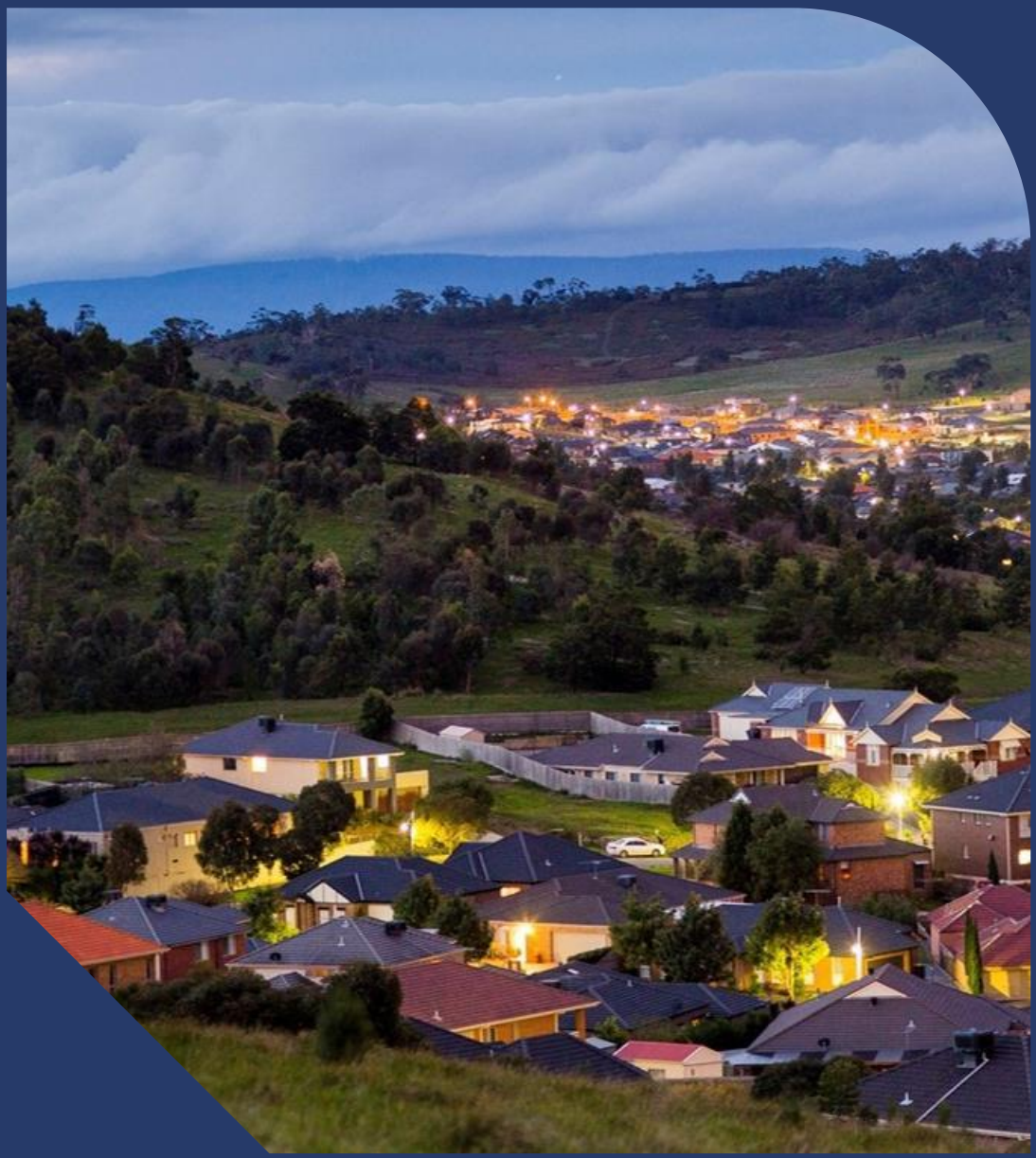
AusNet

GPS Assessment Expectations

Revision 01

Thursday, 11 September 2025



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Disclaimer

This document is intended to aid customers in the connection process for inverter based renewable generators and information in it may be updated or amended time to time. This document describes a generic set of studies / requirements and project specific requirements may differ based on technology and the connection location. More comprehensive studies can be performed by the customer as part of its own assessment of compliance.

This document does not override project specific requirements and does not constitute legal or business advice and should not be relied on as a substitute for obtaining detailed advice about the National Electricity Law, the National Electricity Rules, or any other applicable laws, procedures or policies.

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Abbreviations and Acronyms

Term	Definition
AAS	Automatic access standard
AEMC	Australian Energy Market Commission
AEMO	Australian Energy Market Operator
AGC	Automatic generation control
AVR	Automatic voltage regulator
BESS	Battery energy storage system
Connection Applicant	A Connection Applicant seeking to register as a Generator or Integrated Resource Provider
CUO	Continuous uninterrupted operation
FCAS	Frequency control ancillary services
FRT	Fault ride-through
GS	Generating system
GU	Generating unit
IBR	Inverter-based resource
NER	National Electricity Rules
Pmax	Maximum agreed active power at the PoC in MW
Pmin	Minimum active power at the PoC in MW
PoC	Point of Connection
Qmin	Minimum reactive power at the PoC in MVAr
Qmax	Maximum reactive power at the PoC in MVAr
V_Qmax	Voltage at the PoC during Qmax condition in pu
V_Qmin	Voltage at the PoC during Qmin condition in pu.

1. Background

In accordance with the NER process for establishing a new connection (NER Chapter 5.3), generators must submit a connection application after an initial inquiry.

AEMO has published the below guidelines relevant to connection applications.

- Access Standard Assessment Guidelines [1]
- Generator Performance Standard Template [2]
- Power System Modelling Guidelines [3]

This document is meant to support AEMO's documents and cannot be seen to overrule the requirements in AEMO's documents due to National Electricity Rules (NER) clause S5.2.5.

AusNet requires the Automatic Access Standard over any type of Negotiated Access Standard. The Proponent must provide adequate evidence that it is economically (and technically) unfeasible to meet the Automatic Access Standard in order for AusNet to agree to a Negotiated Access Standard as per NER clauses 5.3.4(b1) and 5.3.4(b2)

Regardless of feasibility, to be accepted any Negotiated Access Standard must still allow AusNet to meet its requirements to the Victorian Electricity Distribution Code and Schedule S5.1a of the National Electricity Rules.

The GPS must be a standalone document and must not refer to documents other than the NER.

2. Optional Pre-Application Stage

As a part of AEMO's Connections Reform Initiatives, AEMO has introduced an optional pre application stage to support the proponents during the connection process. By reducing the level of rework of the connection application, which is usually necessary after the traditional submission process, it provides assurance to the Connection Applicants regarding the requested connection and increases overall efficiency in the process.

A proponent's decision to opt into pre-application support service packages will be context specific. Influencing factors can include: the level of relevant experience of the proponent; the maturity of the technology; the location and complexity of the connection application; and target timelines.

Proponents can select pre-application support service packages that are most relevant and beneficial to them. If a proponent engages in this pre-application process, then re-negotiation of agreed performance standards might not be required during the connection application phase. Performance agreements made during the pre-application process should be robust to any network changes, and AusNet is able to identify potential changes in its network with sufficient lead time to amend the agreement as required. An exception would be when the proponent makes material changes to the plant design or model used to assess the performance. In this instance, performance standards may need to be revised.

Details of this stage could be found on the AEMO website [5] and connection applicants are requested to discuss with AusNet about this stage during the project kick off meeting.

3. Connection Application Package Expectations

The following sections outlines the assessment expectations for various GPS clauses. These comments are intended as general guidance. Additionally, AEMO may have specific requirements and guidelines related to certain clauses.

- **Resilience Requirement**: All inverter-based plants should ensure stable operation post-fault clearance or during voltage disturbances, targeting an SCR of 3, regardless of the minimum fault level.
- **Compliance Assessment**: If the minimum short circuit ratio (SCR) at the Point-of-Connection (PoC) exceeds 3, GPS compliance is not assessed at SCR 3; only stability is evaluated (e.g., avoiding re-triggering fault ride-through and achieving non-oscillatory responses).
- **DMAT Utilization**: Assessment typically relies on DMAT results (site-specific and generic models).
- **Consultation with AusNet**: If the site's minimum SCR significantly exceeds 3 and stable performance at SCR 3 is difficult, consult AusNet. There will still be a need to confirm the plant's capability for stable operation at SCR 3 with alternative settings and to understand the minimum SCR for stability.
- **General Tuning Guidance**:
  - If the SCR is less than 3, the plant should be tuned for stable operation at that minimum fault level.
  - If the SCR exceeds 3, the plant must be compliant for the minimum fault level.

3.1. S5.2.5.1

- Compliance with S5.2.5.1 can be evaluated using either PSS/E or PSCAD SMIB models with main transformer taps enabled.
- The connection study report must include capability curves for PoC voltages of 0.9pu, centre point voltage as defined by AusNet and 1.1pu that;
  - Illustrate the full unrestrained capability of the generating system at the normal operating temperature and derating at the maximum operating temperature.
  - Indicate the agreed capability region, which is compliant with all GPS clauses (including S5.2.5.4 and S5.2.5.13).
- For Battery Energy Storage Systems (BESS), capability must be defined for both charging and discharging modes and for hybrid projects, studies must be conducted considering one source in operation at a time.
- Capability must be demonstrated with all generating units and auxiliary plant operational.
- Local limits and temperature derating should be detailed in the GPS, with additional specifics in the Voltage Control Strategy (VCS).
- Generating unit voltage limitations should be considered when determining the capability curves.
- Zero wind capability in the capability diagram for wind farms and nighttime reactive power capability for solar farms should be included.
- Consider and model the ratings of any 33kV incomer cables if they could impact the generating system's active/reactive power capabilities.

3.2. S5.2.5.2

Proponent to consult AusNet before the assessment.

3.3. S5.2.5.3

- Compliance with S5.2.5.3 can be evaluated using either PSS/E or PSCAD SMIB models, with accurate modelling of frequency protection settings at PoC and the generating unit level.
- The connection study report must include studies to demonstrate compliance of the plant with active power levels of Pmax, P50% and Pmin.
- For BESS connections, above assessments for repeated for charging conditions and for hybrid projects, studies must be conducted considering one source in operation at a time.
- Plant should be dispatched as per the primary reactive power control mode and setpoint in the agreed voltage control strategy (VCS) at the PoC.
- Proponents must;
  - include a figure comparing the AAS requirements and proposed protection settings.
  - demonstrate frequency ride through capability when the frequency is changed with both 4 Hz/s and 3 Hz/s rate within the limits indicated under AAS requirements.
  - include frequency protection operation tests where the frequency is intentionally driven to exceed protection elements to ensure that they pick-up and trip as expected.

3.4. S5.2.5.4

- Compliance with S5.2.5.4 can be evaluated using either PSS/E or PSCAD SMIB models.
- The Connection Study report must include studies to demonstrate compliance of the plant with the conditions indicated in table below, including testing the plant performance at the corner points of the agreed PoC active-reactive power operating region.

Scenario No	Initial Operating Conditions	Connection Point Initial Voltage (pu)	Connection Point Final Voltage (pu)	Remarks
1	Pmax Qmax	1	0.9	* Plant must remain connected * Plant must not reduce P and Q
2	Pmax Qmin	1		
3	Pmin Qmax	1		
4	Pmin Qmin	1		
5	Pmax Qmax	1	1.1	
6	Pmax Qmin	1		
7	Pmin Qmax	1		
8	Pmin Qmin	1		
9	Pmax Qmax	V_Qmax	V_Qmax – 0.1	
10	Pmax Qmin	V_Qmin	V_Qmin – 0.1	
11	Pmax Qmax	V_Qmax	1.1	
12	Pmax Qmin	V_Qmin		
13	Pmax Qmax	V_Qmax	0.9	* Plant must remain connected * Generating units must not remain stuck in Fault Ride Through (FRT) mode.
14	Pmax Qmin	V_Qmin		
15	Pmin Qmax	V_Qmax		
16	Pmin Qmin	V_Qmin		
17	Pmax Qmax	V_Qmax	To 0.7, 0.8, 1.15, 1.2, 1.25, 1.3, 1.35 Vpu	* Plant must remain connected until the time requirements indicated under the AAS ride through settings.
18	Pmax Qmin	V_Qmin		
19	Pmin Qmax	V_Qmax		
20	Pmin Qmin	V_Qmin		

Table 1: S5.2.5.4 dynamic CUO test requirements

- For BESS connections, above assessments for repeated for charging conditions and for hybrid projects, studies must be conducted considering one source in operation at a time.
- V_Qmin and V_Qmax are the expected PoC voltage values when the reactive power output of the plant reaches Qmin and Qmax values for the generators in voltage droop control mode.

- Scenarios 9 to 20 to be assessed, assuming both V_Qmin and V_Qmax are either at 1.0 pu or greater. If either is below 1.0 pu, consult with AusNet regarding the assessments.
- If there are more stringent operating points than those at Pmax and Pmin, discuss these with AusNet in the context of S5.2.5.4 and other GPS assessments.
- The above assessments should be conducted on an infinite grid i.e. no impedance between PoC and the slack bus.
- During a voltage drop to 0.9 Vpu, adjustments in reactive power consumption or charging from passive devices (such as cables and shunt capacitors) may take place. Reactive power at the connection point should be maintained to accommodate these changes from passive equipment.
- The local limit, as specified in S5.2.5.1, must be dynamically calculated to account for any dependence of active power on the Point of Connection (PoC) voltage.
- Proponents must;
  - include a figure comparing the AAS requirements and proposed protection settings.
  - demonstrate voltage ride through capability when the voltage is changed within the limits indicated under AAS requirements.
  - include voltage protection operation tests where the voltage is intentionally driven to exceed protection elements to ensure that they pick-up and trip as expected.

3.5. S5.2.5.5 and S5.2.5.5A

- Compliance with S5.2.5.5 must be evaluated using the methods indicated below.
  - Contingency ride through performance with PSS/E NEM models (minimum and maximum demand models or any other models specified by AusNet)
  - Active power recovery times with PSS/E NEM models
  - Reactive current injection performance in PSCAD SMIB models (using both balanced and unbalanced faults including temporary over voltages)
  - Fault ride through entry range in PSCAD SMIB models
  - Multiple disturbance ride through test in PSCAD SMIB models
- AusNet will provide a list of contingencies to be studied in PSS/E NEM models with clearance times. Assessments should be carried out with Circuit Breaker Failure protection and Primary Protection clearance times as specified by AusNet.
- PSCAD SMIB models assessments should be carried out with the minimum site specific SCR and X/R under;
  - Qzero, Qmax and Qmin conditions for Pmax for all the plants and
  - Qzero, Qmax and Qmin conditions for Pmax for BESSs in charging mode.
- Reactive current injection should aim to provide a reasonable amount of reactive current as a function of the maximum continuous current, on the faulted phase while minimizing increases on un-faulted phases to avoid worsening disturbances.
- For negative sequence current injection, the control systems reduce positive sequence reactive current (Iq pos) and reserve a portion of current capacity to inject negative sequence current, with the objective of supporting voltages in the un-faulted phases during an unbalanced fault. A technical note from the OEM is expected detailing their negative sequence current injection strategy, including the principles, control logic, and any limitations relevant to site-specific grid code compliance.
- For NEM Model studies proponents must include:
  - A summary table with the details of the studied fault, whether plant was able to ride through that fault or not, if any issues were observed
  - Active power recovery times, highlighting any instances where AAS expectations were not met
- For reactive current injection performance studies using a PSCAD Model, proponents must include a summary table with the initial conditions, residual voltage at the PoC during fault, reactive current rise and settling times , reactive current response initiation and active power recovery time highlighting any instances where AAS expectations were not met.
- For fault ride through entry range studies with PSCAD Model, proponents must include a summary table with the initial conditions, inverter threshold and observed threshold at PoC, highlighting any instances where AAS expectations were not met.

- AusNet does not advise on exact disturbances for S5.2.5.5(d) (multiple disturbances). The proponent must show compliance by selecting relevant disturbances as per the AAS requirements. Confirmation from the OEM is required to ensure compliance regarding aspects not modelled for Multiple Fault Ride through performance.
- Discussion on performance of the current injection included, particularly regarding any contribution to voltage increases on un-faulted phases during unbalanced faults. This is especially relevant for generating units with independently configured positive and negative sequence current injections.
- Assessment plots should indicate,, but not limited to;
  - P/Q/V parameters at both PoC and generator unit terminals
  - FRT flags for both PPC and the generator units
  - Positive and negative sequence components of the reactive and active currents including reference signals from the inverters
  - Positive and negative sequence voltages
  - Phase angle
  - Frequency,

3.6. S5.2.5.7

- Compliance with S5.2.5.7 must be evaluated in PSS/E NEM maximum and minimum demand models as indicated below
  - Tripping of a large generator in the Victorian region (credible contingency)
  - Tripping of 30% of loads in Victoria
- Studies must consider the plant being dispatched at the maximum active power capacity and as per the primary Q/V control mode and setpoint in the agreed VCS. If a BESS project is being assessed, studies must be carried out for the maximum charging scenario as well.
- Plots demonstrating the generating systems ability to maintain continuous uninterrupted operation (CUO) following the disturbance must be included.

3.7. S5.2.5.8

- Compliance with S5.2.5.8 must be evaluated in PSS/E SMIB model for the plants which meets the requirements of NER S.5.2.5.8 (a00) (2), by applying the below disturbances to the PoC as indicated in NER clause S5.2.5.8
  - Increase in frequency
  - Increase in voltage
  - Change in voltage phase angle
- PSS/E SMIB models assessments should be carried out with the minimum site-specific SCR and X/R, with plant dispatched at Pmax and as per the primary Q/V control mode and setpoint in the agreed VCS to demonstrate that the plant can remain in operation as required under the performance standard of the relevant protection type as per the AAS requirements.
- Proponents must include details of all protection schemes including any special protection schemes (such as all the protection schemes relating to automatic disconnection of the plant, runback schemes etc.) in the protections study report and referenced in the connections study report.

3.8. S5.2.5.11

- Compliance with S5.2.5.11 must be evaluated either in PSS/E SMIB or PSCAD SMIB model.
- Assessments should be carried out with minimum site-specific SCR and X/R, with plant dispatched at Pmax, Pmin and as per primary Q/V control mode and setpoint in the agreed VCS. If BESS project is being assessed, studies must be carried out for maximum charging scenario as well.
- Studies must demonstrate the plant performance within and outside the frequency deadband of the Primary Frequency Response during frequency increase and decrease events based on the proposed frequency droop characteristics.

3.9. S5.2.5.12

- Prior to the connection application stage, proponents are expected to demonstrate performance of the plant under steady state assessment in PSS/E wide area models, for maximum and minimum demand scenarios. This assessment should include:
  - Thermal loading assessments (with transformer taps enabled and with thermal limit of 100%)
  - Bus voltage assessments (with transformer taps enabled and with voltage limits of 0.9pu to 1.1pu)
  - Voltage step change assessments (with locked transformer taps and with voltage limit of 3% for 66kV and 5% for 22kV)
  - Transformer tap limit assessments (with transformer taps enabled to assess the plant is causing the transformer taps to reach the limits)
  - Fault level assessments (with transformer taps enabled with fault level limit of 13.1kA at 22kV and 21.9kA at 66kV)
  - Terminal station loading (with transformer taps enabled with both forward and reverse power load limits under system normal and N-1)
- It is expected that the plant's operation does not have any adverse impact on the existing network and proponents are expected to include assessments results for pre and post connection conditions to assess the impact of the generator.
- Above assessments must be carried out under both system normal conditions and N-1 outage conditions.
- Based on the findings of the steady state assessment, the requirement for runback schemes could be discussed and agreed with AusNet for any operating condition which might be having an adverse impact on the existing distribution network.
- It may be necessary to assess the performance dynamically in a PSS/E NEM model as well, based on the location of the project. If so AusNet will advise during the kick off meeting for the connection application stage.

3.10. S5.2.5.13

- Compliance with S5.2.5.13 must be evaluated using both PSS/E NEM models and PSCAD SMIB models.
- PSS/E NEM studies must demonstrate the rise and settling times during +/-5% grid disturbance at the PoC, under minimum and maximum demand scenarios.
- For each reactive power control mode (Eg. Power Factor, Q/Reactive Power Control, Voltage droop control), studies must investigate the plants response to a change in reactive power setpoint and a change in voltage at the point of connection.
- Changes in Setpoint
  - When operating in Power Factor control or Reactive Power control mode, changes in the power factor or reactive power setpoint shall be applied to achieve a change in reactive power of +/- 0.5 pu of the reactive capability agreed under S5.2.5.1.
  - When operating in Voltage Droop control mode, a +/- 5% voltage reference step shall be applied.
  - For all control modes, limiter tests should be performed. This involves applying a change in setpoint, such that the plants reactive power controller "steps into" the positive or negative reactive power limit. When operating in Reactive Power or Power Factor control modes, the pre-disturbance operating condition shall be selected such that the limiter would just operate for a change in reactive power of 0.25 pu. When operating in Voltage Droop control, the pre-disturbance operating condition shall be selected such that a +/- 2.5% reference step would just cause the limiter to operate.
- Change in voltage
  - For each control mode, the generating systems response should be investigated for a +/- 5% voltage disturbance at the PoC.
  - For all control modes, limiter tests should be performed. This involves applying a +/- 5% voltage disturbance at the PoC from a pre-disturbance operating condition where a +/- 2.5% voltage disturbance would just cause the limiter to operate.

- For voltage disturbance studies in PSS/E NEM models, voltage disturbances may be applied using a fictitious shunt.

- Using PSCAD SMIB models the following tests must be carried out to calculate the rise and settling time for a plant with primary Q/V control mode of voltage droop control.
  - +/- 5% Voltage setpoint change
  - +/- 5% Voltage setpoint change into a limiting device
  - +/- 5% Voltage step change at the PoC bus
  - +/- 5% Voltage step change into a limiting device
- PSCAD SMIB model studies, pre disturbance reactive power dispatch values are required to be selected such that a 5% voltage reference step or step change would cause the reactive power limiter to operate.
- PSCAD SMIB assessments should include all the control modes including Power Factor and Reactive Power control modes, with reference setpoints / disturbances applied to change PoC reactive power by 50% of Qmax.
- AusNet does not expect the proponents to assess the settling times for Reactive Power and Power Factor control modes, unless any of these modes are the primary control mode.
- PSCAD assessments should be conducted for the minimum SCR conditions.
- The results of each study, supported by assessment plots should be summarized in a data table that shows:
  - All cases studied.
  - The reactive power rise time and settling times for active, reactive power and voltage
  - Plant response during those tests (ex. Stable response) and compliance with the accuracy limits for the setpoints changes.

3.11. S5.2.5.14

- The Connection Study report must include studies to demonstrate the compliance of the plant in either PSS/E SMIB model or PSCAD SMIB model.
- BESS projects should demonstrate the compliance for both discharging and charging modes.
- Assessment needs to be carried out with the minimum SCR scenario and as per primary Q/V control mode and setpoint in the agreed VCS.

3.12. S5.2.5.15

- The Connection Study report must include studies to assess the minimum withstand SCR using a PSCAD SMIB model.
- AusNet may request or nominate additional tests beyond the basic SMIB-based tests (such as those in Appendix B of AEMO SSIAG document [6]) if deemed necessary. The additional tests may be required due to certain factors including technology type, which will be discussed during the kick off meeting for the connection application stage
- For Battery Energy Storage Systems (BESS), tests must be conducted at charging and discharging conditions, up to the maximum registered or proposed capacity. As charging conditions might have some limitations due to power transfer capability based on the SCR and the X/R conditions, it is recommended that the charging studies being conducted based on the recommendations indicated in AEMO's Technical note on assessing power transfer limits [7].
- For hybrid connections (e.g., a combination of different technologies), tests must be completed for each individual technology as well as the combined system.
- Tests are deemed acceptable if the minimum withstand SCR is **≤ 3.0**

3.13. S5.2.8

- The Connection Study report must include studies conducted to assess the fault currents at the PoC.
- In order to assess the maximum fault current the plant would be subjected to, assessments to be carried out using AusNet's PSS/E maximum fault level sub-transmission model with all the generators connected (i.e. IBRs and Synchronous Generators), using ASCC default method in PSS/E (3phG, 2phG, 1phG).
- In order to assess the maximum fault current contribution from the plant, proponent should follow the process indicated below.
    a) Assess the PSS/E pre and post connection fault currents (3phG, 2phG, 1phG) using AusNet's maximum fault level and minimum demand PSS/E sub-transmission models provided during the detailed connection enquiry stage.
    b) Calculate the maximum contribution from the plant (F1) and record the PoC voltage (V1).
    c) Using the historical maximum PoC voltage (V2) obtained from AusNet, calculate the voltage multiplication factor (V2/V1)
    d) Calculate the maximum expected fault current contribution using the equation, F1 x V2 /V1.

4. References

[1] AEMO, "Access Standard Assessment Guidelines", January 2019

[2] AEMO, "Generator Performance Standard Template", August 2025

[3] AEMO, "Power System Modelling Guidelines", Version 2.0, July 2023

[4] AEMC, "National Electricity Rules", **Version 235**

[5] AEMO, "draft-scp-process-map---20240810.pdf"

[6] AEMO, "System Strength Impact Assessment Guidelines", Version 2.2, July 2024

[7] AEMO, "System Strength Impact Assessment Guideline Withstand SCR Methodology Review, Technical Note on Assessing Power Transfer Limits", Version 2.1 February 2025

AusNet Services

Level 31
2 Southbank Boulevard
Southbank VIC 3006
T +613 9695 6000
F +613 9695 6666
Locked Bag 14051 Melbourne City Mail Centre Melbourne VIC 8001
www.AusNetservices.com.au

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