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Title:

Embedded generation

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2	6/09/2023	Remove requirement for installation inspector to inspect every IES prior to permanent electrification.	Dean Starkey	Glenn Cooper

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Scope

This document outlines the requirements for connection of embedded generation to the Ausgrid network. Embedded generators are generators that are able to connect in parallel to Ausgrid's network. Types of generators may include inverter energy systems (such as solar PV and batteries), as well as rotating machines (such as synchronous and asynchronous turbines/alternators).

This standard is primarily focussed on anti-islanding protection requirements, along with select other technical requirements which are related to protection, or are often implemented using the same equipment (e.g. voltage and power quality control). There are differing requirements depending on generator type and rated capacity.

It also covers earthing requirements for embedded generators and establishes technical review and approval requirements based on type of generator connection.

The requirements for embedded generator short circuit protection systems are not covered in this standard. Further information can be found in AS/NZS 3000, NSW Service & Installation Rules, and the National Electricity Rules.

Standby generators which will never operate in parallel with the Ausgrid's network are covered in Section 8.3 of the NSW Service & Installation Rules and AS/NZS 3010 Electrical Generating Sets Safety, to which there are no additional requirements as a result of this standard.

This standard only defines specific requirements for connection of Inverter Energy Systems to Ausgrid's network which are variations of, or additional to AS/NZS 4777.

Reference Documents

All work covered in this document must conform to all relevant Legislation, Standards, Codes of Practice and Network Standards. Current Network Standards are available on Ausgrid's Internet site at www.ausgrid.com.au.

Ausgrid Documents

NS116 Design Standards for Distribution Earthing

NS194B Guidelines for Rotating Machines Connected to Ausgrid Network

Negotiated Ongoing Connection Contract: Embedded Generators.

Ausgrid Deemed Standard Connection Contract

NS238 Supply Quality

Other Standards and Documents

AS 2467:2008 Maintenance of electrical switchgear

AS/NZS 3000:2018 Electrical installations

AS/NZS 3008.1.1:2017 Electrical installations – Selection of cables

AS/NZS 3010:2017 Generating sets

AS/NZS 3017:2007 Electrical installations – Verification guidelines

AS/NZS 3835 Earth potential rise – protection of telecommunication network users, personnel and plant

AS/NZS 4853 Electrical hazards on metallic pipelines

AS/NZS 4777.1:2016 Grid connection of energy systems via inverters
Part 1: Installation requirements

AS/NZS 4777.2:2020 Grid connection of energy systems via inverters
Part 2: Inverter requirements

AS/NZS 5033:2014 Installation and safety requirements for photovoltaic (PV) arrays

AS 60038:2012 Standard voltages

AS/NZS 61000.3.2 – Electromagnetic compatibility (EMC) – Limits for harmonic current emissions (equipment input current =16 A per phase)

Australian Clean Energy Council website (<https://www.cleanenergycouncil.org.au>)

ENA Doc 001-2019 National Electricity Network Safety Code

ENA DOC 025-2010 EG-0 Power System Earthing Guide Pt 1: Management Principles

ENA Guideline for the preparation for connection of Embedded Generation within Distribution Networks – 2011

IEC 60255 Measuring relays and protection equipment – multiple parts

National Electricity Rules

Service & Installation Rules of NSW.

Acts and Regulations

Electricity Supply (General) Regulation 2014 (NSW)

Electricity Supply (Safety and Network Management) Regulation 2014

Work Health and Safety Act 2011 and Regulation 2017

Clause Standard Requirements**1 Fault Levels, Loading and Scheduling**

- 1.1 Ausgrid shall prohibit the connection of a generator where Ausgrid's network may become compromised under high-fault level or abnormal conditions or curtail the generation level to ensure Ausgrid's network is not overloaded.
- 1.2 In some locations, connection may be allowed with the additional provision of a control signal from Ausgrid that results in the generating unit being either taken off-line (i.e. a 'soft-trip') or inhibited from starting up. Also see Clause 7.7– Inter-tripping (and Communications Link).
- 1.3 Upon assessment of the proposed connection, Ausgrid will advise the proponent if any fault level or loading issues exist whereby scheduling may be required as part of the installation.

2 Sydney CBD Network

- 2.1 It is unlikely large rotating machine generators can be connected to Ausgrid's Sydney CBD triplex network due the fault level contribution. Generator proponents shall consult with Ausgrid early in the connection planning process to investigate feasibility of generator connections in Sydney CBD.

3 Standby Generators

- 3.1 Where standby generation and transfer switch is installed upstream from an inverter energy system the installation or control system shall be designed to prevent the inverter energy system synchronising with the standby generator.
- 3.2 Standby generators which are paralleled with Ausgrid's network for a short time before the installation is disconnected from the grid shall comply with Section 8.4 of the NSW Service & Installation Rules as Synchronise Close Transfer Trip (SCTT) generators (sometimes referred to as bumpless transfer generators, or short time transfer generators). SCTT generators that parallel with the grid for greater than 1s shall be assessed as parallel generation under this standard.
- 3.3 For SCTT generators above 30kVA a technical review by Ausgrid is required to confirm that the possible fault level contribution will not result in equipment ratings being exceeded in the surrounding network.

4 Registered Generators

- 4.1 For generators intended to connect to the Ausgrid network under the NER Chapter 5 framework, subject to a detailed application and offer to connect, the installation (point of connection/private installation incoming supply) may be required to comply with this Network Standard where not in conflict with Schedule 5.2 of the NER.

5 Inverter Energy Systems**5.1 General**

- 5.1.1 Inverter Energy Systems (IES) are comprised of one or more power sources (e.g. solar PV, wind energy or batteries) connected through one or more inverters to the same electrical installation. IES to be connected to Ausgrid's network shall be compliant with AS/NZS 4777.1, be approved by the Clean Energy Council and be installed by a Clean Energy Council certified installer. A list of Clean Energy Council approved equipment can be found at:
<https://www.cleanenergycouncil.org.au>

5.2 **Inverter power quality settings**

5.2.1 Inverter power quality settings shall be enabled and configured in accordance with AS/NZS 4777.2

5.2.2 The Region setting shall be set to “Australia A”. For all other modes and operation that are not covered by a regional setting then default settings of AS/NZS 4777.2:2020 apply.

5.3 **Single Phase IES**

5.3.1 As a limited variation to AS/NZS 4777.1, If the consumer installation is single or two phase, Ausgrid will allow for a total IES export capacity of up to 10kVA to be connected to a *single* phase. Ausgrid will also allow additional inverter capacity for battery inverters to be installed on the single phase such that the notional 10kVA limit is exceeded. Table 1 specifies the single phase IES capacity and export limits for single and two phase consumer installations.

5.3.2 For single phase IES outside of the scope of table 1, an online preliminary enquiry form with details of your proposal will be required.

Table 1 Single Phase Inverter Capacity & Export limits

Energy Source Configuration	Maximum Export Limit	Total Single Phase IES Capacity Limits	Notes
PV (Solar) and/or Wind Energy	10kVA	10kVA	Notes 1 & 2
PV (Solar) and/or Wind Energy plus Energy Storage (Battery)	10kVA	PV/Wind: 10kVA Battery: 10kVA	Notes 1, 2 & 3

¹ This allowance can be considered to negate the AS/NZS 4777.1 requirement for phase balance centralised protection for an IES smaller than 30kVA. Above 30kVA phase balance protection is required exactly as prescribed in AS/NZS 4777. This allowance does not negate the other AS/NZS 4777 requirements for phase balancing.

² Total IES capacity limit is based on the summated inverter nameplate rating of all inverters connected to either an exclusive or shared connection point to Ausgrid’s network.

³ Single phase IES above 10kVA must implement export limiting to 10kVA or less.

5.4 **Inverter energy systems greater than 30kVA and less than or equal to 200kVA**

5.4.1 For an IES above 30kVA and less than or equal to 200kVA, AS/NZS 4777.1 requires the implementation of centralised protection. Ausgrid requires the following modifications to AS/NZS 4777.1 Central protection requirements:

5.4.2 Centralised protection shall obtain its measured input values (e.g. voltage, current) upstream (i.e. closer to the point of connection) than all inverters connected at the electrical installation.

5.4.3 The IES or central protection shall be designed to prevent synchronisation with island generation sources (e.g. standby generation).

5.4.4 In installations such as multi-tenanted or multi-customer sites, with a single connection point to Ausgrid’s network, multiple centralised protection schemes may be used instead of one single scheme provided there is a centralised protection scheme upstream of every inverter energy system. (Refer to Annexure F for examples of multi-tenanted sites).

5.4.5 In addition to the Australian Standard, the centralised protection of an IES of above 30kVA and less than or equal to 200kVA shall also incorporate the following anti-islanding elements, as per Table A2 in Annexure A (set as per Annexure C – Protection Set Point Limits):

- Rate of Change of Frequency (ROCOF), and
- Vector Shift (VS).

5.4.6 Suitable test and isolation links must be provided on all inputs and outputs of the centralised protection device or devices to allow secondary injection testing without the need to disconnect and then re-terminate wires.

5.5 [Inverter energy systems greater than 200kVA](#)

5.5.1 For connection of an IES of capacity greater than 200kVA, all requirements of AS/NZS 4777.1:2016 and clause 5.4 of this standard shall be met.

5.5.2 In addition to the Australian Standard, Ausgrid's requirements for anti-islanding protection shall apply as per Chapter 7 – Anti-Islanding Protection, and Annexure A – IES Protection Summary.

6 **Rotating Machines**

6.1 [General](#)

6.1.1 In the first instance, synchronous and asynchronous rotating machines to be connected to Ausgrid's network shall comply with the protection requirements of the Service and Installation Rules of NSW, Section 8 – Alternative Sources of Supply.

6.1.2 For additional guidance on the connection of rotating machine generators, see NS194B - Guidelines for Rotating Machines Connected to the Ausgrid Network.

6.1.3 For embedded rotating generators of above 30kVA, Ausgrid's requirements for anti-islanding protection shall apply as per Chapter 7 – Anti-Islanding Protection, and Annexure B – Rotating Machine Protection Summary.

6.2 [Check synchronisation](#)

6.2.1 Synchronous machines shall only be able to be paralleled to Ausgrid's network if their control device performs Check Synchronisation (CS) to verify the machine is in synchronism with Ausgrid's network. See also Section 7.10 – Connection, Reconnection and Synchronisation.

7 **Anti-Islanding protection**

7.1 [General](#)

7.1.1 The following anti-islanding protection design requirements are applicable to all Inverter Energy Systems of greater than 200kVA, and for all rotating machines of greater than 30kVA in accordance with Annexure A – IES Protection Summary, and Annexure B – Rotating Machine Protection Summary.

7.1.2 Embedded generation anti-islanding protection shall be designed to prevent parallel generation from synchronising with island generation sources e.g. standby generation.

7.2 [Redundancy and circuit breaker fail](#)

7.2.1 The anti-islanding protection system shall include sufficient redundancy to ensure that the generator/s disconnect from the network with any single protection element out of service. This may include but is not limited to relays, circuit breakers, and power supplies.

7.2.2 This will typically require 'Main' and 'Backup' protection schemes. The system shall also make allowance for Circuit Breaker Fail (CBF) scenarios in their design.

7.2.3 CBF protection may be achieved by having the Main and Backup schemes operate independent circuit breakers/contactors. See also Section 7.9 – Fail-Safe.

7.2.4 AS4777.2 compliant inverters are considered to provide the 'Main' protection.

7.2.5 Main and Backup anti-islanding protection should disconnect the generator only, and not isolate other loads in the electrical installation.

7.3 [Voltage and frequency limits](#)

7.3.1 Ausgrid's allowable ranges for voltage and frequency elements for Inverter Energy Systems and rotating machines are detailed in Annexure C – Protection Set Point Limits.

7.3.2 Suitable voltage settings for HV operating generators must be negotiated on a case-by-case basis.

- 7.3.3 For HV connections, sustained overvoltage protection is not required to protect Ausgrid's network.
- 7.4 [Export embedded generators](#)
- 7.4.1 For generators that are intended to export power to Ausgrid's network, refer to the requirements of Annexures A, B and C.
- 7.4.2 Inter-tripping is the preferred anti-islanding protection (see also Section 7.7) for export embedded generators and may be mandated as a requirement for some sites as part of a technical review by Ausgrid¹.
- 7.5 [No-export embedded generators](#)
- 7.5.1 For generators which are not intended to export power to Ausgrid's network, refer to the requirements of Annexures A, B and C.
- 7.5.2 Duplicate Low Forward Power or Inter-trip is the preferred anti-islanding protection for no-export embedded generators.
- 7.5.3 Settings and details of Grid Low Forward/Reverse Power protection must be negotiated with Ausgrid on a case-by-case basis².
- 7.6 [Neutral voltage displacement](#)
- 7.6.1 Embedded generator installations with a HV connection point to Ausgrid's network with generation greater than 30kVA for rotating machine or 200kVA for IES should implement Neutral Voltage Displacement (NVD) protection.
- 7.6.2 Neutral Voltage Displacement shall use Voltage Transformers (VT's) connected at the High Voltage connection point voltage. (i.e 11kV for an 11kV connection). Particular attention is needed to confirm that the VT's are of the correct configuration/type for use with this form of protection.
- 7.6.3 Refer to Annexure F for Voltage Transformer technical requirements when used for NVD protection.
- 7.6.4 Suitable NVD settings shall be negotiated with Ausgrid on a case-by-case basis. Refer to Annexure C: Protection Set Points Limits.
- 7.6.5 For embedded generator installations with a low voltage connection point, NVD is typically not required. Where NVD is identified as a site specific condition by Ausgrid as part of technical review the location and responsibility of installing VTs shall be negotiated during the assessment process.
- 7.7 [Inter-tripping \(including Communications Link\) between Ausgrid and Customer](#)
- 7.7.1 Where inter-tripping is the anti-islanding protection, it shall be appropriate for all credible islanding scenarios as determined by Ausgrid.
- 7.7.2 Inter-tripping shall meet the requirements of fail-safe as per Clause 7.9.
- 7.7.3 A communications link shall be continuously monitored for integrity.
- 7.7.4 In the event that the communication link fails, the generator shall be automatically disconnected within 1 second and remain disconnected until the link is restored.
- 7.7.5 Inter-tripping and communications between Ausgrid and the generator facility shall be provided over dedicated dark fibre cores.
- 7.8 [Inter-tripping and Communications within a Generator Facility](#)
- 7.8.1 Where the customer is using communications to provide remote tripping to meet the requirements of this standard, this shall be fail safe in accordance with Clause 7.9.

¹ If the proponent implements Vector Shift and ROCOF protection, they must accept that the anti-islanding protection may trip for system disturbances and fault events both within and external to the local network that the generator is connected to. Experience has shown setting of these schemes to be difficult to avoid nuisance tripping while providing adequate protection.

² Grid Reverse Power Protection is not the same as Generator Reverse Power Protection.

- 7.8.2 In the event that the communication link fails then the generator shall be automatically disconnected within 2 seconds and remain disconnected until the link is restored.
- 7.8.3 A relay trip signal to a remote contactor/CB over communications link shall be via a dedicated signal, i.e. cannot trip the remote CB/contactor by disrupting the comms and waiting for the loss of comms operation.
- 7.9 **Fail-Safe**
- 7.9.1 Relay power supplies, tripping, communications link and circuitry associated with the anti-islanding protection systems shall be fail safe. That is any failure of any part of the system shall result in the generator being disconnected and unable to be re-connected to Ausgrid's network.
- 7.9.2 Circuit breakers with shunt trips shall not be used. Where AC (or DC) supplies are proposed to be used, normally open contactors held in by healthy AC (or DC) volts or undervoltage release of circuit breakers on loss of AC (or DC) supply, relay fail and system fail shall be required.
- 7.9.3 Alternate arrangements to clause 7.9.1 and 7.9.2 will be considered providing the following 2 points are met.
- The proponent has an approved Installation Safety Management Plan.
 - Requirements for the ongoing inspection, maintenance and testing of the network and anti-islanding protection systems are specified within the Connection Agreement.
- 7.10 **Connection, reconnection and synchronisation**
- 7.10.1 The device controlling generator connection to the grid shall verify normal supply conditions on the grid for all connected phases (i.e. all three phases for a three phase connection) for a period of at least 1 minute prior to the device enabling connection.
- 7.10.2 Synchronisation or zero voltage on the generator side of the switching point shall be confirmed before the generator is paralleled to Ausgrid's network. When these conditions are met, automatic reconnection is permitted.
- 7.10.3 Where there are multiple points of automatic reconnection in the installation, each point shall independently monitor and verify normal supply conditions on the grid for all connected phases for a period of at least 1 minute before enabling automatic reconnection.
- 7.10.4 Where a manual reset has been nominated as required by Ausgrid, the generator will not be allowed to be automatically reconnected to the network. Ausgrid will negotiate the requirements of these proposals on a case by case basis with the proponent.
- 7.11 **Relay requirements**
- 7.11.1 Relays used to meet the requirements of Section 7 of this standard shall be approved by Ausgrid. A list of pre-approved relays and their available functions can be found on Ausgrid's website 'NS194 Approved Protection Relay List'.
- 7.11.2 For HV connected installations, at least one layer of protection (backup or main) shall be compliant with the appropriate severity class of IEC 60255.
- 7.12 **Testing and verification facilities**
- 7.12.1 Inputs and outputs of anti-islanding protection relays shall be provided with suitable facilities to allow secondary injection testing of the relay to be undertaken without the need to disconnect and re-terminate wires. This includes:
- Isolation links on protection relay AC measurement inputs,
 - Isolation links in series with protection relay contact outputs,
 - Test injection and measurement points compatible with 4 mm banana plugs. Measurement points must be available on both sides of relay contacts, and
 - Separate relay fail contact to allow testing
- 7.12.2 All protection cabling shall be appropriately labelled, and the labels shall corroborate with all drawings and documentation provided in the Protection Design Pack.
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- 7.12.3 Anti-islanding devices that are to undergo secondary injection testing shall also be capable of indicating locally what protection element has operated – this can be done via Human Interface Devices such as screens, LEDs or via a locally connected computer.
- 7.12.4 Prior to the installation being energised, it shall be possible to check the operation of any CBs & contactors operated by the anti-islanding protection. This is to be done without the generator/IES being in operation.

8 Protection Design Review and Commissioning

8.1 General

Ausgrid has different requirements for anti-islanding protection design review and commissioning depending on the embedded generator size and type. The following review and testing requirements are in addition to testing to applicable Australian Standards and the Service & Installation Rules of NSW.

8.2 Embedded generation of 30kVA or less

System design is not requested by Ausgrid for review. Installation inspection is conducted on Audit basis.

8.3 IES of greater than 30kVA and less than or equal to 200kVA

8.3.1 Design approval

- 8.3.1.1 The central protection design shall be produced and approved by an appropriately qualified designer with relevant experience with AS/NZS 4777, and this standard (NS194).
- 8.3.1.2 A complete Protection Design Pack (see Annexure E – Protection Design Pack) shall be submitted as part of the connection application for record keeping and auditing.

8.3.2 Commissioning

- 8.3.2.1 In addition to all testing and commissioning requirements of AS/NZS 4777.1, and AS/NZS 4777.2, secondary injection testing of the centralised protection relay shall be carried out on-site to confirm the system meets the requirements of this standard, including but not limited to failsafe, tripping logic, and protection element accuracy.
- 8.3.2.2 The secondary injection testing shall be carried out by a qualified electrical tester with calibrated test equipment, and the results shall be recorded in a test report along with the results of testing detailed in AS/NZS 4777.1, 7.6 – Commissioning.
- 8.3.2.3 The test report shall be signed by the qualified electrical tester. This report shall be provided to Ausgrid for record keeping.

8.3.3 Inspections and compliance auditing

- 8.3.3.1 Ausgrid reserves the right to audit any designs and testing used for embedded generation connection to its network. In accordance with Ausgrid's Customer Installation Safety Plan an embedded generator may be inspected for electrical safety, compliance with the relevant standards and consistency with supplied design information at any time.
- 8.3.3.2 Where a major defect is identified, the IES shall be disconnected until the defect is rectified and the installation is reinspected to the satisfaction of Ausgrid. Where a minor defect is identified Ausgrid's standard defect process shall be followed.
- 8.3.3.3 If reinspection of an IES is required it will incur a reinspection fee in accordance with Ausgrid's Alternative Control Services Fee Schedule.

- 8.4 **IES of above 200kVA and rotating machines above 30kW**
- 8.4.1 **Conceptual approval**
- 8.4.1.1 As part of the application for connection, a Conceptual Design Information Pack is required to be submitted to Ausgrid to define the generator connection details and demonstrate how it complies with this standard.
- Refer to Conceptual Design Information Pack (see Annexure D)
- 8.4.2 **Design approval**
- 8.4.2.1 Following receipt of the proponent's complete Protection Design Pack (see Annexure E), Ausgrid will conduct a technical review to confirm compliance with this standard, and to identify the need for any site specific conditions.
- 8.4.3 **Commissioning**
- 8.4.3.1 Following design approval, the proponent shall provide Ausgrid with an appropriate test plan to be used for commissioning. Ausgrid must inform the proponent if the plan is adequate, or if any changes are needed to confirm that the generator's anti-islanding protection systems are adequately tested.
- 8.4.3.2 The proponent shall arrange with Ausgrid for an Ausgrid representative to be present for all testing relating to the anti-islanding protection. The testing shall include at a minimum:
- Secondary injection testing of relay logic, failsafe, and set point accuracy,
 - Correct operation of all disconnection devices (tested prior to generator connection to the grid),
 - Scheme logic, synchronisation, and reconnection procedure, and
 - Primary anti-islanding testing in accordance with Clause 8.5.
- 8.4.3.3 Proponents shall allocate sufficient time to allow test plan review and resource allocation by Ausgrid. Ausgrid accepts no liability or warranty for any designs or equipment as part of the design approval or witness testing process.
- 8.5 **Primary Anti-islanding testing**
- 8.5.1 Primary anti-islanding testing is required to confirm the adequacy of the Vector Shift and ROCOF settings.
- 8.5.2 The requirements of primary anti-islanding testing will depend on the characteristics of the generator and the electrical installation. Proponents should note that primary anti-islanding testing will often require the switching of a significant amount of active load, which may necessitate disruptions to normal electrical supply in the electrical installation. For example, opening off the generator installation from the Ausgrid network to simulate a 'real world' event.
- 8.5.3 Details on all primary anti-islanding testing configurations and requirements are to be discussed and agreed with Ausgrid.
- 8.5.4 Where primary testing of anti-islanding testing does not confirm positive operation, more sensitive Vector Shift and/or ROCOF settings may be required.
- 9 Earthing**
- 9.1 **General**
- 9.1.1 The proponent is required to demonstrate that the generator installation has an earthing system that has been designed to limit any step, touch and transferred potentials to safe values using the principles detailed in "ENA DOC 025-2010 EG-0 Power System Earthing Guide Pt1: Management Principles".
- 9.1.2 Equipment used to interface to the distribution network (e.g. step up transformer or circuit breaker) shall comply with NS116 – Design Standards for Distribution Earthing.
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- 9.1.3 Additionally, the earthing system of the Generator shall be designed to limit the voltages impressed onto surrounding utility infrastructure under earth fault conditions. For metallic pipelines the tolerable voltages (or acceptable assumptions to determine them) are presented in AS/NZS 4853 and for telecommunications assets the voltage limits should comply with AS/NZS 3835.
- 9.1.4 Generation schemes working in parallel with the distribution network in effect become an integral part of the electricity distribution network. Therefore, neutral earthing arrangements for the private generators and any interconnection transformers shall be designed to suit the requirements of both the distribution network and the electrical installation and details provided to Ausgrid.
- 9.2 **Low voltage generators**
- 9.2.1 Generators connected to the network via a delta/star transformer with the delta on the network side may have their neutral directly connected to earth (ie via an MEN link).
- 9.2.2 Effective isolation of this neutral may be required to inhibit the flow of harmonics through the neutral and the generator's method to limit harmonics may be discussed and agreed to by Ausgrid. The use of 4-pole switching may be required if the generator can operate in standby mode.
- 9.3 **High voltage generators**
- 9.3.1 The generator's high voltage star point shall be effectively isolated from earth (ie isolated or earthed via a high impedance) to avoid any earth fault contributions flowing into the Ausgrid system and to inhibit the flow of harmonic currents through the neutral. Each case will be discussed with the proponent on its merits.

10 Multiple Embedded Generator Systems

- 10.1 **Mixed embedded generator systems**
- 10.1.1 Where a combination of embedded IES and rotating machines are connected at an electrical installation, they shall meet the requirements of this standard for the respective generator type of capacity equal to the total nameplate rating of all embedded generator types connected there³.
- 10.2 **Centralised backup protection**
- 10.2.1 Where multiple generator units are embedded in an electrical installation with a total capacity of greater than 30kVA, there shall be at least one layer of anti-islanding protection meeting the relevant requirements of this standard (Clause 5.4 for IES of up to 200kVA or Section 7 for other types), the operation of which results in the disconnection of all embedded generators in the electrical installation.
- 10.3 **Existing embedded generators**
- 10.3.1 Where an electrical installation already has embedded generation installed, and new generating sources are proposed to be connected, the entire installation shall comply with this standard. This may require upgrading or retrofitting existing protection systems.

³ For example, if a 150kVA rotating machine is to be connected to an electrical installation which already has a 60kVA IES installed, the anti-islanding protection for the rotating machine and IES must meet the requirements of this standard for a rotating machine greater than 200kVA, and an IES greater than 200kVA, respectively.

11 Alteration to Approved Design

- 11.1 The premises owner or occupier shall not modify the approved design, change protection equipment or protection settings of the embedded generator equipment without informing and receiving prior written authorisation from Ausgrid.
- 11.2 Upon receipt of a written request to modify the approved design and/or settings, Ausgrid will advise the proponent if it is considered necessary to undertake a new technical assessment on the impact on Ausgrid's network.
- 11.3 If a new technical assessment is required then it will be charged in accordance with Ausgrid's alternative control services fee schedule.

Annexure A: IES Protection Summary

A1 Table A1: IES greater than 200kVA protection requirements

Backup Protection and Associated Requirements	Reference Section
Mandatory backup protection requirements	Annexure C and
Neutral Voltage Displacement (For HV connections only)	7.6
Under voltage and Overvoltage	7.3
Under frequency and Over frequency	7.3
Sustained Overvoltage	7.3
At least 1 of the following 4 backup anti-islanding protections	
Grid Reverse Power	7.5
Grid Low Forward Power	7.5
Inter-tripping	7.7, 7.8
ROCOF and Vector Shift (Note 1)	7.4

¹ If Vector Shift and ROCOF protection are implemented, it must accept that the anti-islanding protection may trip for system disturbances and fault events both within and external to the local network that the generator is connected to. Experience has shown setting of these schemes to be difficult to avoid nuisance tripping while providing adequate protection.

A2 Table A2: IES greater than 30kVA and less than or equal to 200kVA protection requirements

Backup Protection and Associated Requirements	Reference Section
Mandatory backup protection requirements in Centralised Protection Device	
Under voltage and Overvoltage	7.3
Under frequency and Over frequency	7.3
Sustained Overvoltage	7.3
ROCOF and Vector Shift	7.4

Annexure B: Rotating Machine Protection Summary

B1 Table B1: Rotating machines greater than 30kVA protection requirements

Protection and Associated Requirements	Reference Section
Mandatory Protection Requirements	
Neutral Voltage Displacement (For HV connections only)	7.6
Duplicate Under voltage and Overvoltage	7.3
Duplicate Under frequency and Over frequency	7.3
Check Synchronisation*	7.10
At least 1 of the below sets of anti-islanding protections	
Grid Low Forward Power (main) and Grid Reverse Power (backup) implemented in separate relays.	7.5
Duplicate Grid Low Forward Power implemented in separate relays	7.5
Inter-tripping	7.7, 7.8
Duplicate ROCOF and Vector Shift (Note 1)	7.4

* Asynchronous machines do not require synchronising facilities.

¹ If Vector Shift and ROCOF protection are implemented, it must accept that the anti-islanding protection may trip for system disturbances and fault events both within and external to the local network that the generator is connected to. Experience has shown setting of these schemes to be difficult to avoid nuisance tripping while providing adequate protection.

Annexure C: Protection Set Point Limits

C1 The following table defines the outer limits that will be considered acceptable for Main or Backup anti-islanding protection. Set-points may be chosen as required to suit the proponent's generator/installation within these limits. Tested accuracy should be based on manufacturer's specification, however it must not exceed +/- 2% for voltage based elements, +/- 1% for Under frequency and Over frequency elements, and +/- 5% for time delays (smaller accuracy tolerances may be required in some instances for grading purposes).

Appropriate settings for HV OV/UV protection must be negotiated with Ausgrid when required.

Main protection settings are to be at least as sensitive and at least as fast as the Backup protection settings.

Table C1: Protection elements and set point limits

Protection Element	Pickup	Delay
Inverter Energy Systems		
Sustained Overvoltage (10min average)	258V	3 s
Over Voltage (OV)	Main protection settings as per AS/NZS 4777 part 2 – Inverter Requirements and Back-up or central protection settings as per AS/NZS 4777 part 1 – Installation Requirements	
Under Voltage (UV)		
Over Frequency (OF)		
Under Frequency (UF)		
Rotating Machines		
Over Voltage (OV)	265 V	2 s
Under Voltage (UV)	180 V	2 s
Over Frequency (OF)	52 Hz	2 s
Under Frequency (UF)	47 Hz	2 s
All generator types as required		
Rate of Change of Frequency (ROCOF) for IES greater than 30kVA and less than 200kVA	As per AS/NZS 4777.2 Clause 4.5.6	
	4Hz/s	0.25 s
Rate of Change of Frequency (ROCOF) for IES greater than 200kVA and Rotating machines	1 Hz/s	1 s
Vector Shift (VS) for IES greater than 30kVA and less than 200kVA	As per AS/NZS 4777.2 Clause 4.5.5	
	20 degrees	0 s
Vector Shift (VS) for IES greater than 200kVA and Rotating machines	8 degrees (strong/urban network)	0 s
	12 degrees (weak/rural network)	
Grid Reverse Power (GRP)	Negotiated during assessment	
Grid Low Forward Power (GLFP)	Negotiated during assessment	
Neutral Voltage Displacement (NVD)	10%-20% of Phase to Neutral Voltage	2s

Annexure D: Concept Design Pack (for > 200kVA IES and Rotating Machines)

D1 A Conceptual Design Information Pack must be supplied as part of the connection process to facilitate a conceptual review of the proposed generator connection.

The Conceptual Design Information Pack does not replace the need for a Detailed Design Pack as per Annexure D to be provided for approval of the connection.

The Conceptual Design Information Pack must include.

- A statement on whether the generator will operate in parallel with Ausgrid's network, including details on.
 - If the connection will be a Synchronised Closed Transfer Trip arrangement as per Section 8.4 of the NSW Service and Installation Rules, including the frequency and duration of paralleling
- Confirmation on whether the generator is a rotating machine or Inverter Energy System connection
- A statement confirming whether the generator is intending to export
- Single Line Diagram detailing.
 - Generator size and location
 - Synchronisation points
 - Location of all CTs and VTs and CB's providing the protection required to meet the requirements of this standard
 - The connection of VTs, CTs to relay and tripping sequence of relays being proposed to meet the requirements of this document
 - Clear identification of 'A' and 'B' or 'No.1' and 'No.2' protection where the protection is required to be duplicated
 - Clear identification of the back-up protection locations for IES connection, including CT, VT and tripping arrangement
 - Specification, ratio and class of CTs and VTs being used for protection requirements of this documents
- List of protection functions being proposed to meet the requirements of this standard, referring to Annexure A or Annexure B including the make and model of each relay
- If Inter-tripping is used as the anti-islanding protection, clear statement and identification of how the inter-trip and communications link will meet the requirements of fail safe in Section 8.8.
- A description on the proposed modes of operation of the generator
- Details of any existing generators connected to Ausgrid's network within the same connection point

Annexure E: Detailed Design Pack

- E1 The following anti-islanding protection details and drawings must be submitted to Ausgrid for all embedded generation connections greater than 30kVA:
- Single Line Diagram
 - A 3 phase AC schematic diagram of protection and control systems. Main and backup protection set-points should also be tabled on this drawing for ease of comparison (this includes relevant inverter set-points).
 - DC schematic diagram (where applicable) of all protection schemes and associated logic.
 - Details of primary and secondary interfaces to the network.
 - Details of all protection and metering CTs and VTs, including:
 - Connections to protection relays and other equipment.
 - Available ratios (eg 1000-500/1).
 - Connected ratio (eg 500/1).
 - Class (eg 10P20, 5 VA on 500/1)
 - Applicable standard (eg AS1675, AS60044.1, AS60044.2).
 - Details of the protection relay(s) being proposed, including:
 - Manufacturer.
 - Full model number / order code showing selected options.
 - Full settings list of all configurable set-points as intended to be programmed.
 - Details of all circuit breakers and contactors which form part of the scheme, including:
 - Manufacturer.
 - Model number.
 - Coil burden(s).
 - Continuous contact rating.
 - Fault break rating (circuit breakers).
 - Inverter details (if used), including at a minimum:
 - Manufacturer.
 - Model number.
 - Compliance with AS/NZS4777.2 and any adjusted settings.

It must be possible from review of the Detailed Design Pack to determine the full behaviour of the scheme without ambiguity. The relationship between protection device inputs, protection device elements, protection device output contacts and switchgear must be clear and readily apparent.

All drawings must be appropriately titled, revision controlled, and marked with the name and contact details of the responsible suitably qualified person.

Annexure F: Instrument Transformer Requirements

F1 Magnetic Voltage Transformers as per IEC.61869-3:

Voltage transformers used for Neutral Voltage Displacement must meet the following criteria;

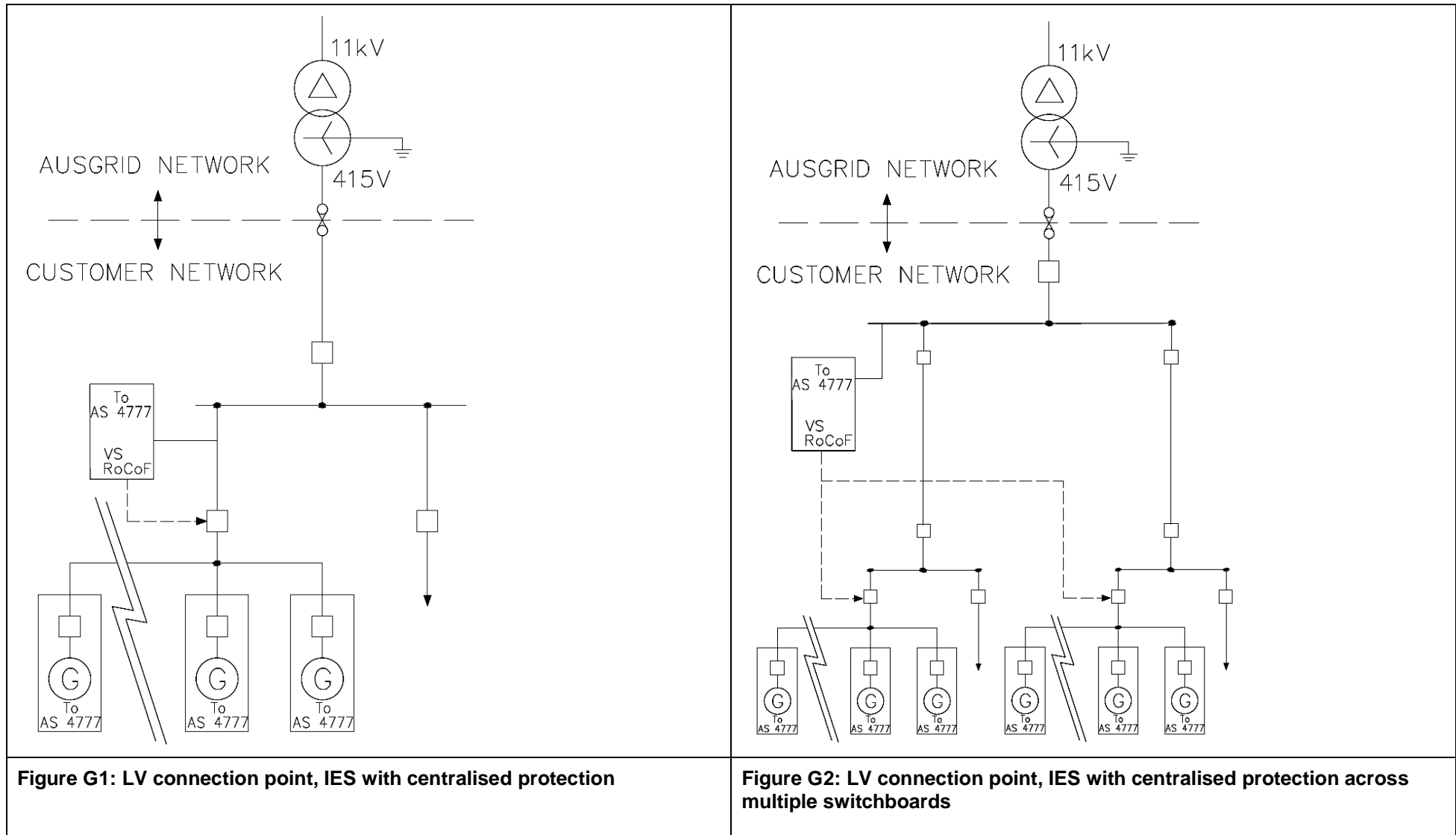
- Ratio: Primary Voltage/110V (line to line voltages), For example on an 11kV system, 11,000V/110V.
- Protection class VT (3 x single-phase or 5 limb 3-phase),
- Rated accuracy class $\leq 5\%$, e.g. 3P,
- Rated voltage factor of 1.9 for isolated neutral systems; and
- Rated burden that is suitable for the relay installation (including secondary wiring, etc).

F2 Current Transformers as per IEC.61869-3:

Current transforms for Low Forward Power and Reverse Power Protection must meet the following criteria;

- Metering Class with 5% accuracy

Annexure G: Examples Single Line Diagrams



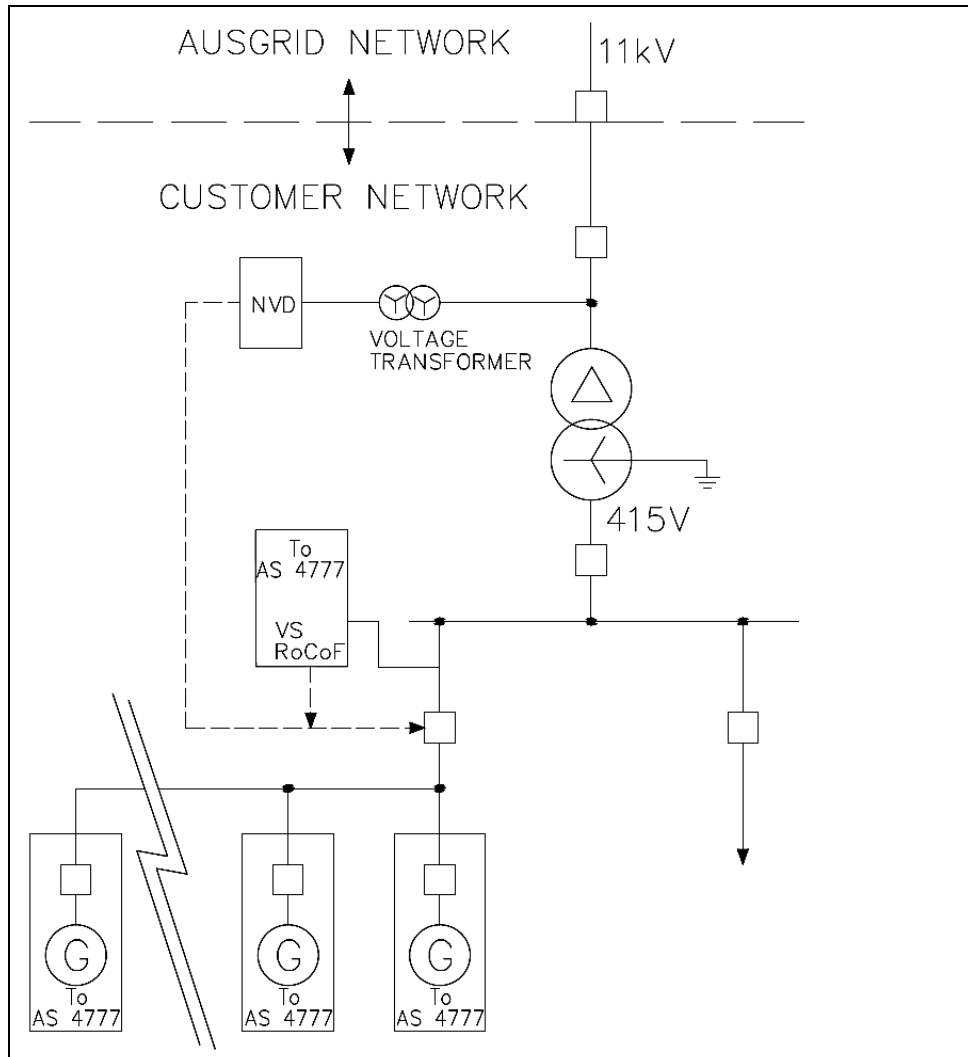


Figure G3: HV connection point, >200kVA IES with centralised protection

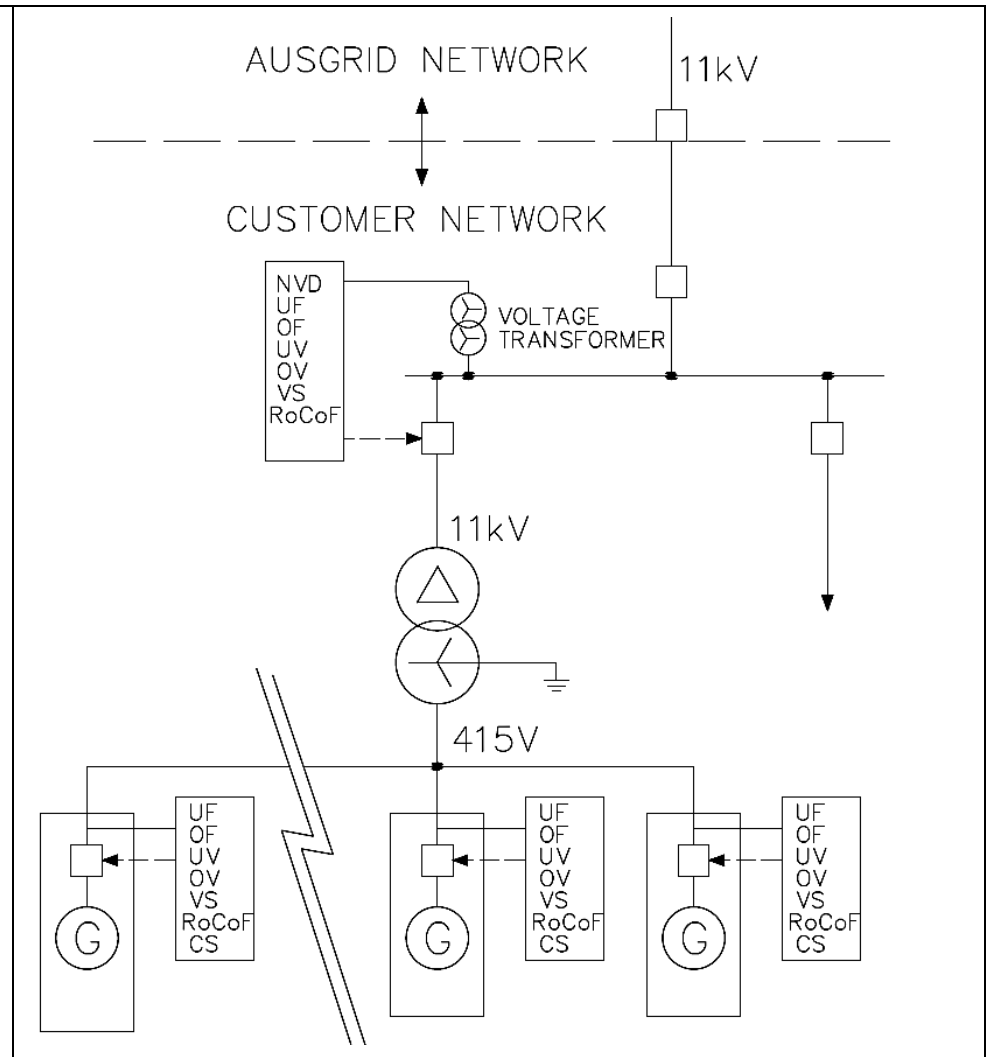


Figure G4: HV connection point, Export Rotating Machines

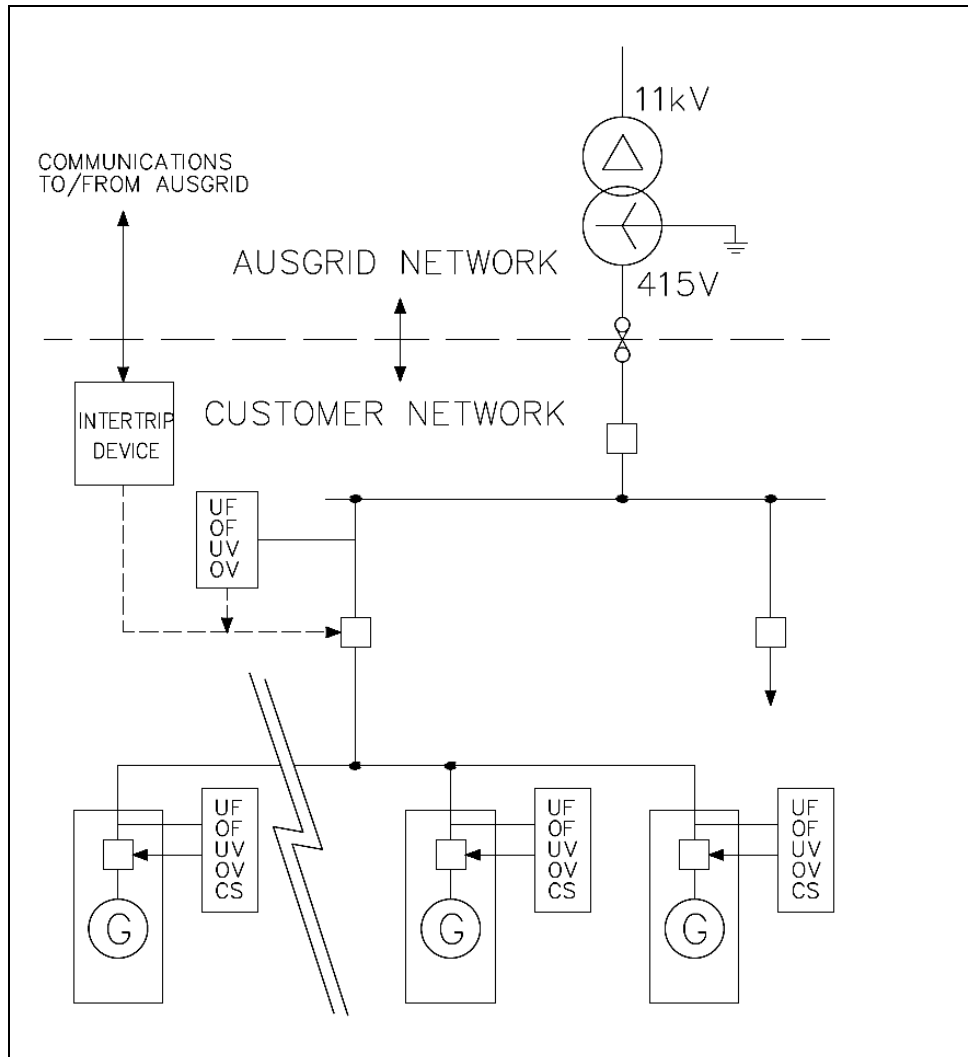


Figure G5: LV connection point, Export Rotating Machines with Inter-tripping

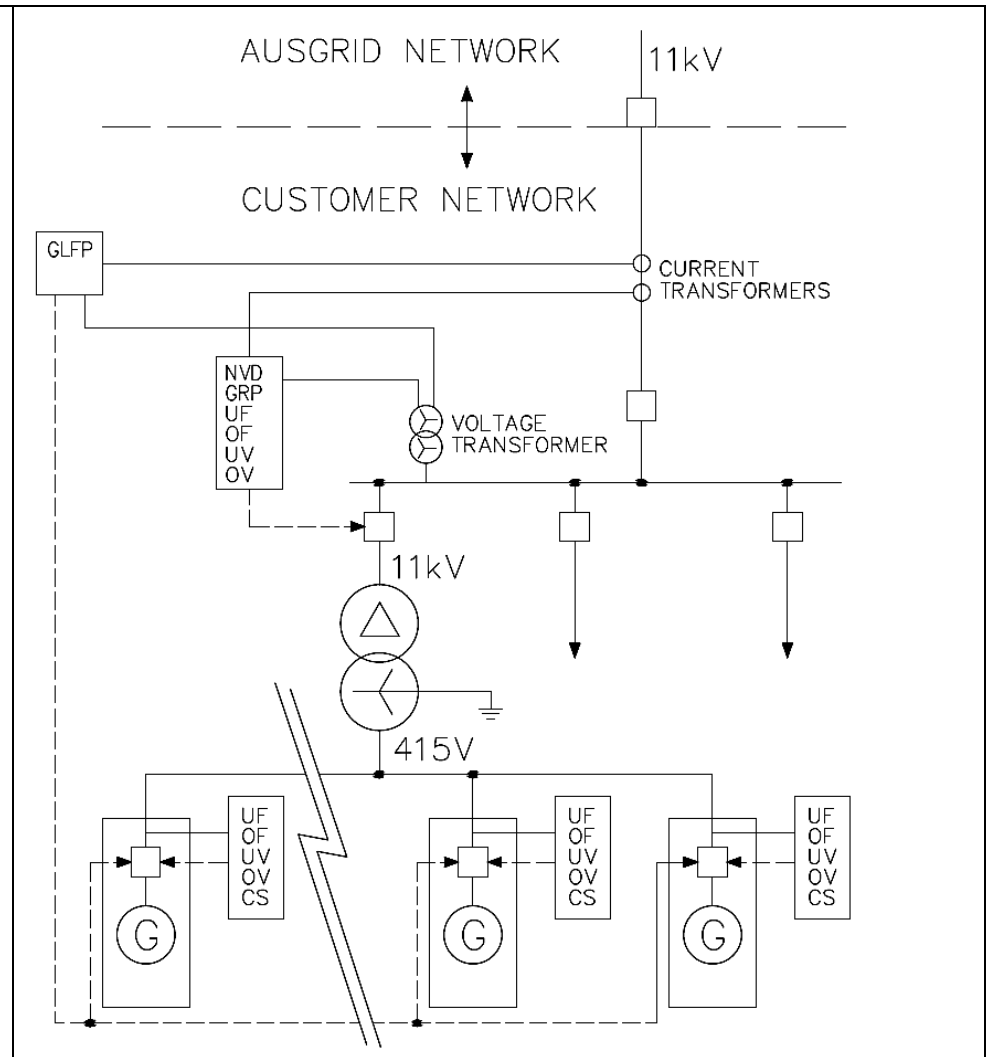


Figure G6: HV connection point, No-Export Rotating Machines

Annexure H: Multi-tenanted Site Examples

