1. Overview of GPS Compliance Assessment and R2 Validation Tests

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| GPS | HP 0  (0 MW) | HP1  (XX MW) | HP2  (YY MW) | HP3  (ZZ MW) | Alternative assessment methodology | Descriptions/notes  Test conducted at each HP:  Notes on alternative assessment methodology if required | New or upgraded generating system |
| Reactive Power Capability (S5.2.5.1) |  |  |  |  |  |  | ✓ |
| Quality of electricity generated (S5.2.5.2) |  |  |  |  |  |  | ✓ |
| Response to frequency disturbances (S5.2.5.3) |  |  |  |  |  |  | ✓ |
| Response to voltage disturbances (S5.2.5.4) |  |  |  |  |  |  | ✓ |
| Generating system response to disturbances following contingency events (S5.2.5.5) |  |  |  |  |  |  | ✓ |
| Quality of electricity generated and continuous uninterrupted operation (S5.2.5.6) |  |  |  |  |  |  | ✓ |
| Partial load rejection (S5.2.5.7) |  |  |  |  |  |  | ✓ |
| Protection of generating systems from power system disturbances (S5.2.5.8) |  |  |  |  |  |  | ✓ |
| Protection systems that impact on power system security (S5.2.5.9) |  |  |  |  |  |  |  |
| Protection to trip plant for unstable operation (S5.2.5.10) |  |  |  |  |  |  |  |
| Frequency Control (S5.2.5.11) |  |  |  |  |  |  | ✓ |
| Impact on network capability (S5.2.5.12) |  |  |  |  |  |  |  |
| Voltage and reactive power control (S5.2.5.13) |  |  |  |  |  |  | ✓ |
| Active power control (S5.2.5.14) |  |  |  |  |  |  | ✓ |
| Monitoring and control requirements (S5.2.6) |  |  |  |  |  |  | ✓ |
| Fault current (S5.2.8) |  |  |  |  |  |  |  |
| **Power station auxiliary supplies (S5.2.7)** |  |  |  |  |  |  |  |

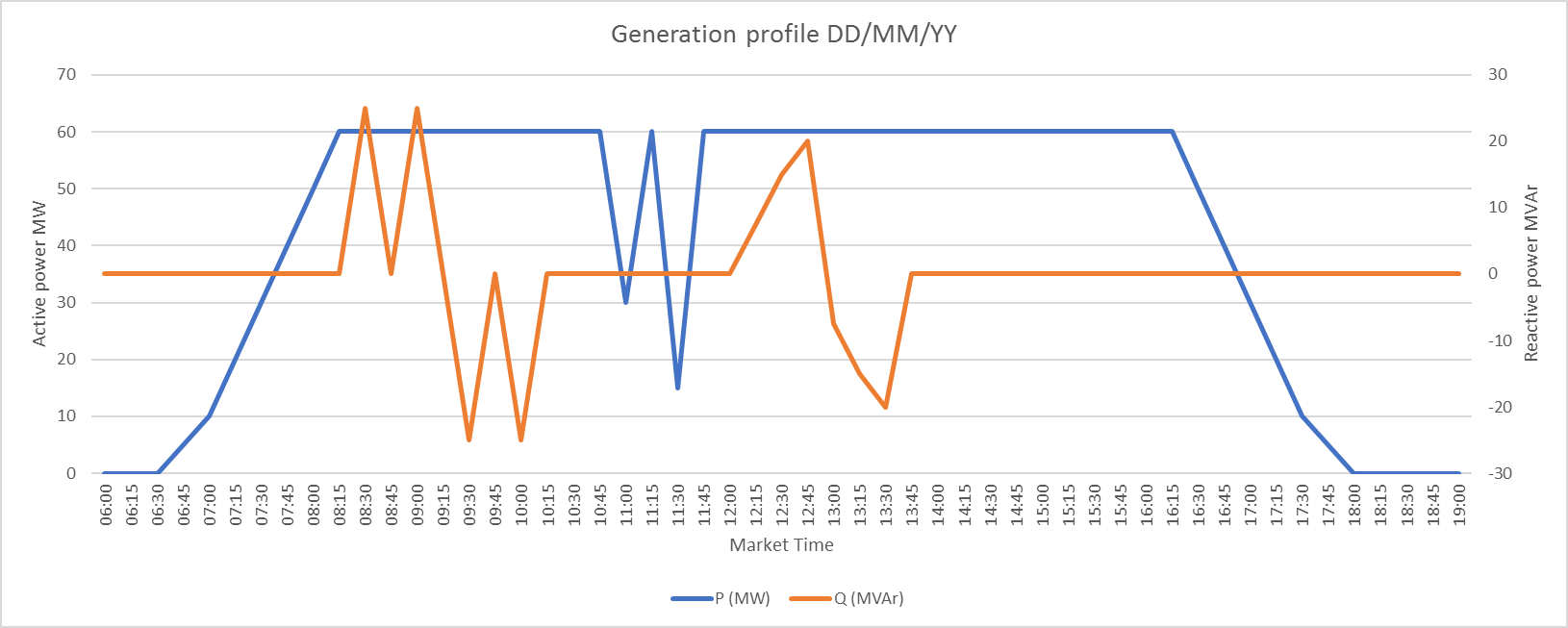
* 1. Test schedule

1. Test schedule example

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Item | Day | Date | Activity | Initial Operating Conditions | Test Reference | GPS Clause Validation | MW Initial | MW Change | MVAr Initial | MVAr Change | Start  (Market Time) | Finish  (Market Time) | |
| 1 | Hold Point 0 | | | | | | | | | | | | |
| 2 | 0 | 16/09/2019 – 22/09/2019 | Background power quality measurements |  | HP0\_WFPQT/HP0\_SFPQT |  |  |  |  |  |  |  |
| 3 | 1 | 23/09/2019 | Synchronous dynamic reactive support device (SDRD) control test. |  | HP0\_SDR |  |  |  |  |  | *To be populated as appropriate for specific project…* |  |
| 4 | 1 | 23/09/2019 | Asynchronous dynamic reactive support device (DRD) control system test. |  | HP0\_NDR |  |  |  |  |  |  |  |
| 5 | 2 | 24/09/2019 | Reactive power capability test. |  | HP0\_NDR Test A |  |  |  |  |  |  |  |
| 6 | 3 | 25/09/2019 | Voltage control test |  | HP0\_NDR Test B |  |  |  |  |  |  |  |
| 7 | 4 | 26/09/2019 | End to end communication delay test |  | HP0\_WFCD/HP0\_SFCD |  |  |  |  |  |  |  |
| 8 | 5 | 26/09/2019 | Generating unit signal injection tests |  | HP0\_WFSI/HP1\_SFSI |  |  |  |  |  |  |  |
| 8 | … | … | (Additional tests as necessary) |  | … |  |  |  |  |  |  |  |
| 10 | HP 0 report submission date | 30/09/2019 |  | | | | | | | | | |
| 11 | NSP and AEMO approval of HP 0 report | 03/10/2019 |  | | | | | | | | | |
| 12 | Hold Point 1 | | | | | | | | | | | | |
| 13 | 10 | 07/10/2019 | Power quality test |  | HP1\_WFPQT/HP1\_SFPQT |  |  |  |  |  |  |  |
| 14 | 10 | 07/10/2019 | Generating unit and park dispatch control test |  | HP1\_WTG/HP1\_SI |  |  |  |  |  |  |  |
| 15 | 11 | 08/10/2019 | Generating system reactive power capability test |  | HP1\_WFRCT/HP1\_SFRCT |  |  |  |  |  |  |  |
| 16 | 11 | 08/10/2019 | Static reactive support device manual switching test |  | HP1\_WFCAP/HP1\_SFCAP |  |  |  |  |  |  |  |
| 17 | 12 | 09/10/2019 | Generating system active power control test |  | HP1\_WFAPC/HP1\_SFAPC |  |  |  |  |  |  |  |
| 18 | 12 | 09/10/2019 | Generating system reactive power reference test |  | HP1\_WFRPT/HP1\_SFRPT |  |  |  |  |  |  |  |
| 19 | 13 | 10/10/2019 | Generating system voltage reference step test |  | HP1\_WFVCT/HP1\_SFVCT |  |  |  |  |  |  |  |
| 20 | 14 | 11/10/2019 | Generating system power factor reference step test |  | HP1\_WFPFT/HP1\_SFPFT |  |  |  |  |  |  |  |
| 21 | 14 | 11/10/2019 | Generating system manual tap position change test |  | HP1\_WFTXT/HP1\_SFTXT |  |  |  |  |  |  |  |
| 22 | … | … | (Additional tests as necessary) |  | … |  |  |  |  |  |  |  |
| 23 | HP 1 report submission date | 15/10/2019 |  | | | | | | | | | |
| 24 | NSP and AEMO approval of HP 1 report | 18/10/2019 |  | | | | | | | | | |
| 25 | Hold Point 2 | | | | | | | | | | | |
| 26 | 24 | 21/10/2019 | Power quality test |  | HP2\_WFPQT/HP2\_SFPQT |  |  |  |  |  |  |  |
| 27 | 25 | 22/10/2019 | Generating system reactive power capability test |  | HP2\_WFRCT/HP2\_SFRCT |  |  |  | *To be populated as appropriate for specific project…* |  |  |  |
| 28 | 25 | 22/10/2019 | Generating system active power control test |  | HP2\_WFAPT/HP2\_SFAPT |  |  |  |  |  |  |  |
| 29 | 26 | 23/10/2019 | Generating system reactive power reference test |  | HP2\_WFRPT/HP2\_SFRPT |  |  |  |  |  |  |  |
| 30 | 27 | 24/10/2019 | Generating system voltage reference step test |  | HP2\_WFVCT/HP2\_SFVCT |  |  |  |  |  |  |  |
| 31 | 28 | 25/10/2019 | Generating system power factor reference step test |  | HP2\_WFPFT/HP2\_SFPFT |  |  |  |  |  |  |  |
| 32 | 28 | 25/10/2019 | Generating system transformer manual tap position change test |  | HP2\_WFTXT/HP2\_SFTXT |  |  |  |  |  |  |  |
| 33 | 29 | 26/10/2019 | Generating system communication fail test |  | HP2\_WFCOMFAIL/HP2\_SFCOMFAIL |  |  |  |  |  |  |  |
| … | … |  | (Additional tests as necessary) |  | … |  |  |  |  |  |  |  |
| 34 | HP 2 report submission date | 31/10/2019 |  | | | | | | | | | |
| 35 | NSP and AEMO approval of HP 2 report | 06/11/2019 |  | | | | | | | | | |
| 36 | Hold Point 3 | | | | | | | | | | | |
| 37 | 36 | 07/11/2019 | Power quality test |  | HP3\_WFPQT/HP3\_SFPQT |  |  |  |  |  |  |  |
| 38 | 37 | 08/11/2019 | Generating system reactive power capability test |  | HP3\_WFRCT/HP3\_SFRCT |  |  |  |  |  |  |  |
| 39 | 37 | 08/11/2019 | Generating system active power control test |  | HP3\_WFAPT/HP3\_SFAPT |  |  |  |  |  |  |  |
| 40 | 37 | 08/11/2019 | Generating system reactive power reference test |  | HP3\_WFRPT/HP3\_SFRPT |  |  |  |  |  |  |  |
| 41 | 38 | 09/11/2019 | Generating system voltage reference step test |  | HP3\_WFVCT/HP3\_SFVCT |  |  |  |  |  |  |  |
| 42 | 39 | 10/11/2019 | Generating system power factor reference step test |  | HP3\_WFPFT/HP3\_SFPFT |  |  |  |  |  |  |  |
| 43 | 39 | 10/11/2019 | Generating system transformer manual tap position change test |  | HP3\_WFTXT/HP3\_SFTXT |  |  |  |  |  |  |  |
| 44 | 40 | 11/11/2019 | Generating system frequency control test |  | HP3\_WFFCT/HP3\_SFFCT |  |  |  |  |  |  |  |
| 45 | 40 | 11/11/2019 | Partial generating system trip test |  | HP3\_WFPTT/HP3\_SFPTT |  |  |  |  |  |  |  |
| 46 | 41 | 12/11/2019 | Trip or runback scheme test |  | HP3\_WFRBK/HP3\_SFRBK |  |  |  |  |  |  |  |
| 47 | 41 | 12/11/2019 | Network capacitor or rector switching test |  | HP3\_WFRBK/HP3\_SFRBK |  |  |  |  |  |  |  |
| 48 | 42 | 13/11/2019 | Low irradiance/wind tests |  | HP3\_WFLIVCT/HP3\_SFLIVCT |  |  |  |  |  |  |  |
| 49 | 42 | 13/11/2019 | Temperature dependent local active power limit test |  | HP3\_WFLLCAL/HP3\_SFLLCAL |  |  |  |  |  |  |  |
| … | … |  | (Additional tests as necessary) |  | … |  |  |  |  |  |  |  |
| 50 | HP 3 report submission date | 20/11/2019 |  | | | | | | | | | |
| 51 | NSP and AEMO approval of HP 3 report | 26/11/2019 |  | | | | | | | | | |
| 52 | 55 | 26/11/2019 | Solar/Windfarm released for unrestricted commercial operation |  | | | | | | | | | |

* 1. Generation profile

1. Generation profile example



Please note: The daily generation profile indicated above, only includes certain selected active power and reactive power tests specified in this test plan and must be amended in-line with the commissioning schedule.

1. Generation profile table example

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Time | P (MW) | Q (MVAr) | Planned HP Test | Remark |
| 06:00 | 0 | 0 |  | 45 solar inverters in service |
| 06:15 | 0 | 0 |  |  |
| 06:30 | 0 | 0 |  |  |
| 06:45 | 5 | 0 |  |  |
| 07:00 | 10 | 0 |  |  |
| 07:15 | 20 | 0 |  |  |
| 07:30 | 30 | 0 |  |  |
| 07:45 | 40 | 0 |  |  |
| 08:00 | 50 | 0 |  |  |
| 08:15 | 60 | 0 |  |  |
| 08:30 | 60 | 25 | HP2\_SFVCT\_LIM |  |
| 08:45 | 60 | 0 | HP2\_SFVCT\_LIM |  |
| 09:00 | 60 | 25 | HP2\_SFVCT\_LIM |  |
| 09:15 | 60 | 0 | HP2\_SFVCT\_LIM |  |
| 09:30 | 60 | -25 | HP2\_SFVCT\_LIM |  |
| 09:45 | 60 | 0 | HP2\_SFVCT\_LIM |  |
| 10:00 | 60 | -25 | HP2\_SFVCT\_LIM |  |
| 10:15 | 60 | 0 |  |  |
| 10:30 | 60 | 0 |  |  |
| 10:45 | 60 | 0 | HP2\_SFAPT |  |
| 11:00 | 30 | 0 | HP2\_SFAPT |  |
| 11:15 | 60 | 0 | HP2\_SFAPT |  |
| 11:30 | 15 | 0 | HP2\_SFAPT |  |
| 11:45 | 60 | 0 | HP2\_SFAPT |  |
| 12:00 | 60 | 0 |  |  |
| 12:15 | 60 | 7.5 | HP2\_SFRPT |  |
| 12:30 | 60 | 15 | HP2\_SFRPT |  |
| 12:45 | 60 | 20 | HP2\_SFRPT |  |
| 13:00 | 60 | -7.5 | HP2\_SFRPT |  |
| 13:15 | 60 | -15 | HP2\_SFRPT |  |
| 13:30 | 60 | -20 | HP2\_SFRPT |  |
| 13:45 | 60 | 0 |  |  |
| 14:00 | 60 | 0 |  |  |
| 14:15 | 60 | 0 |  |  |
| 14:30 | 60 | 0 |  |  |
| 14:45 | 60 | 0 |  |  |
| 15:00 | 60 | 0 |  |  |
| 15:15 | 60 | 0 |  |  |
| 15:30 | 60 | 0 |  |  |
| 15:45 | 60 | 0 |  |  |
| 16:00 | 60 | 0 |  |  |
| 16:15 | 60 | 0 |  |  |
| 16:30 | 50 | 0 |  |  |
| 16:45 | 40 | 0 |  |  |
| 17:00 | 30 | 0 |  |  |
| 17:15 | 20 | 0 |  |  |
| 17:30 | 10 | 0 |  |  |
| 17:45 | 5 | 0 |  |  |
| 18:00 | 0 | 0 |  |  |
| 18:15 | 0 | 0 |  |  |
| 18:30 | 0 | 0 |  |  |
| 18:45 | 0 | 0 |  |  |
| 19:00 | 0 | 0 |  |  |

* 1. Risk assessment

1. Risk matrix example

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Probability of occurrence¹ | Severity of consequence² | | | |
| 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 |

¹ You may define the probability of occurrence e.g. most likely (more than 80% chance of occurrence).

² You may 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).

1. Risk assessment example – voltage reference step test

|  |  |  |  |
| --- | --- | --- | --- |
| Risk event | Likelihood | Consequence | Risk score |
| Non-compliance to work health and safety requirements | Unlikely | Major | High |
| Voltage outside the equipment withstand level | Unlikely | Moderate | Medium |
| Connection point voltage outside the normal operating level | Likely | Insignificant | Medium |
| Unexpected protection trip due to incorrect setting or malfunction | Unlikely | Insignificant | Low |
| Insufficient solar irradiance due to cloud cover | Likely | Insignificant | Medium |
| Instability of the plant during the test | Unlikely | Major | High |

1. Risk controls example – voltage reference step test

|  |  |  |
| --- | --- | --- |
| Item no | Risk controls | Sign off |
| 1 | Commissioning lead/manager in attendance at all times |  |
| 2 | Commissioning engineer in direct line of sight and communication at all times |  |
| 3 | Confirm all plant quantities are within normal equipment withstand levels |  |
| 4 | Confirm step size and reference change consistency with the test plan |  |
| 5 | Communicate with NSP / AEMO control room to configure network reactive plants, OLTC etc to allow tests to be conducted as required. |  |
| 6 | Any deviation to the test plan pre-approved and appended to the test plan. |  |

* 1. Test conditions, file name and time stamp summary– voltage reference step test

1. Test conditions example – voltage reference step test

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Test | Vref\_initial (kV) | Vref\_step (kV) | SF P(MW) | SF Q (MVar) | Main TF tap |
| HP2\_SFVCT\_UPF\_POS\_3PCT |  |  |  |  |  |
| HP2\_SFVCT\_UPF\_NEG\_3PCT |  |  |  |  |  |
| HP2\_SFVCT\_UPF\_POS\_5PCT |  |  |  |  |  |
| HP2\_SFVCT\_UPF\_NEG\_5PCT |  |  |  |  |  |
| HP2\_SFVCT\_OER\_POS\_3PCT |  |  |  |  |  |
| HP2\_SFVCT\_OER\_NEG\_3PCT |  |  |  |  |  |
| HP2\_SFVCT\_OER\_POS\_5PCT |  |  |  |  |  |
| HP2\_SFVCT\_OER\_NEG\_5PCT |  |  |  |  |  |
| HP2\_SFVCT\_UER\_POS\_3PCT |  |  |  |  |  |
| HP2\_SFVCT\_UER\_NEG\_3PCT |  |  |  |  |  |
| HP2\_SFVCT\_UER\_POS\_5PCT |  |  |  |  |  |
| HP2\_SFVCT\_UER\_NEG\_5PCT |  |  |  |  |  |
| HP2\_SFVCT\_OER\_LIM\_NEG\_2P5PCT |  |  |  |  |  |
| HP2\_SFVCT\_OER\_LIM\_ POS\_5PCT |  |  |  |  |  |
| HP2\_SFVCT\_UER\_LIM\_ POS\_2P5PCT |  |  |  |  |  |
| HP2\_SFVCT\_OER\_LIM\_ NEG\_5PCT |  |  |  |  |  |

1. File name and time stamp summary example – voltage reference step test

|  |  |  |
| --- | --- | --- |
| Test | Timestamp | File names |
| HP4\_SFVCT\_UPF\_POS\_3PCT | DD/MM/YYYY HH:MM:SS AM | SF\_PoC\_132kV\_HP4\_SFVCT\_UPF\_+3pc.csv  SF\_MV\_33kV\_HP4\_SFVCT\_UPF\_+3pc.csv  SF\_LV\_PCU1\_HP4\_SFVCT\_UPF\_+3pc.csv  SF\_LV\_PCU45\_HP4\_SFVCT\_UPF\_+3pc.csv |
| HP4\_SFVCT\_UPF\_NEG\_3PCT |  |  |
| HP4\_SFVCT\_UPF\_POS\_5PCT |  |  |
| HP4\_SFVCT\_UPF\_NEG\_5PCT |  |  |
| HP4\_SFVCT\_OER\_POS\_3PCT |  |  |
| HP4\_SFVCT\_OER\_NEG\_3PCT |  |  |
| HP4\_SFVCT\_OER\_POS\_5PCT |  |  |
| HP4\_SFVCT\_OER\_NEG\_5PCT |  |  |
| HP4\_SFVCT\_UER\_POS\_3PCT |  |  |
| HP4\_SFVCT\_UER\_NEG\_3PCT |  |  |
| HP4\_SFVCT\_UER\_POS\_5PCT |  |  |
| HP4\_SFVCT\_UER\_NEG\_5PCT |  |  |
| HP4\_SFVCT\_OER\_LIM\_NEG\_2P5PCT |  |  |
| HP4\_SFVCT\_OER\_LIM\_ POS\_5PCT |  |  |
| HP4\_SFVCT\_UER\_LIM\_ POS\_2P5PCT |  |  |
| HP4\_SFVCT\_OER\_LIM\_ NEG\_5PCT |  |  |

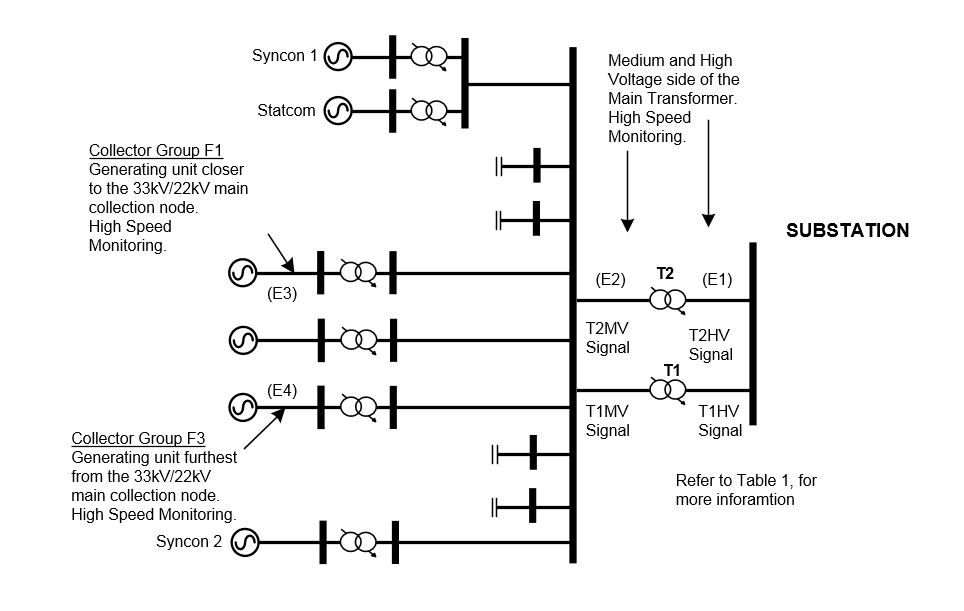
* 1. Compliance summary

1. Compliance Summary Example

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Test | Assessment subclause | Test Results | GPS requirement | Compliance |
| HP3\_SFPQT | Harmonics | Results within the allocated limits | Harmonic allocation in the GPS | Yes  No |
|  | Flicker | Results within the threshold | Epst Eplt thresholds in the GPS | Yes  No |
|  | Negative phase sequence | Results within the limits | Negative sequence voltage limits in the GPS | Yes  No |
| HP3\_SFRCT | Reactive power capability | Meets the agreed performance standard. | 0.395 \* rated active power | Yes  No |
| HP3\_SFRPT | Follow reactive power reference within accuracy limits | Results within 2% of the rating | 2% of the rating expressed in MVAr. | Yes  No |
|  | Stability | Plant response stable and adequately damped | Plant response stable and adequately damped | Yes  No |
| HP3\_SFVCT | Voltage error | Less than 0.5% | Less than 0.5% | Yes  No |
|  | Reactive power rise time | Less than 2 s | Less than 2 s | Yes  No |
|  | Settling time without limiter action | Less than 5 s | Less than 5 s | Yes  No |
|  | Settling time with limiter action | Less than 5 s | Less than 7.5 s | Yes  No |
|  | Stability | Plant response stable and adequately damped | Plant response stable and adequately damped | Yes  No |
| HP3\_SFCAP | Stability | Plant response stable and adequately damped | Plant response stable and adequately damped | Yes  No |
|  | Continuous uninterrupted operation (CUO) | Plant response meets the CUO requirement | Plant capable of CUO | Yes  No |
| HP3\_SFAPC | Constant rate | Active power ramps in a constant rate until end of 5 min DI | Active power ramps at a constant rate until end of DI | Yes  No |
|  | Reach the target | Active power ramps reach the target at the end of 5 min DI | Active power ramps reach the target at the end of DI | Yes  No |
|  | Linear ramping | Active power ramps linearly | Active power ramps linearly until end of DI | Yes  No |
|  | Ramp rate algorithm consistent with System Operating Procedure S0\_OP\_3705 | Automatically reducing or increasing its active power output linearly at the end of the DI linearly. | automatically reducing or increasing its active power output linearly within 5 minutes at a constant rate. | Yes  No |
|  | Follow AGC target | Plan can receive and automatically follow targets from AGC | Plan can receive and automatically follow target from AGC | Yes  No |
|  | Dispatch target maximum processing delay within 30 seconds | 30 seconds | N/A | Yes  No |
|  | Adequately damped | Active power control adequately damped | Active power control adequately damped | Yes  No |
| HP3\_SFFCT | Increase in response to a rise in frequency | No increase | No increase | Yes  No |
|  | Decrease in response to a fall in frequency | No decrease | No decrease | Yes  No |
|  | Automatic proportional decrease and increase in frequency control mode | Plant can automatically decrease and increase active power proportionally. | Plant can automatically decrease and increase active power proportionally. | Yes  No |
|  | Control system response adequately damped | Plant response stable and adequately damped | Plant response stable and adequately damped | Yes  No |
|  | Set deadband (0 to ± 1.0 Hz) and droop(2% to 10% ). | Plant response stable and adequately damped in tested deadband and droop settings | Plant can set deadband (0 to ± 1.0 Hz) and droop( 2% to 10% ). | Yes  No |
|  | Active power reduction for over frequency (GPS S5.2.5.8(a)(2)) | Active power reduction within GPS S5.2.5.8(a)(2) requirements. | Reduce at least by half above or reaching frequency limit | Yes  No |
| HP3\_SFLLCAL | Temperature dependent local controls | Active power ramps linearly based on temperature. | Active power ramps linearly based on temperature. | Yes  No |
|  | Accuracy of local limit calculation | Local limit algorithm accurate with the design | algorithm accuracy for unit/ plant outages | Yes  No |
| HP2\_SFCOMFAIL | Communication failure failsafe mechanism | Plant response consistent with agreed failsafe mechanism logic | N/A | Yes  No |
| (Additional tests as necessary) | … | … | … | … |

* 1. Measurement point layout example

1. Measurement point layout



* 1. Test Plan checklist

1. Test plan checklist

|  |  |  |  |
| --- | --- | --- | --- |
|  | Item | Comment | Checkbox |
| 1 | Title reflects the name of power station, unit under test (if applicable), name of the plant owner and the name of the consultancy company prepared the document |  | Yes  No |
| 2 | Date of release, revision number and revision history table |  | Yes  No |
| 3 | Distribution list for companies it has been supplied | Optional | Yes  No |
| 4 | Structure has contents, list of abbreviations, glossary of terms, introduction, test objective , scope of the test plan and references |  | Yes  No |
| 5 | Main point of contacts | See Section 2.2 and Appendix A1.11 | Yes  No |
| 6 | Key plant information | See Section 2.3 and Appendix A1.2 | Yes  No |
| 7 | Communication protocol | See Section 2.4 | Yes  No |
| 8 | Risk assessment included for each test | See Section 2.5 and Appendix A1.7 | Yes  No |
| 9 | Measurement equipment information | See section 2.8 | Yes  No |
| 10 | Simulation software for overlays agreed for each test | PSS®E and/or PSCADTM/EMTDCTM | Yes  No |
| 11 | Test data file name format details | See section 2.9 | Yes  No |
| 12 | Pre-requisites to commence testing | See section 2.1 | Yes  No |
| 13 | Scope of the pre-test simulations |  | Yes  No |
| 14 | Hold point details | See Section 2.7 and Appendix A1.3 | Yes  No |
| 15 | HP test details | Pre requisites  Risk assessment  Purpose, pre-test conditions, methodology and procedure  Signal to measured and plotted  Measured data file name and format  Acceptance criteria | Yes  No  Yes  No  Yes  No  Yes  No  Yes  No  Yes  No Yes  No |
| 16 | All tables and figures appropriately numbered and referenced |  | Yes  No |
| 17 | Appendix | Single line diagram  Reactive power capability  Measurement point layout  Schedule and generation profile | Yes  No  Yes  No  Yes  No  Yes  No |

* 1. Hold point report checklist

1. Hold point report checklist

|  |  |  |  |
| --- | --- | --- | --- |
|  | Item | Comment | Checkbox |
| 1 | Title reflects the name of power station, unit under test (if applicable), the name of the consultancy company prepared the document and HP point |  | Yes  No |
| 2 | Date of release, revision number and revision history table |  | Yes  No |
| 3 | Distribution list for companies it has been supplied |  | Yes  No |
| 4 | Structure has contents, list of abbreviations, glossary of terms, background and references |  | Yes  No |
| 5 | Summary of HP tests |  | Yes  No |
| 6 | Applicable firmware and simulation models (PSS®ETM and PSCADTM/EMTDC™) versions summary |  | Yes  No |
| 7 | Risk assessment was completed before each HP test |  | Yes  No |
| 8 | Test results | Details of test records (See Appendix A1.8).  File name summary (See Appendix A1.8)  HMI screenshots.  Plots and overlays as agreed in the Test plan.  Summary of test results for each test.  Conclusion and compliance with acceptance criteria. | Yes  No  Yes  No  Yes  No  Yes  No  Yes  No  Yes  No |
| 9 | Overlays include 10% accuracy bands |  | Yes  No |
| 10 | Summary of HP test results | See Appendix A1.9 | Yes  No |
| 11 | Conclusion of the HP |  | Yes  No |
| 12 | All plots in appropriate scale |  | Yes  No |
| 13 | All plots are clearly labelled |  | Yes  No |
| 14 | Relevant reference signals are plotted |  | Yes  No |
| 15 | All simulation files used for the overlays are provided |  | Yes  No |
| 16 | All HP measured data files are provided |  | Yes  No |
| 17 | Details of any model parameters modified are provided |  | Yes  No |
| 18 | Test data file name format consistent with the test plan requirements | See section 2.9 | Yes  No |
| 19 | Applicable setting summary table comparing physical settings downloaded from actual controllers on site with the R1 PSS®ETM and PSCADTM/EMTDC™ model settings as an appendix |  | Yes  No |

1. See Dispatch Procedure SO\_OP\_3705. [↑](#footnote-ref-1)
2. It is expected that independent equipment is installed to collect test results separately from the device under test. [↑](#footnote-ref-2)
3. Alternatively, this test may be conducted at other HPs. [↑](#footnote-ref-3)
4. Specific minimum generation level at each HP must be agreed with AEMO and the NSP. [↑](#footnote-ref-4)
5. Specific minimum *generation* level at each hold point must be agreed with AEMO and NSP. [↑](#footnote-ref-5)
6. For *generating systems* with fast and slow ramp options, testing should be conducted with both ramp rates. [↑](#footnote-ref-6)
7. Specific minimum generation level at each hold point must be agreed with AEMO and NSP. [↑](#footnote-ref-7)
8. For *generating systems* with fast and slow ramp options, the test should be conducted with both ramp rates. [↑](#footnote-ref-8)
9. Specific minimum generation level at each hold point must be agreed with AEMO and NSP. [↑](#footnote-ref-9)
10. Specific minimum generation level at each hold point must be agreed with AEMO and NSP. [↑](#footnote-ref-10)
11. Specific minimum generation level at each hold point must be agreed with AEMO and NSP. [↑](#footnote-ref-11)
12. Specific minimum generation level at each HP must be agreed with AEMO and NSP. [↑](#footnote-ref-12)
13. Specific minimum generation level at each hold point must be agreed with AEMO and NSP. [↑](#footnote-ref-13)
14. This requirement anticipates the making of the National Electricity Amendment (Mandatory primary frequency response) Rule 2020, expected to occur on or about 26 March 2020. See <https://www.aemc.gov.au/rule-changes/mandatory-primary-frequency-response>. [↑](#footnote-ref-14)
15. Step sizes for *frequency* injection signal must be agreed with AEMO and NSP. [↑](#footnote-ref-15)
16. This requirement anticipates the making of the National Electricity Amendment (Mandatory primary frequency response) Rule 2020, expected to occur on or about 26 March 2020. See <https://www.aemc.gov.au/rule-changes/mandatory-primary-frequency-response>. [↑](#footnote-ref-16)
17. Specific minimum generation level at each HP must be agreed with AEMO and the NSP. [↑](#footnote-ref-17)
18. Notifiable exemption allows maximum combined *nameplate rating* of all *generating units* simultaneously *connected* at the *connection point* less than 5 MW . [↑](#footnote-ref-18)