Fact sheet

Multiple Disturbance Ride Through Assessment Guideline

Background

The South West Interconnected System (SWIS) is currently undergoing a significant technology transition. The introduction of embedded generation in customer premises is becoming an increasingly significant source of electricity. In tandem, new large-scale grid connected renewable generation projects such as wind and solar photovoltaic (PV) farms are also being developed. Both household rooftop PV and large-scale renewable generation are inverter based, non-synchronous generation. As more non-synchronous generation continues to connect, the power system will have lower levels of synchronous generators.

It is important that Generator Performance Standards are set appropriately and recognise the evolving characteristic of the power system. Understanding generators' performance during normal operation, during contingency events and understanding generators' voltage and frequency regulation capability to maintain stable power system operation is crucial in accurately determining system security limits. When a new generator is proposed to connect to the SWIS, it is important that there is clarity regarding the level of performance that the generator is required to deliver to ensure that its connection does not degrade the security of the power system.

To enable this, the new Wholesale Electricity Market (WEM) rules have been introduced and will be in effect on Monday, 1st February 2021. Appendix 12 of the WEM rules stipulates new requirements (access standards) for all types of generation to ride through multiple disturbances (faults), as part of its proposed rule change on generator technical performance standards. These new access standards aim to balance power system security requirements and maintenance of plant integrity.

Power system modelling and analysis demonstrated that the proposed access standards can be met by a range of new and existing synchronous and non-synchronous generation. Where a generating system failed to ride through multiple simulated disturbances, results showed that the disturbance sequence exceeded the requirements of the proposed access standards.

Aim of this document is to give the generators an indication on the assessment methodology of the multiple disturbance ride through technical requirement.

Technical Requirement for Disturbance Ride Through for Multiple Disturbances

Common requirements - A12.9.1 WEM Rules

The Common Requirements for disturbance ride through for multiple disturbances as they apply to different Generating Systems, are specified in Table A12.9.1.1 of Appendix 12. The Generator Performance

Standard must include any operational arrangements to ensure the generating system, including all operating generating Units, will meet their agreed performance levels under abnormal network or generating system conditions. When assessing multiple disturbances, a fault that is re-established following the operation of an automatic reclose Protection Scheme shall be counted as a separate disturbance.

Synchronous Generating Systems and Units

For a generating system comprised solely of synchronous generating units, the reactive current contribution as measured at the connection point must equal or exceed 250% of the maximum continuous current of the generating system. For a synchronous generating unit in any other generating system, the reactive current contribution may be limited to 250% of the maximum continuous current of that synchronous generating unit.

Asynchronous Generating Systems

For a Generating System comprised of Asynchronous Generating Units:

(a) the reactive current contribution as measured at the Connection Point must equal or exceed the Maximum Continuous Current of the Generating System, including all operating Asynchronous Generating Units;

(b) the reactive current contribution and voltage deviation may be measured at a location other than the Connection Point (including within the relevant Generating System) where agreed with AEMO and the Network Operator, in which case the reactive current contribution and voltage deviation will be assessed at that agreed location;

(c) the reactive current contribution required may be calculated using phase to phase, phase to ground or sequence components of voltages. The ratio of the negative sequence to positive sequence components of the reactive current contribution must be agreed with AEMO and the Network Operator for the types of disturbances specified in this Technical Requirement; and

(d) the Generator Performance Standard must record all conditions (which may include temperature) considered relevant by AEMO and the Network Operator under which the reactive current response is required.

Ideal Generator Performance Standard - A12.9.2 WEM Rules

Ideal Generator Performance Standard stipulates that the Generating System and each of its operating Generating Units must remain in Continuous Uninterrupted Operation for any disturbances caused by:

a. a Credible Contingency Event;

b. a three-phase fault in a Transmission System cleared by all relevant primary Protection Systems; and

c. a two phase to ground, phase to phase or phase to ground fault in a transmission or distribution system or a three-phase fault in a distribution system cleared in:

(i) the longest time expected to be taken for a relevant breaker fail Protection System to clear the fault; or

(ii) if a Protection System referred to in clause c.(i) above is not installed, the greater of 450 milliseconds and the longest time expected to be taken for all relevant primary protection to clear the fault.

provided that the event is not one that would disconnect the Generating Unit from the SWIS by removing Network elements from service or as a result of the operation of an existing inter-trip, Protection Scheme or runback scheme approved by the Network Operator and AEMO.

A Generating System and each of its operating Generating Units must remain in Continuous Uninterrupted Operation for a series of up to 15 disturbances within any 5-minute period caused by any combination of the events described in the previous paragraph where:

- The fault is considered to have occurred at the Generating System's point of connection;
- Immunity must be guaranteed for three phase, two phase and single-phase faults;
- A combination of three sequential faults is included in the series – single phase, two phase to ground followed by a three phase fault, each 1 second apart, and which causes the positive sequence voltage to drop to 70%, 60% and 50% of nominal voltage respectively. The cumulative duration of these faults must stay below 900ms (i.e. the combination of one Circuit breaker failure and two primary protection);
- The CB failure times are as per Table 2.10 for existing equipment in the Technical Rules[1] for both local and remote end; and
- The generating units also need to ride through an overvoltage followed by fault clearance within the envelope specified in Section 2.2.10 of the Technical Rules.

An example is given in Figure 2. **Please note that this is only for illustrative purposes.**

The generating units are also required to ride through an undervoltage followed by fault clearance within the envelopes specified in Figure A12.8.2.1 of Appendix 12 of WEM rules, provided that:

- none of the events would result in the islanding of the generating system or a material reduction in power transfer capability by removing network elements from service; and
- there is a minimum of 30 minutes where no disturbances occur following a five-minute period of multiple disturbances.

[1] In this document, the 1 December 2016 version of the Technical Rules applies which is available at: https://www.erawa.com.au/cproot/14411/2/edm%2040518689%20-%20technical%20rules%201st%20august%202016%20publish%20version%20-%20fri.pdf

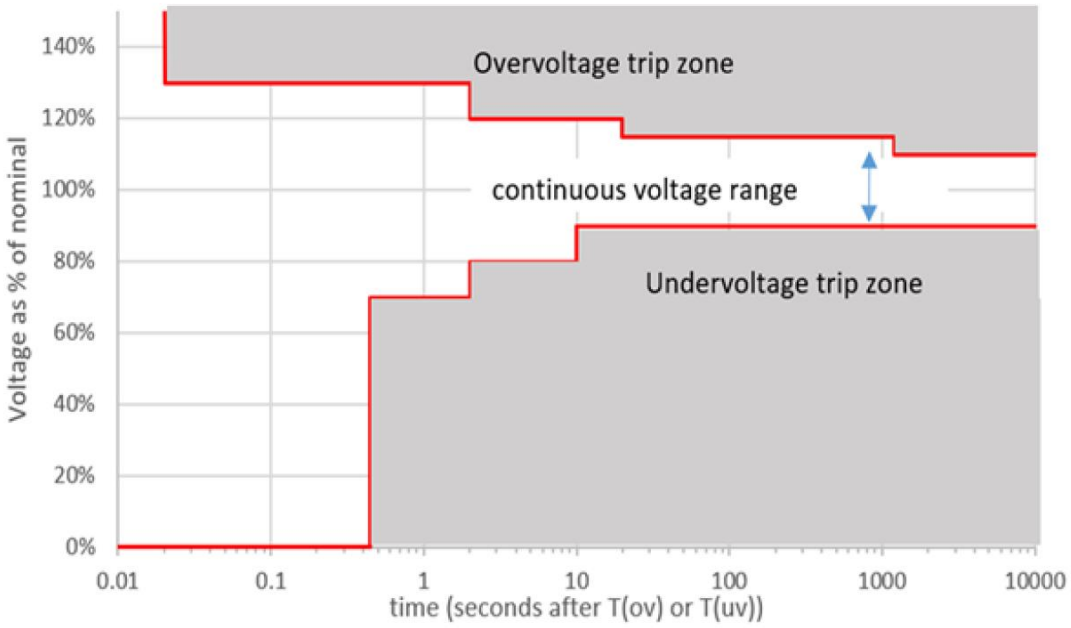

Figure A12.8.2.1: Voltage variations that a Generating System must ride through to meet the Ideal Generator Performance Standard

Other considerations:

- Applicants must only apply the disturbances listed in the type of disturbances discussed above to assess whether they can meet the proposed generator performance standards with respect to multiple voltage disturbances;
- The fault clearance time for each fault in isolation must be within the relevant primary protection or circuit breaker failure clearance time for the specific faults appropriate to the generating system under consideration, and as specified in the generator performance standards for that facility;
- The fault clearance times applied to synchronous machines for this assessment must be below their respective critical fault clearance time. Longer duration faults must not be applied; and
- Some generating systems connected to remote distribution systems can be subject to deep faults with fault clearance times in the order of several seconds and with possible auto-reclosure. Such long duration disturbances are outside the scope of the proposed access standards, as these types of disturbances affect a very limited part of the network. Therefore, an inability to ride through several such disturbances is anticipated to have a limited impact on power system security. An example of such a disturbance sequence is illustrated in Figure 1.

Synchronous Generating Systems and asynchronous generating systems should comply with the technical requirements of A12.9.2.4 and A 12.9.2.5 of WEM Rules Appendix 12. Generators should also comply with the technical requirements stipulated in A12.9.2.6, A 12.9.2.7 and A12.9.2.8

Minimum Generator Performance Standard- A12.9.3 WEM Rules

A12.9.3 of Appendix 12 stipulates the minimum Generator Performance Standard for multiple ride through requirement. Clause 12.9.3.2 states that a Generating System and each of its operating Generating Units must remain in Continuous Uninterrupted Operation for any disturbance caused by:

> (a) a Credible Contingency Event; or
>
> (b) a single phase to ground, phase to phase or two phase to ground fault or three phase fault in a transmission or distribution system cleared in the longest time expected to be taken for all relevant primary Protection Systems to clear the fault,

provided that the event is not one that would disconnect the Generating Unit from the SWIS by removing Network elements from service or as a result of the operation of an inter-trip, Protection Scheme or runback scheme approved by the Network Operator and AEMO.

A Generating System and each of its operating Generating Units must remain in Continuous Uninterrupted Operation for a series of up to 6 disturbances within any 5-minute period where:

- Fault will occur at point of connection
- Immunity should be guaranteed for three phase, two phase and single-phase faults
- A combination of a sequence of three faults -single phase, two phase to ground followed by a three-phase fault each 1 second apart which causes the positive sequence voltage to drop to 70%, 60% and 50%. The summation of the duration of all these faults should stay below 900ms (i.e. the combination of one CBF and two primary protection).
- The CB failure time are as per Table 2.10 existing equipment of Technical Rules
- The generating unit also need to ride through an overvoltage followed by fault clearance within the envelope specified in Section 2.2.10 of current Technical Rules

<u>Other considerations:</u>

- Applicants must only apply the disturbances listed in the type of disturbances discussed above to assess whether they can meet the proposed generator performance standards with respect to multiple voltage disturbances.
- The fault clearance time for each fault in isolation must be within the relevant primary protection or circuit breaker failure clearance time for the specific faults appropriate to the generating system under consideration, and as specified in the generator performance standards for that facility.
- The fault clearance times applied to synchronous machines for this assessment must be below the respective critical clearing time. Longer duration faults must not be applied.
- Some generating systems connected to remote distribution systems can be subject to deep faults with fault clearance times in the order of several seconds with possible auto-reclosure. Such long duration disturbances are outside the scope of the proposed access standards, as these types of disturbances affect a very limited part of the network. Therefore, an inability to ride through several such disturbances will have a limited impact on power system security. An example of such a disturbance sequence is illustrated in Figure 1.

Synchronous generating systems and Asynchronous generating systems should comply with A12.9.3.4 and A12.9.3.5 of Appendix 12. Generators are also expected to comply with A 12.9.3.6, A12.9.3.7 and A12.9.3.8

Negotiation Criteria -A12.9.4 WEM Rules

A12.9.4 of Appendix 12 stipulates the negotiation criteria for multiple ride through. A Proposed Negotiated Generator Performance Standard may be accepted if the connection of the Generating System at the proposed performance level would not cause other Generating Systems or Loads to trip as a result of an event, when they would otherwise not have tripped for the same event.

High Level Methodology for Assessments

Western Power will test Multiple ride through criteria in PowerFactory RMS model – SMIB model which is extended to the nearest substation. Faults are applied by either short line or impedance to achieve the required residual voltage. System will be represented by Thevenin equivalent for both maximum and minimum fault levels. Generating units require to comply with these criteria at their maximum declared active and reactive capability and all control modes.

EMT studies will be conducted to check the results if needed mainly to evaluate inverter-based generating units stability after faults for weak system connections. Three phase faults will be minimised specific to synchronous machines limited to two faults at least 10s apart. All inverter based generating units are required to have their protection system modelled as part of their FRT control state.

Example Plots:

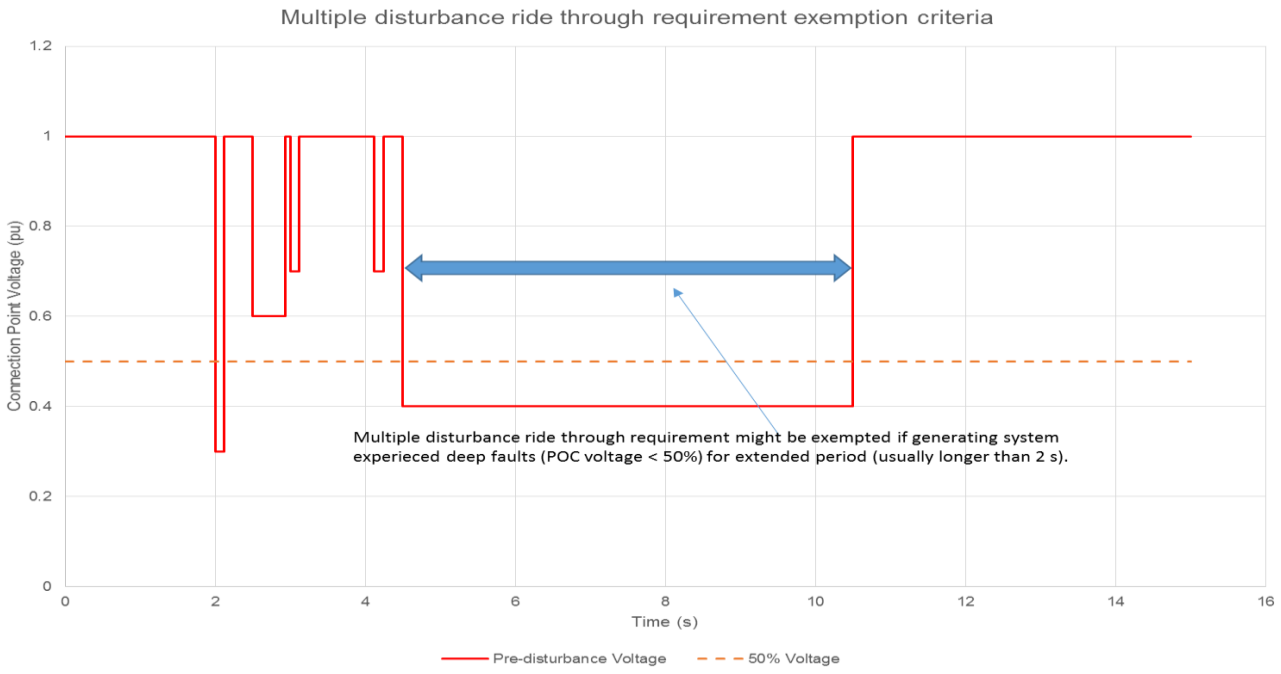

Figure 1: Example of Deep fault

In the above example, the generating system had successfully ridden through the first four disturbances. The fifth disturbance caused the connection point voltage to drop below 50% for five seconds. The generating system is not, therefore, required to ride through the fifth long duration disturbance

Contact

Please contact system.analysis@westernpower.com.au for any queries or comments on this factsheet

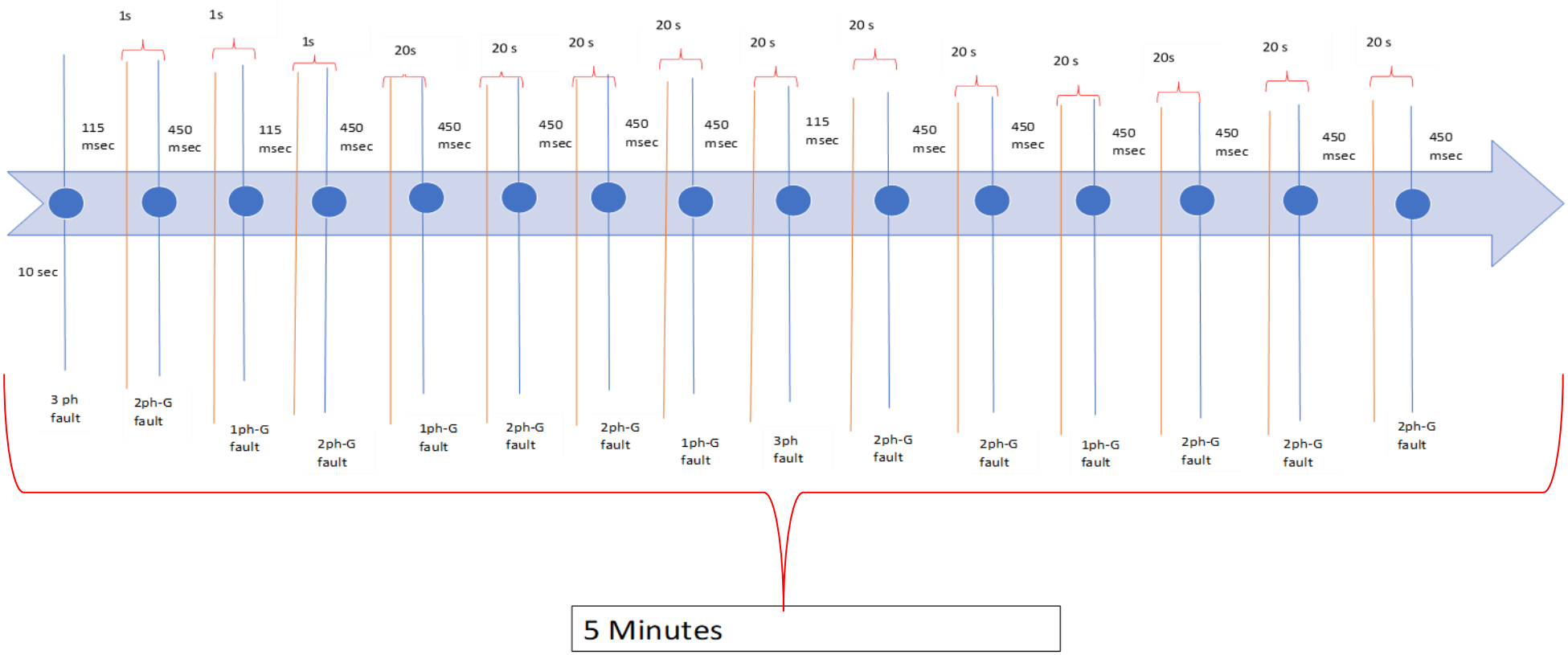

Figure 2 : Multiple ride through example for 15 faults in 5-minute timeframe (illustration Purpose only)