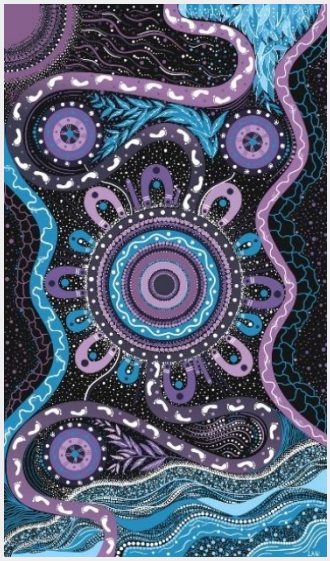
AEMO
AUSTRALIAN ENERGY MARKET OPERATOR
Victorian Planning

Power Quality Testing Guideline for Victorian Transmission Connections

September 2024 v1.0

AEMO Victorian Planning and Connections



We acknowledge the Traditional Custodians of the land, seas and waters across Australia. We honour the wisdom of Aboriginal and Torres Strait Islander Elders past and present and embrace future generations.

We acknowledge that, wherever we work, we do so on Aboriginal and Torres Strait Islander lands. We pay respect to the world's oldest continuing culture and First Nations peoples' deep and continuing connection to Country; and hope that our work can benefit both people and Country.

'Journey of unity: AEMO's Reconciliation Path' by Lani Balzan

AEMO Group is proud to have launched its first Reconciliation Action Plan in May 2024. 'Journey of unity: AEMO's Reconciliation Path' was created by Wiradjuri artist Lani Balzan to visually narrate our ongoing journey towards reconciliation - a collaborative endeavour that honours First Nations cultures, fosters mutual understanding, and paves the way for a brighter, more inclusive future.

Important notice

Purpose

AEMO has prepared this document to provide information about the expected power quality testing requirements during R2 testing for connections to the Victorian Declared Shared Network, as at the date of publication.

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Version control

Version	Release date	Changes
1.0	24/9/2024	Initial version

Contents

Tables

1 Introduction

This document has been prepared by AEMO Victorian Planning and Connections to guide power quality compliance testing when commissioning new generators connecting to the Victorian Declared Shared Network. If any clarification is required, please contact AEMO Victorian Planning and Connections at vic.connections@aemo.com.au.

The methodology in this guideline is intended to minimise discrepancies in plant harmonic emission calculations due to changes in network profile between the time power quality measurements are taken and the commencement of commissioning.

Table 1 summarises the types of testing required at each Hold Point (HP). Testing requirements can vary from this guideline and the specific requirements for each individual project must be discussed and confirmed with AEMO Victorian Planning and Connections.

Table 1 Power quality test requirements at each hold point (X means the test is required)

Hold point	1 week background measurement	1 week monitoring network harmonics	On/off test of harmonic contributions
HP0	X		
HP1 onwards (excluding Final HP)		X	If required based on network harmonics
Final HP		X	X

2 Background measurements at HP0

The power quality meter must be installed and in service prior to the connection of the plant. As soon as the power quality meter is in service, it must be switched on and start recording. Please note that:

- Prior to connecting the plant, the power quality meter should be installed, commissioned, and the data checked, to ensure that the meter is correctly configured.
- Generating units must not be connected prior to the installation and commissioning of the power quality meter. Large reactive plant may also be subject to restrictions if the power quality meter has not been brought into service.
- Generally the power quality meter will be required to record data for a minimum of one week immediately before the connection of plant at HP0.
- All connection assets should be disconnected during the first period of background harmonic measurement. If this is not practical, please advise AEMO Victorian Planning and Connections. Further studies may be requested prior to energisation if not all assets can be disconnected.

3 Methodology for HP1 onwards

Harmonic voltages at the Point of Connection are to be monitored. If network harmonics approach the planning limit, then further action and testing is needed. It is preferred that at least one week of network measurements from the Connection Point are used for this assessment.

If harmonic levels at these Hold Points are not approaching planning limits, then the plant may only need to assess harmonic contributions at the final Hold Point.

However, if harmonic levels are found to be near or above planning limits, an on/off approach may need to be taken for the measurement of harmonic contribution. This involves the plant being disconnected from the grid for a short period of time to ensure that up to date background data is used for the compliance assessment. More details on this approach can be found under Methodology for the final Hold Point.

4 Methodology for the final Hold Point

The final Hold Point contains two different sets of measurements as part of testing; up to date background measurements, and final hold point harmonic voltages.

Both measurements are described in this section.

4.1 Background harmonics measurement at final Hold Point

For a period of time agreed with AEMO Victorian Planning and Connections (typically 24 hours), the plant should be disconnected from the Declared Shared Network (DSN) and the connection assets de-energised with the Power Quality meter remaining in service. Should the disconnection of all connection assets present an issue, please discuss with the AEMO Victorian Planning and Connections project team.

If disconnection of all connection assets is not feasible, some options may include:

- Leaving limited connection assets connected to the DSN.
- Utilising a different meter in the DSN (where a suitable meter is available).

All considerations for the switching of the connection assets should be discussed with the AEMO Victorian Planning and Connections project team.

Please note that:

- If part of the connection assets remain in service during background harmonic measurements, harmonic modelling must be performed prior to measurement to demonstrate the harmonic amplification and emissions of this connected plant.
- Background harmonics should be measured for one continuous period over an agreed time interval. Bidding and availability should reflect the plant's de-energisation.

- Measurement of harmonic data with the generator in service should be conducted immediately after re-energising the plant.

4.2 Recording of final Hold Point harmonic voltages

After the generating system has been returned to service, record the harmonics at the Connection Point for a week of normal operation.

5 Assessment criteria

During the final hold point, harmonic performance would be assessed based on voltage distortion limits agreed under clause S5.2.5.2 of the Generator Performance Standards (GPS). However, for stages prior to the last hold point, point of connection harmonic voltages are to be monitored without the subtraction of background measurements.

For all harmonic voltage measurements, the values used for assessment should be 10-minute average measurements on each phase for each harmonic order.

5.1 Assessment of harmonic levels at Hold Points prior to the final Hold Point

If the 95th percentile of network harmonics are found to be above 80% of planning levels at any Hold Point, then further testing/action may be required including:

- Further measurement prior to moving to the next Hold Point.
- Assessment of plant emission contributions at that Hold Point (that is, disconnecting the plant for a short period of time to determine the plant's contributions).
- Investigation of network harmonic levels to determine whether there is another source of the high measurements.

Different switching arrangements can be agreed during commissioning (such as if a filter is not available during the first Hold Point), if AEMO Victorian Planning and Connections approves. In these cases:

- Further studies may be required to accept these situations.
- There may be added conditions during these initial arrangements.

5.2 Assessment of harmonic contributions at the final Hold Point

Harmonic contributions at the final hold point are calculated as the difference between the 95th percentile of the harmonic voltages with the plant in service, and the 95th percentile of the harmonic voltages while the plant is disconnected.

The difference should be calculated for each harmonic order using the harmonic exponents from Table 5 of AS/NZS 61000.3.6:2001.

If the final hold point is non-compliant with the GPS voltage distortion limits, further action is required which may include:

- Registration of a non-compliance.
- Further testing.
- Disconnection of generating units or the generating system.
- Other mitigation plans.

The specific actions taken if a non-compliance is identified will need to be discussed and agreed with AEMO Victorian Planning and Connections with regard to the site specific details of the issue identified.

6 Measurement of flicker and unbalance

Using the power quality measurement data collected at the final hold point, flicker and voltage unbalance must also be assessed to ensure compliance with the agreed performance standard.

6.1 Flicker

Flicker is to be quantified using two quantities, P_{st} (short-term) and P_{lt} (long-term) which can be measured using a AS/NZS 61000.4.15:2005 compliant flicker meter. P_{lt} is derived from 12 consecutive P_{st} values.

The 99th percentile per-phase values should be calculated from measurement data with the plant in service, $P_{st99_{HP}}$ and $P_{lt99_{HP}}$, and without the plant in service, $P_{st99_{BG}}$ and $P_{lt99_{BG}}$. Flicker measured at the final hold point should be subtracted from background flicker for both P_{st} and P_{lt} (for each phase) using the cubic summation law equations (3) and (4) in section 6 of AS/NZS 61000.3.7:2001. The subtraction is as follows:

$$P_{st_e} = \sqrt[3]{({P_{st99_{HP}}}^3 - {P_{st99_{BG}}}^3}$$

$$P_{lt_e} = \sqrt[3]{({P_{lt99_{HP}}}^3 - {P_{lt99_{BG}}}^3}$$

The resultant P_{lt_e} and P_{st_e} are metrics for per-phase flicker emission. Maximum P_{lte} and P_{ste} of the three phases shall be calculated and compared against the P_{st} and P_{lt} allocations defined in the generator performance standard to ensure compliance.

6.2 Voltage unbalance

To determine voltage unbalance contribution of the connecting plant, utilise the power quality data collected at the final hold point. Consider the negative sequence voltage (as a percentage of nominal voltage) with the plant in service and subtract negative sequence voltage with the connecting plant out of service.

This calculation shall be performed for each data set on the maximum of the 1-minute average data, maximum of the 10-minute average data, and maximum of the 30-minute average data.

These calculated values shall be compared against the agreed performance standard to ensure compliance.

For connections applying in areas of existing high voltage unbalance, novel assessment methodologies may be considered. It is recommended to discuss the existing network voltage unbalance with AEMO Victorian Planning and Connections.