ESP005 Technical Requirements for the connection of distributed generation

Standard

© Vector Limited 2026

The information contained in this document is proprietary to Vector Limited. It may not be used, reproduced, or disclosed to others except employees of the recipient of this document who have the need to know for the purposes of this assignment. Prior to such disclosure, the recipient of this document must obtain the agreement of such employees or other parties to receive and use such information as proprietary and confidential and subject to non-disclosure on the same conditions as set out above.

The recipient by retaining and using this document agrees to the above restrictions and shall protect the document and information contained in it from loss, theft and misuse.

Table of Contents

i. Document Control 4

ii. Related Documents 5

1. Introduction 7

1.1 Purpose 7

1.2 Scope 7

1.3 Definitions 9

2. Health, Safety and Environment 12

2.1 Public Safety Risk 12

2.2 Equipment Damage Risk 12

3. Compliance 15

4. General Technical Requirements 15

4.1 Network capacity headroom to host new or increased generation 15

4.2 Inverter and Installation Standards 16

4.2.1 AS/NZS 4777.1:2024 – Grid connection of energy systems via inverters Part 1: Installation requirements 16

4.2.2 AS/NZS 4777.2:2020 – Grid connection of energy systems via inverters – Part 2: Inverter requirements 16

4.3 Embedded Networks 17

4.3.1 Protection Requirements 17

4.3.2 SCADA and Control Requirements 17

4.4 Network Islanding 17

4.5 Power Quality 17

4.6 Availability of protection and communication functionality 17

4.7 Synchronising 18

4.8 HV Network (11kV or 22kV) Neutral Earthing 18

5. Generator Protection and Interface Protection requirements 18

5.1 Anti-islanding protection 18

5.1.1 Passive anti-islanding protection 19

5.1.2 Active anti-islanding protection 19

5.1.3 Communication based anti-islanding protection methods 20

5.2 Inverter protection & voltage control 20

5.2.1 Voltage and Frequency Settings 20

5.2.2 Rate Of Change Of Frequency (ROCOF) settings 21

5.3 Voltage Control Requirements 21

5.3.1 Volt-VAR Control 22

5.3.2 Volt-Watt Control 23
5.4 Inverter connected energy storage systems (charging behaviour) 24
5.4.1 Volt-Watt Control for energy storage systems 24
5.5 Interface Protection 26
5.5.1 Voltage and Frequency Settings 26
6. Vector's SCADA and control requirements 26
6.1 High Risk installations or export >200kVA 26
6.2 High Risk installation SCADA requirements 28
7. Technical Requirements – Standby Generators 29
7.1 Stand-by Generation using Open Transition Switching 30
7.2 Stand-by Generation using Fast Closed Transition Switching 30
7.3 Stand-by Generation Extended Closed Transition Switching 32
8. Required Studies 32
9. Pre-commissioning (pre-connection requirements) 32
10. Post-Commissioning and ongoing maintenance requirements 33

I. DOCUMENT CONTROL

Document Author	Diviya Chhagan	Engineer Network Planning
Document Owner:	Jacques de la Bat	Future Networks and Planning Manager
Review By:	Shaurya Duggal	Manager LV & Flexibility
	Jacques de la Bat	Future Network Planning Manager
	Haydar Alsharefi	Manager Protection and Control
	Darshana Diyagama	Operational Technology Engineering Team Lead
Approved By:	Steve Heinen	General Manager Asset Management and Network Planning
MUSA Change Control Approvers: (If Applicable)	NA	
Date for Next Review	November 2027	

Approved Versions	Date	Revision Notes
1.0	June 2018	First Release.
2.0	November 2021	Standby generation separated to form a new ESP008 standard. Updated Volt-Watt and Volt-Var requirements.
2.1	November 2022	Updated references to AS/NZS 3000 and 4777.2
3.0	November 2026	This standard is updated to include: • Technical requirements for dynamic connections • References of AS/NZS 4777.1 2024 and AS/NZS 4777.2 2020 updated • Reflect regulatory voltage limit changes to +/-10%.

II.RELATED DOCUMENTS

Internal Documents	Document Title and Description
ESP009	ESP009 Technical Requirements for Small-Scale Inverter Connected Distributed Generation (DG)
ESA002	Network Connection Standards

External Documents	Document Title and Description
Electricity (Safety) Regulations	Electricity (Safety) Regulations 2010
AS/NZS 3000:2018	Electrical Installations, known as the Australian / New Zealand Wiring Rules
AS/NZS 4777.1:2024	Grid connection of energy systems via inverters, Part 1: Installation requirements
AS/NZS 4777.2:2020 and 2:2024	Grid connection of energy systems via inverters, Part 2: Inverter requirements
AS/NZS 3010:2017	Electrical installations – Generating sets
Vector's Network Connection Standards	Technical requirements for the connection to Vector's electricity network (published on the Vector website)
AS/NZS 61000 / IEC 61000 suite of standards	Electromagnetic compatibility (EMC), Suite of Power Quality Standards
Clean Energy Council (CEC) Approved Inverter List	The Clean Energy Council (CEC) publishes a dynamic list of AS/NZS 4777.2 compliant inverters and denotes whether the inverter has CSIP communication capabilities. This list can be accessed using the following link. Listed inverters with Software Communication Client field populated are approved as CSIP capable. Inverters | Clean Energy Council
EEA (NZ) Connection of Small-Scale Inverter Based Generation	Guideline for the Connection of Small-Scale Inverter based Distributed Generation
EEA (NZ) Power Quality Guidelines	Guidance and advice on power quality to meet the requirements of Electricity (Safety) Regulations 2010
EEA (NZ) Connection of Generation Plant	Guide for the Connection of Generation Plant
IEC 60255 suite of standards	Measuring relays and protection equipment (All relevant Standards)

IEC 60068 suite of standards	Environmental testing
The Code	Electricity Industry Participation Code 2010

1. Introduction

1.1 Purpose

The purpose of this standard is to define the technical requirements for consumers who wish to connect distributed generation connections greater than 30kVA to Vector's distribution network. This standard defines the minimum protection and control requirements for connecting distributed generation. Typical applications include connection of solar panels, batteries or wind generation.

Distributed generation satisfying the requirements of this standard may apply for connection to the Vector distribution network using the appropriate application process as required by The Code (Schedule 6.1 of the Code).

A distributed generator meeting the minimum requirements as set out in this document does not exempt the distributed generator owner from any statutory responsibilities.

1.2 Scope

The scope of this technical standard applies to connections of all distributed generation with installed capacity greater than 30kVA connected or proposed to be connected to the Vector's distribution network. This standard applies to the following:

- Distributed generation connected directly to Vector's distribution network or indirectly via customer's installations.
- Distributed generation that is capable but does not export to the grid e.g. generation only used to offset customer load.
- Distributed generation, including non-exporting generation, that has the potential to continue energising any part of Vector's distribution network (for example, due to failure of protection system to operate correctly).
- Intermittent generators (e.g. wind generators) that are connected to the distribution network but not always generating.
- Battery Energy Storage Systems (BESS) connected to Vector's distribution network.
- Vehicle to Grid (V2G) connected to Vector's distribution network.
- Generation embedded within third party networks connected to Vector's distribution network.
- The requirements for standby generators to synchronise momentarily with the Vector distribution network either directly or via a customer's installation which is connected to the distribution network.
- The circumstances that standby generators are allowed to synchronise momentarily with the Vector distribution network.

The following are excluded from the scope of this standard:

- The connection of small-scale inverter-based distributed generation systems rated up to 30kVA to Vector's distribution network.

The requirements for connection of these distributed generators are addressed in the Vector Standard ESP009.

1.3 Definitions

Term	Description
Active anti-islanding protection	Is a method used to detect a network island when the network load matches the generator output (or multiple generators) output. There are various methods described in AS/NZS 4777.2 for active anti-islanding protection.
Automatic Transfer Switch (ATS)	Automatic transfer switch (ATS) is designed to transfer electrical loads between two power sources. According to clause 2.7.9 of AS/NZS 3010:2017 standards, an automatic transfer switch used as a main switch shall have operating handles or controls associated with the ATS that enable the main switch to be manually operated, single action, mechanical and shall consist of a handle, lever, push buttons or similar device.
Bespoke limits assessment methodology (BELAM)	Bespoke export limits assessment methodology (BELAM) required for export limit assessments set out by the Electricity Authority (EA)
Common Smart Inverter Profile (CSIP)	CSIP (Common Smart Inverter Profile) is a technical communication standard based on IEEE 2030.5 that enables secure, interoperable communication between electricity networks and smart inverters
Distributed Energy Resources	A Distributed Energy Resource (DER) is any device connected to the distribution network that generates (produces), stores or consumes electricity and can be controlled locally or remotely to alter its electricity production, storage or consumption pattern.
Distributed Generation (DG)	Distributed generation as defined in the Code means generating plant connected to a distribution network or to a consumer installation that is connected to a distribution network. Distributed generation excludes generating plants that are not normally connected or prevented from connecting to the distribution network or are only momentarily synchronised with the distribution network. For the purposes of this document, distributed generation includes generation that is capable of exporting electrical energy into the distribution network irrespective of whether they are exporting or not.
Export limits assessment methodology (ELAM)	Export limits assessment methodology (ELAM) required for export limit assessments set out by the Electricity Authority (EA)
Fault level, fault current	The amount of electrical energy that can be exported from a generator connected to the Vector distribution network during a network fault.

	Fault level is expressed as the current (in kA) flowing into the network fault.
Non-Exporting Generation	The generation is connected to and synchronised with the distribution network used to offset customer load. Non-exporting generation has the ability to inject electrical energy (such as fault energy in the event of network faults) into the distribution network but does not normally export electricity into Vector's distribution network. Technical requirements for non-exporting generators are the same as those for distributed generators.
High risk generation	High-risk generation is any generation connected to Vector's network that has the potential (combined with existing generation) to sustain a network island on any part of Vector's overhead network for longer than 2 seconds. Vector determines high risk installations using a risk-based assessment.
Network island or islanding	A condition in which a portion of the Vector's network, while electrically isolated from the rest of the Vector's distribution network, remains energised by one or more generators.
Neutral Voltage Displacement (NVD) protection	Also known as residual voltage protection (ANSI code 59N). Used to detect single phase to earth faults on an unearthed neutral network, there being no zero-sequence current contribution from the energising source for conventional current based (residual current) protection to detect an earth fault.
Passive anti-Islanding protection	Passive anti-islanding protection works by designing the inverter to inherently disrupt the grid connection in the event of an islanding condition. Passive anti-islanding protection is not able to detect an islanding condition on its own but instead relies on changes in the grid parameters caused by islanding to trigger the protection mechanism.
Point of Connection (POC), Point of Common Coupling (PCC)	Is the point at which the distributed generator is connected to Vector's distribution network either directly or via a consumer's installation.
ROCOF	Rate of Change of Frequency (ROCOF) protection is similar to Voltage Vector Shift (VVS). This is required to prevent the frequency of a power system from deviating significantly from its nominal value. This protection detects abnormal frequency changes by monitoring the rate of change of frequency over time. If the rate of change exceeds a certain threshold, the ROCOF relay trips and initiates corrective action.
Standby Generator	A standby generator (or backup generator) is a generator installed inside a customer's premises for the purpose of providing backup supply in the event that the mains supply fails. Standby generators are not normally synchronised to Vector's distribution network (directly or

	via the customer's installation). In the event the mains supply fails, the customer's load will be switched to the standby generator. The standby generator remains isolated from the mains supply all the time.
Synchronised or Synchronising	Synchronised is when two network points have the same voltage magnitude and frequency and zero phase difference. Synchronising is the act of bringing two separated points of the network into synchronism. A generator synchronised with the network is connected to the network.

2. Health, Safety and Environment

No distributed generation shall be connected to Vector's distribution network, including temporary connection, the addition of capacity to existing DG connections without Vector's prior written approval. Distributed generation connected to Vector's distribution network (either directly or via an inverter) poses a public safety risk and could potentially cause damage to the network and or other customers' equipment.

Directly connected rotating distributed generation (i.e., Synchronous or Asynchronous machines) presents a significantly higher risk compared to equivalently sized inverter-connected generation due to generator inertia and the significantly higher fault current contribution. Inverter-connected distributed generation meeting AS/NZS 4777.2 requirements has active anti-islanding protection that conventional generation does not have, thereby providing an additional risk mitigation factor. All Inverter-based distributed generation systems must be installed in adherence to AS/NZS 4777.1 2024

Inverters that are not AS/NZS 4777.2 certified are expected to have the same functionality if connected to the Vector network.

The responsibility for safe generation operation and avoiding damages to Vector's network remains that with the distributed generator owner. All distributed generator owners must be aware of their responsibilities regarding public safety and potential damage the distribution network and or other customers' equipment.

2.1 Public Safety Risk

The potential for distributed generation to continue to energise Vector's network (particularly a faulted network) after Vector's upstream circuit breaker has opened (or tripped) creates a potential public electrocution risk. This risk is higher on overhead networks. The following risk factors need to be evaluated for each prospective distributed generation connection and mitigation measures must be implemented.

- Public safety (downed conductor) risk for distributed generation connected to Vector's overhead network (includes upstream overhead, and likely back-feed overhead).
- Sustained Network Islanding risk. If the distributed generation or the distributed generation in combination with other network generations can sustain an island on part of Vector's distribution network.

A combination of the above two factors poses an increased risk.

2.2 Equipment Damage Risk

Should a distributed generation installation (or a distributed generation installation in combination with a cluster of other distributed generation installations) not trip out immediately following the onset of a network island, a resultant unchecked extreme over-voltage transient could result in widespread equipment damage to customers connected to Vector's network in the immediate vicinity of the generator. Below lists potential impacts including

- Over-voltages due to large, distributed generation plants connected to rural overhead 11kV networks particularly during low network load periods.

- Presence of large solar generation plants connected to the network during an unusually low network midday summer load (too low to offset the generation output) e.g., during holidays.

- Growth in inverter-based generation connecting to Vector's distribution network, particularly solar generation, and battery storage is anticipated. Therefore, when evaluating the distributed generator's ability to sustain a network island, allowance must be made for the addition of future generation and prudent future proofing measures should be included to safeguard against a significant future risk.

Lifecycle Stage	Risk	Risk Rating	Control	Section Ref
Operational	Generation continues energising a downed conductor. Public electrocution risk.	Very High	Ensure adequate dual protection. Vector independent protection and, where applicable, SCADA are used for the point of connection circuit breaker. Ensure residual voltage protection Ensure robust commissioning and ongoing maintenance of the Protection and Control systems.	Section 5, 6 and 7 Section 5 Section 9 and 10
Operational	Generator/s cause transient over-voltage during onset of a network island. Customer equipment damaged by network transient over-voltage.	High	Ensure fast main and fast backup tripping of the generator for severe over-voltages. Ensure robust commissioning and ongoing maintenance of the Protection and Control systems.	Section 5 Section 9 and 10
Operational	Generators continue exporting unconstrained power and reactive power output during a network sustained elevated voltage resulting in the local network voltage exceeding regulatory maximum limits and the sustained over-voltage causing customer equipment failure and complaint	High	Ensure sustained over-voltage tripping is implemented in protection systems. Ensure generators have Volt-VAR (Voltage influence) and Volt-Watt (Over-voltage load curtailment) controls enabled and correctly configured.	Section 5
Operational	Out of Sync closing damaging Vector network equipment and generation.	Low (low risk to Vector, high risk to the generator owner)	Ensure the generator/s site has robust and documented operational procedures to connect generation to Vector's network and robust interlocking systems to prevent out of sync closing.	Section 4.7

3. Compliance

The design, installation and operation shall comply with the latest editions of the standards and guides listed in II. RELATED DOCUMENTS.

4. General Technical Requirements

All distributed generation connected to or proposed to be connected to Vector's distribution network shall comply with the requirements of this standard and Vector's Network Connection Standard, "*ESA002 Electricity Network Connection Standard*."

All inverter-based distributed generation of capacities less than or equal to 10kVA single phase and 30kVA three phase connected to or proposed to be connected to Vector's distribution network shall comply with the requirements of Vector's standards, *"ESP009 Technical Requirements for Small-Scale Inverter Connected Distributed Generation (DG)"* and *"ESA002 Electricity Network Connection Standard."* These documents can be found on Vector's website.

Any distributed generation system with installed capacity greater than 1MVA will be required to meet Transpower's set of requirements. This includes distribution generation which has been aggregated to form one system of 1MVA or greater. Additional information can be found on the Transpower website (*Connecting generation through a local network).*

All distributed generation must meet all relevant statutory requirements including all applicable safety codes and standards.

4.1 Network capacity headroom to host new or increased generation

Distributed generation may be connected if there is sufficient network capacity to host (support) the distribution generation. As a minimum, the following criteria must be met:

a) Maximum network design fault ratings are not exceeded.

b) Equipment fault ratings are not exceeded.

c) Equipment thermal ratings are not exceeded. Connection will not result in sustained over-voltage to the Vector distribution network and its customers.

d) Power quality complies with relevant NZ Electricity Regulations, NZ Electrical Codes of Practice and AS/NZS 61000 series of Standards and Technical Reports.

The assessment of headroom capacity to host the distributed generation is the first step in approving a distributed generator connection and will be in line with the export limits assessment methodology (ELAM) or Bespoke Export Limits Assessment Methodology (BELAM) as set out by the Electricity Authority (EA).

Should reinforcement or changes to Vector's distribution network be required to allow the connection of the distributed generation then the generator owner may be required to bear the cost of these changes.

4.2 Inverter and Installation Standards

Regulation 60 of the Electricity (Safety) Regulations 2010 requires installation of low voltage mains parallel generation systems to comply with AS/NZS 3000, AS/NZS 3010 and AS 4777.1:2024. Inverters must be configured in accordance with AS/NZS 4777.2 2020 Australia A (AUS-A) settings and is preferred to be CSIP capable.

4.2.1 AS/NZS 4777.1:2024 – Grid connection of energy systems via inverters Part 1: Installation requirements

AS/NZS 4777.1:2024 “Grid connection of energy systems via inverters – Part 1: Installation requirements” specifies the safety and installation requirements for all inverter-based generation systems connected to a distribution network or to a consumer installation that is connected to a distribution network. The interface protection voltage and frequency protection settings are defined in this standard.

All installations of distributed generation with aggregated rated capacities greater than 200kVA at Vector’s point of connection are required to install interface protection. This interface protection must be capable of

a) Coordinating multiple inverter-based devices for a single point of connection to the Vector network.

b) Provide protection using one device for all inverter-based devices installed within a single point of connection to the Vector network.

c) Provide backup islanding protection to the connected network.

d) Preserve safety of personnel working on the network and the general public.

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

AS/NZS 4777.2:2020 “Grid connection of energy systems via inverters – Part 2: Inverter requirements” specifies the New Zealand and Australian voltage and frequency protection settings for inverter-based devices.

The standard also provides the Volt-Var and Volt-Watt setting values required for all inverter-based devices installed on Vector’s network. Compliance with the Australia A (AUS A) settings for all voltage and frequency protection settings and Volt-VAR and Volt-Watt settings stated in this standard is required.

Inverters not compliant with AS/NZS 4777.2: 2020 will need to display equivalent capabilities by providing relevant documentation.

4.3 Embedded Networks

4.3.1 Protection Requirements

The protection requirements at the point of connection will shall consider the size of individual customers and installations within the embedded network.

4.3.2 SCADA and Control Requirements

Embedded networks consisting of Commercial and/or Industrial customers shall have their SCADA and control requirements based on its aggregate installed capacity and export.

4.4 Network Islanding

The distributed generator shall cease to energise the Vector distribution network within maximum of two (2) seconds of the formation of an island.

The distributed generation may remain operating as an island to supply the customer's internal load, but only after any connection with Vector’s distribution network is disconnected.

4.5 Power Quality

The distributed generator shall not cause voltage fluctuation and flicker levels greater than the emission level allocations based on AS/NZS 61000 suite of standards including AS/NZS 61000 technical reports. The capacity of the distributed generator shall be considered as the equivalent load capacity for the purposes of applying these standards.

Distributed generators shall not inject DC current greater than 0.5% of full rated inverter output current into the point of connection.

The harmonic currents of the inverter shall not exceed the limits specified in Tables 2.2 and 2.3 of section 2.7 of AS/NZS 4777.2:2020. The total harmonic current distortion (ITHD) to the 50th harmonic shall be less than 5%.

All exporting distributed generation with installed capacities greater than 1MVA require Vector to install Power Quality Metering (PQM) at the point of connection. Besides providing Power Quality recordings this metering is required for Vector to determine its total response during under-frequency transient events to prove Vector’s compliance to the Electricity Authority’s load shedding requirements.

4.6 Availability of protection and communication functionality

The distributed generator owner shall ensure that all its equipment is adequately protected for generation risk and that all elements of the protection system, including associated inter-tripping, and DC supplies are available at all times. The health of the tripping supply shall be continuously monitored (i.e. trip circuit supervision), alarmed and maintained.

Any unavailability of the protection functions or other associated equipment shall require the distributed generation to be immediately taken out of service.

Additionally, any unavailability of the communication systems, including the export curtailment functionality and any other associated equipment shall require the distributed generation export limit be reduced.

4.7 Synchronising

All distributed generators synchronising to the distribution network shall be the sole responsibility of the distributed generator owner. Vector will not be responsible for any damages resulting from out-of-synchronised closing. The distributed generator owner must always assume the Vector distribution network is energised at all times, and if momentarily de-energised (such as during an outage), can be re-energised at any time.

The distributed generator owner shall provide and install automatic synchronising checking facilities on all distributed generator circuit breakers and any other circuit breakers that are capable of connecting the distributed generator to the network.

Prior to the initial connection of a generator to the Vector distribution network, the distributed generator owner and Vector shall agree on the operational procedures necessary for synchronisation.

Vector owned circuit breakers must not be used for the final connection of the distributed generation to Vector's distribution network (sync closing). Sync closing should be carried out by the distributed generation owner's circuit-breaker.

To prevent out-of-synchronism closing, the following measures should be implemented.

4.8 HV Network (11kV or 22kV) Neutral Earthing

Vector does not allow additional neutral earth points on its HV network. Additional neutral earth points on the network may cause maloperation of network protection.

A customer's HV neutral earth-point may be required in addition to the existing Vector neutral earth point if the customer wants to energise part of their internal HV network (11kV or 22kV) when disconnected from the Vector distribution network. In such cases the neutral connection to earth needs to be implemented by customer switching and will require robust interlocking by the customer to ensure the customer's neutral earth-point is disconnected when re-connecting back to Vector's network. The robustness of the interlocking will need to meet Vector's requirements.

The distributed generator must apply to Vector for approval to install its HV earth point.

5. Generator Protection and Interface Protection requirements

5.1 Anti-islanding protection

Connected generation with installed capacities greater than 200kVA shall provide two independent network protection levels. A summary distinguishing between the requirements for different installation sizes is provided in the appendix. The anti-islanding protection can be categorized into three main types:

a) Passive anti-islanding protection

b) Active anti-islanding protection

c) Communications-based anti-islanding protection

The anti-islanding protection methods are not fail-safe, and therefore below are methods which can be adopted in addition to the above.

a) Grid Reverse Power

Applicable only to non-exporting generation for detecting power flow into Vector's network)

b) Neutral Voltage Displacement (NVD) protection

Will be required if installation is deemed as high risk determined by Vector risk assessment. High risk installations can include any generation connected (combined with existing generation) to Vector's network with the ability to liven overhead network. If a Vector-owned point of connection circuit breaker is installed having the required protection elements (>V.<V.>F,<F,>I, NVD) and SCADA connection, then the customer is still required to provide interface protection in addition to distributed generator protection.

Note, the Vector point of connection protection does not exclude the customer-required generator protection that contains at least one active anti-islanding protection method.

5.1.1 Passive anti-islanding protection

Each distributed generator shall meet the requirements for the following passive anti-islanding settings.

a) Over-voltage (>V)

b) Under-voltage (<V)

c) Over-Frequency (>F)

d) Under-Frequency (<F)

Other passive-islanding protection settings include:

a) ROCOF (Rate of Change of Frequency)

b) Voltage Vector Shift (VVS)

5.1.2 Active anti-islanding protection

Active anti-islanding protection detects the islanding condition by injecting of changing the performance of the distributed generation and then respond to the grid disturbances by disconnection. Each distributed generator or within the distributed generator's interface protection

shall have active anti-islanding protection in addition to the passive anti-islanding protection methods. AS/NZS 4777.2.2020 specifies the following active anti-islanding protection methods:

a) Frequency shift

   Shifting the frequency of the inverter away from nominal conditions in the absence of reference frequency.

b) Frequency instability

   Allowing frequency of the inverter to be inherently unstable.

c) Power variation

   Periodically varying the power output of the inverter.

d) Current injection

   Monitoring for sudden changes in the impedance of the grid by periodically injecting a current pulse.

5.1.3 Communication based anti-islanding protection methods

Communication-based anti-islanding protection uses communications systems to actively detect the formation of an upstream island and initiate the isolation of the generator. Some examples of these methods include inter-trips.

5.2 Inverter protection & voltage control

5.2.1 Voltage and Frequency Settings

The inverter voltage and frequency protection (including ROCOF) settings should comply with the Australia A (AUS A) settings set out in the standard, AS/NZS 4777.2 2020. Active anti-islanding is required to be enabled. The voltage and frequency protection settings should be as prescribed in the tables below.

Table 1: Inverter voltage protection settings in accordance with AS/NZS 4777.2:2020

Voltage Setting Parameters	Voltage Settings (p.u,)	Voltage Settings (230V) (V)	Voltage Settings (400V) (V)	Trip delay time (s)	Max Disconnection Time (s)
Under voltage 2 (V<<)	0.304 p.u.	70 V	122 V	1 s	2 s
Under voltage 1 (V<)	0.783 p.u.	180 V	313 V	10 s	11 s
Over voltage 1 (V>)	1.152 p.u.	265 V	461 V	1 s	2 s
Over voltage 2 (V>>)	1.196 p.u.	275 V	478 V	- s	0.2 s

Table 2: Inverter frequency protection settings in accordance with AS/NZS 4777.2:2020

Frequency Setting Parameters	Frequency Settings (Hz)	Trip Delay Time (s)	Max Disconnection Time (s)
Under Frequency (F<)	47 Hz	1 s	2 s
Over Frequency (F>)	52 Hz	- s	0.2 s

5.2.2 Rate Of Change Of Frequency (ROCOF) settings

The inverter should disconnect if the ROCOF is greater than ±4 Hz/s for a duration of 0.25s.

5.3 Voltage Control Requirements

As more distributed generation connects to Vector's distribution network, the risk the voltage exceeding the regulatory or operational limits increases. For inverter-connected generation, Volt-VAR and Volt-Watt controls help limit local voltage rises when export is high and demand is low. These controls allow more generation to connect while keeping voltage within regulatory limits.

Volt-VAR responses shall be smooth enough to avoid voltage fluctuations or flicker. As voltage rises, distributed generators shall aim to reduce it by absorbing reactive power (VAR).

All inverter-based energy storage systems require Volt-Watt control when charging to help prevent voltage falling below the regulatory limit.

Generation connected at HV (11kV, 22kV or 33kV) shall meet stricter requirements at the point of connection to minimise its impact on the LV network.

Volt-Watt and Volt-VAR response modes for exporting generation and charging must be implemented when connected to the Vector distribution network as described in this section. The settings are also described in sections 3.3 and 3.4 of AS/NZS 4777.2.

5.3.1 Volt-VAR Control

Table 3 shows the Volt-VAR response settings in accordance with AS/NZS 4777.2:2020 Australia A for LV (400V/230V) connected generation.

For generation connected at HV, the Volt-VAR response should keep the system voltage within a +/- 4% threshold. Table 4 provides an indicative Volt-VAR response settings for HV connected customers. The Volt-VAR settings must be agreed on during the DG application process.

Table 3: Volt-Var response set-point values for LV connected generation.

Reference	Inverter Reactive Power Level (Q) % of S_{Rated}	LV 1-ph Voltage (V)	LV 3-ph Voltage (V)
V1	44% Supplying (capacitive)	207	360
V2	0%	220	383
V3	0%	240	417
V4	60% Absorbing (inductive)	258	449

Table 4: Indicative Volt-Var response set-point values for HV connected generation

Reference	Inverter Reactive Power Level (Q) % of S_{Rated}	HV Connected Voltage (p.u.))
V1	30% Supplying (capacitive)	0.960 pu
V2	0%	0.975 p.u
V3	0%	1.025 p.u
V4	30% Absorbing (inductive)	1.040 p.u

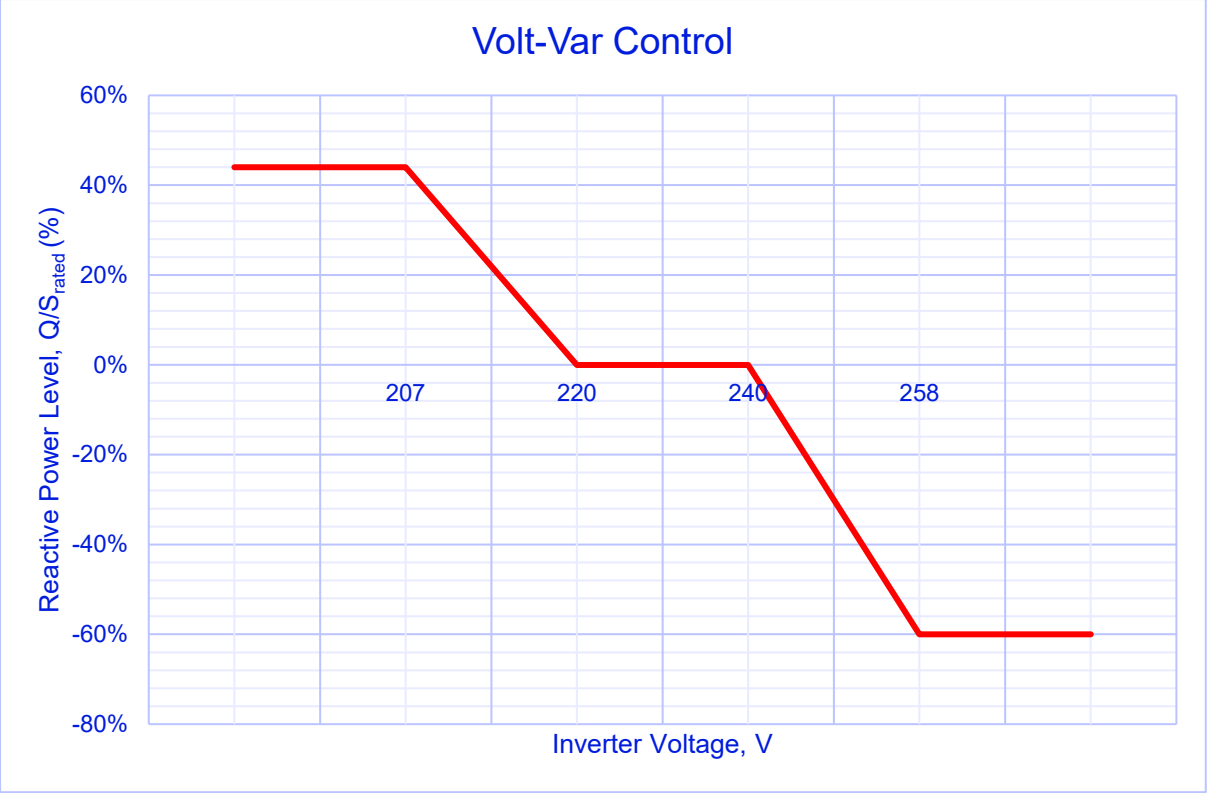

Figure 1: Volt-Var response curve (for LV connected customers)

5.3.2 Volt-Watt Control

For LV (400V/230V) connected generation, the generator will begin to curtail when the point of connection exceeds 253V. At 260V, the generator will reach 20% of its nameplate rating. Table 5 defines the required Volt-Watt response setting for LV (400V/230V).

For generation connected at HV, an indicative Volt-Watt response is provided in Table 6. The Volt-Watt settings must be agreed on during the DG application process.

Table 5: Volt-Watt response set-point values for inverters exporting connected at LV.

Reference	Inverter Maximum Output Power (P) % of S_{Rated}	LV 1-ph Voltage (V)	LV 3-ph Voltage (V)
V1	100%	253	360
V2	20%	260	383

Table 6: Indicative Volt-Watt response set-point values for inverters exporting connected at HV.

Reference	Inverter Maximum Output Power (P) % of S_{Rated}	HV Connection
V1	100%	1.040 p.u.
V2	20%	1.050 p.u

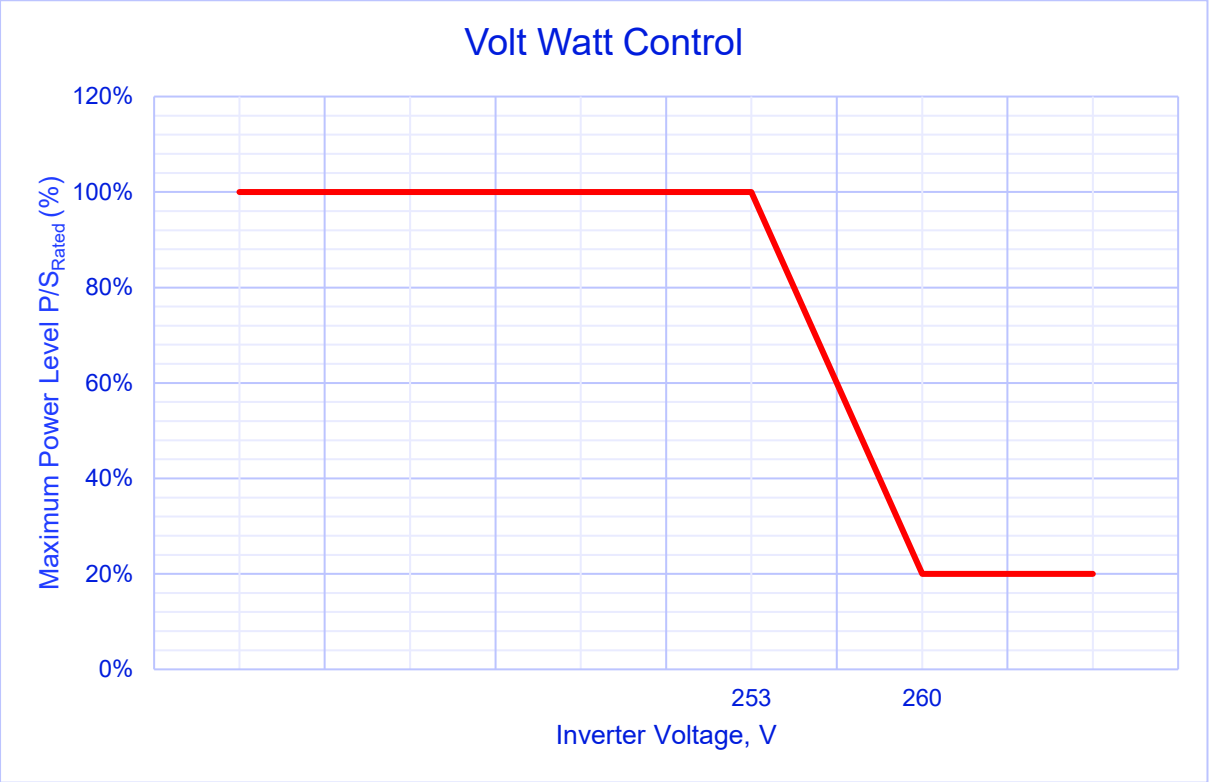

Figure 2: Volt-Watt response mode curve for inverter exporting connected at LV.

5.4 Inverter connected energy storage systems (charging behaviour)

5.4.1 Volt-Watt Control for energy storage systems

For LV (400V/230V) connected, inverter-based energy storage systems, charging curtailment shall commence when the voltage at the point of connection falls below 215V. At 207V, the charger will reach 20% of its nameplate rating. Table 7 defines the required Volt-Watt response setting for LV (400V/230V) connected inverter-based energy storage systems.

For energy storage systems connected at HV, an indicative Volt-Watt response is provided in Table 8. The Volt-Watt control settings must be agreed on during the DG application process.

Table 7: Volt-Watt response set-point values for inverters charging connected at LV.

Reference	Inverter Maximum P_{charge} ./P_{Rated}	1-ph Voltage (LV)	3-ph Voltage (LV)
V1	20%	207 V	360 V
V2	100%	215 V	374 V

Table 8: Indicative Volt-Watt response set-point values for inverters charging connected at HV.

Reference	Inverter Maximum P_{charge} ./P_{Rated}	HV connected (%)
V1	20%	0.950 p.u
V2	100%	0.960 p.u

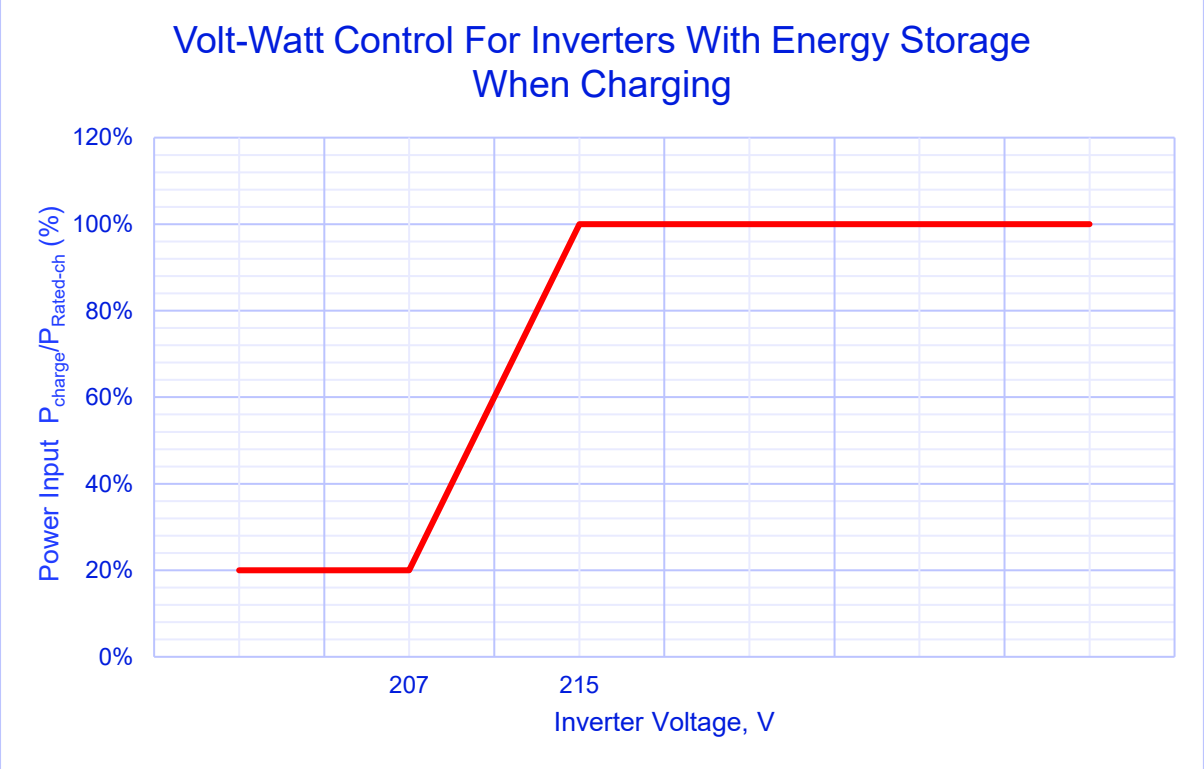

Figure 3: Volt-Watt response mode curve for inverters charging.

5.5 Interface Protection

5.5.1 Voltage and Frequency Settings

The voltage and frequency protection settings (including ROCOF) for interface protection relays should comply with the Australia A (AUS A) settings set out in the standard, AS/NZS 4777.1 2024. The voltage and frequency protection settings should be as prescribed in the tables below.

The inverter trip must occur between the trip delay and max disconnection time.

Table 9: Voltage protection settings in accordance with AS/NZS 4777.1:2024

Voltage Setting Parameters	Voltage Settings	Voltage Settings (230V)	Voltage Settings (400V)	Trip Delay Time	Max Disconnection Time
Under voltage 2 (V<<)	0.30 p.u.	69 V	120 V	2.5 s	3.s
Under voltage 1 (V<)	0.778 p.u.	179 V	311 V	11.5 s	12 s
Over voltage 1 (V>)	1.161 p.u.	267 V	464 V	2.5 s	3 s

Table 10: Frequency protection settings in accordance with AS/NZS 4777.1:2024

Frequency Setting Parameters	Frequency Settings	Trip Delay Time	Max Disconnection Time
Under Frequency (F<)	47 Hz	2.5 s	3 s
Over Frequency (F>)	52 Hz	1.0 s	1.5 s
Rate of change of Frequency (ROCOF)	±4 Hz/s	0.5 s	1 s

6. Vector's SCADA and control requirements

Two categories relating to SCADA visibility and control exist within the network architecture.

a) Export >200kVA

b) High risk installations

A summary of the requirements can be found in Appendix A.

6.1 High Risk installations or export >200kVA

For DG connections with export limits greater than 200kVA, Vector's operational control room require the ability to dynamically adjust the export level of plant. This will be used during any

network contingency when necessary to protect Vector assets from thermal overloading. For connection with a combination of a load and DG connection, this functionality enables the export seen on the Vector network to be reduced without electrically disconnecting the connection from the network

A multimode fibre serial communications connection will be required from the customer's centralised DG plant controller to the Vector control panel. The Vector RTU will use the DNP3 protocol (serial) to communicate with the customer plant controller. The high-level connectivity of the communications equipment necessary for DG connections is displayed in Figure 4.

The customer will be responsible for supplying, installing, and owning the multimode fibre serial communications connection between their centralised DG plant controller and the Vector control panel.

The Input/Output (IO) signals include but are not limited to those listed below:

a) Analogue Indications

    i. Feedback to max allowable export setpoint (kW)

    ii. Active power output (kW)

    iii. Reactive power output (kVAr)

b) Analogue Output:

    i. Max allowable export setpoint (kW)

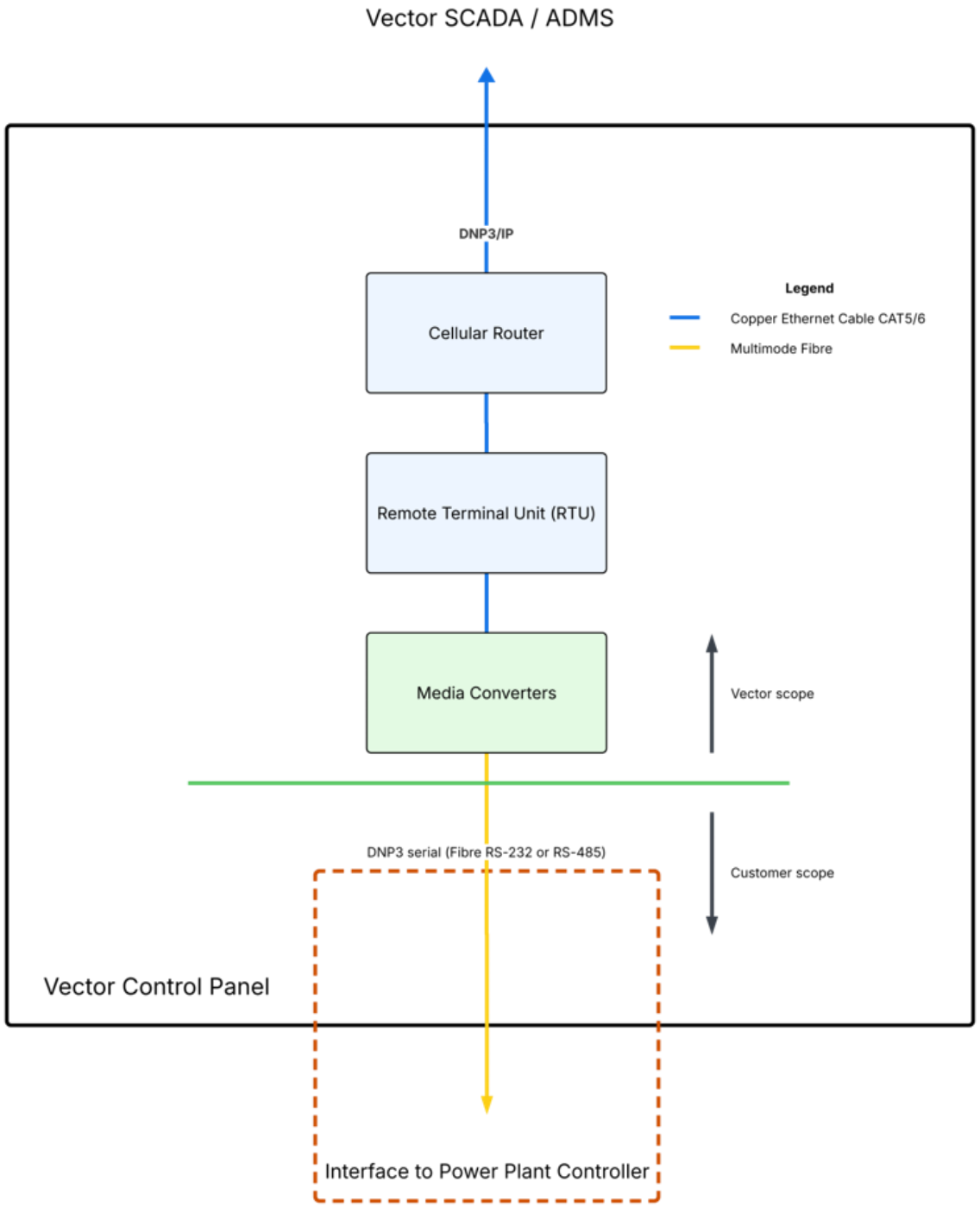

Figure 4: High level protection and communication equipment connectivity

6.2 High Risk installation SCADA requirements

For deemed high risk distributed generation, Vector requires a connection to SCADA interface from customer owned circuit breaker or of the distributed generator interface protection.

The following minimum remote SCADA points are required:

- Circuit breaker open command (i.e. Emergency trip command).

- Circuit breaker status open indication.
- Circuit breaker closed indication.
- Analogue voltage per phase indication.
- Analogue current per phase indication.
- Real power (kW) import (-) and export (+).
- Reactive power (kVAr) import (-) and export (+).
- Protection relay health indication.
- Trip circuit health indication.
- Protection trip issued indication.

7. Technical Requirements – Standby Generators

Standby generators are those generators installed at customers' premises to provide alternative supply of electricity in the event that supply from the distribution network fails. These generators are not connected to the distribution network. When the supply from the electricity distribution network fails, the customer's installation is first disconnected from the distribution network while the standby generator starts up and then takes over the supply to the customer's load. During this process of change-over, the standby generator does not synchronise with the distribution network. As standby generators are not intended, designed or constructed to synchronise with the distribution network, there should be no risk of the standby generator supplying electrical energy into the distribution network risking the safety of personnel working on the network or damaging equipment and appliances connected to it.

When the network fault is repaired and Network supply is restored, the customer's supply can be switched back to the network supply using a break-before-make change-over switch (open transition). This switch back process also does not involve synchronisation between the standby generator and the distribution network.

However, some customers may prefer to avoid a short break in supply when returning from standby generator to network supply by using a make-before-break process (closed transition). While this process allows the customer to avoid a brief supply interruption, it introduces a number of significant hazards and risks to operating personnel and equipment and customers connected to it.

Some other customers may wish to carry out routine (on load) tests on their standby generators without supply interruptions. This will require the generator to synchronise with the distribution network. Refer to the Appendix to determine necessary protection requirements for installations.

7.1 Stand-by Generation using Open Transition Switching

For open transition switching, interlocking (hard-wired or mechanical) is mandatory to ensure that the generation does not start until the PCC mechanical interlock (or incomer circuit breaker) is confirmed to be open. The interlock or circuit breaker must also be blocked from closing while the generation is running. The interlocking scheme shall be approved by Vector Protection and Control. The open transition switching is usually a break-before-make-transfer operation and is a non-parallel type of operation.

The pre-commissioning (Section 9) and commissioning (Section 10) requirements are applicable and may be requested by Vector.

7.2 Stand-by Generation using Fast Closed Transition Switching

Automatic transfer switches (ATSs) are designed to transfer electrical loads between two power sources. Fast closed transition is one of the modes of the automatic transfer switch (ATS) controller. This is intended to allow standby generation to transition back to a Vector supply following a Vector outage, without having to meet this standard's technical requirements for connected generation. This type of switching is not intended for frequent (e.g. daily) operation.

Vector approval is required for all schemes that will have a parallel operation. Standby generation which does not have the ability to liven Vector's network as the minimum customer load exceeds the generator capacity is deemed low risk whereas standby generation capable of livening the HV or LV overhead network is deemed high risk and requires a more thorough review.

Vector's requirements for fast-closed transition switching are as follows:

a) If the upstream HV network (11kV) is an overhead line, then Vector may require SCADA control of the POC circuit breaker (refer to Appendix B table).

b) The maximum allowable generator capacity (or combined generator capacity) switched by a closed transition is limited to 1.5 MVA.

c) The closed-overlap transition shall be designed and verified to be less than 100 milliseconds (0.1 seconds). This is the maximum allowed duration in which both sources are simultaneously connected or paralleled.

d) Ensure that the breakers, transfer switches, and cable are sized to handle the surge current that may result from sources being a few degrees out-of-phase at closure as the sync check system allows.

e) Two independent failure protection methods of disconnecting the generation from Vector's network shall be provided to protect against a transition switching mal-operation.

f) One method shall disconnect the generator/s within 250 milliseconds from the start of the closed transition.

g) A second independent method (should the first method fail) shall disconnect the Vector network within 1 second by an independent circuit breaker to the first method (installed between the Vector network and the generation).

h) The independence of the second method must include an independent tripping supply and an independent circuit breaker.

i) The close transition ATS may also be used to transition switch to generation before a planned Vector outage.

j) Operational testing shall be limited to a maximum of six operations per year (six transfers to generation and six transfers back to Vector supply).

k) The close transition shall only take place after the Vector supply has returned to a healthy state for at least 30 minutes. The 30-minute delay is to allow the completion of field switching operations on the network.

l) Should a transition malfunction, and the two methods fail to disconnect the generator, the generation must be immediately shut down manually, and Vector control must be informed.

m) ASCO 7000 closed transition transfer switch is a Vector-approved ATS scheme.

n) Pre-Commissioning (Section 9) requirements and Testing, Commissioning and maintenance (Section 10) requirements are applicable.

As a minimum requirement for Vector approval of low-risk generation installations, Vector requires a Single Line Diagram (SLD) or Relay and Instrumentation diagram (R&I) that includes the following information:

- The generator connectivity route goes through to the Vector supply point.
- All the ATS switches and the maximum transition times.
- Indication of the generator network-related protection elements.
- Second independent tripping method (if not an approved Vector ATS scheme).

All ATS schemes (other than Vector-approved ASCO 7000) shall be designed by an Electrical Engineering Consultancy with the required recent experience designing interlocking schemes. Vector requires design documentation describing the design (including Single Line Diagrams, Protection Settings, and the proposed scheme function testing) and includes an assertion by the Electrical Consultant that the design meets all of Vector's ATS requirements.

For deemed high-risk (refer to the definition of high-risk generation), robust scrutiny may also require the acceptance of protection settings and the acceptance of commissioning test results.

The process to approve an ATS scheme shall be undertaken outside project timelines due to the required level of detailed scrutiny.

7.3 Stand-by Generation Extended Closed Transition Switching

Vector may allow longer transitions up to a maximum of three (3) seconds. This is assessed on a case-by-case basis and may require the installation to be supplied via a Vector-owned HV (11kV) PCC circuit breaker with appropriate network voltage protection elements (refer to Appendix B) installed. Vector's conditional approval is required prior to proceeding.

The requirements for closed transition switching are required except for c, d, e, f and g, which are not required.

8. Required Studies

For all DG applications, conditions of approval will confirm which studies are necessary to be undertaken.

Vector will conduct integration studies for DG within its own network during the application stage. This will establish whether the DG installation will be able to operate on the Vector network. If any specialist studies are identified, they will be completed by an accredited Vector consultant at the applicant's own cost.

The DG applicant will need to engage a Transpower accredited consultant to determine and carry out the appropriate GXP impact studies. More information can be found at the Transpower website.

Any protection studies will form part of the connection project and will be completed by an accredited Vector consultant.

9. Pre-commissioning (pre-connection requirements)

The DG application process is defined by The Code. All applications with export limits between 10kW – 299kW or greater than 300kW will be processed under Process 2 or 3 respectively.

Rotating generation of all sizes and all inverter-based generation >200kW shall provide the following information to the satisfaction of Vector's Protection and Control team prior to connecting to Vector's distribution network:

a) Connection approval

   Vector may decline the connection of distributed generation to Vector's distribution network if the equipment does not meet the specified technical requirement (as stated in this document).

b) Protection settings submission

   The distributed generator owner shall provide Vector with full details of the protection settings to be applied at least two months prior to the expected commissioning date.

c) Testing responsibility

All the testing and associated costs are the responsibility of the distributed generator owner. Vector or Vector's representative reserves the right to witness the testing.

d) Qualified contractor

The distributed generator shall use a contractor who is experienced in commissioning generators and network protection equipment and is accredited to work on either Vector's or Transpower's networks.

e) Required Information

For all rotating and inverter-based generation >200kVA: Prior to the connection, the owner must provide Vector's protection and control team with:

- Testing and commissioning of the protective equipment shall be agreed upon between the distributed generator owner and Vector before commissioning.
- The distributed generator owner shall provide Vector with a testing and commissioning plan one month before commissioning.
- Protection settings sheets, signed and dated for all the implemented protection elements.
- A signed As Built complete set of SLD's and R&I drawings.
- Signed confirmation that the complete protection system is in a serviceable state and appropriately set and tested.
- Signed confirmation that all the customer requirements as required in the protection study report have been completed.

f) Record Keeping

The distributed generator owner shall keep written records of test results and protection settings. A copy of the records must be sent to Vector.

g) Contact Information

The distributed generator owner shall provide 24-hour telephone numbers of contact personnel.

10. Post-Commissioning and ongoing maintenance requirements

Distributed generator owners shall ensure that all associated communication equipment, protection equipment and interface protection, including associated inter-tripping:

a) Is always available. Unavailability of the communication or protection will require the distributed generation to be immediately taken out of service or export limit reduced.

b) Any failure of the distributed generator protection circuit breakers or failure of the circuit breaker secondary circuits or failure of the trip circuits shall be alarmed within the distributed generator owner's installation. Operating procedures shall be put in place to immediately switch out the generation. A copy of the authorised procedure must be sent to Vector for records.

c) Regularly maintained in accordance with good electrical industry practice. Records shall be kept of such maintenance, and these may be reviewed by Vector when requested.

d) No changes (including setting changes) shall be made to the generator protection or the interface protection with Vector's prior written approval.

Appendix A Table of Minimum Requirements (Inverter-Based installations)

Installed rated capacity	Ability to liven overhead network	RMU & CB connected	Inverter Protection	Interface Protection	Vector Studies / Transpower
<=200 kVA	No	No	AS/NZS 4777.2 2020, Volt-Watt, Volt-VAR		No
	Yes	No	AS/NZS 4777.2 2020, Volt-Watt, Volt-VAR		No
>200 to < 1MVA	No	No	AS/NZS 4777.2 2020, Volt-Watt, Volt-VAR	AS/NZS 4777.1 2024	No
	Yes	Yes	AS/NZS 4777.2 2020, Volt-Watt, Volt-VAR	AS/NZS 4777.1 2024	No
1 MVA to < 5MVA	No	Yes	AS/NZS 4777.2 2020, Volt-Watt, Volt-VAR	AS/NZS 4777.1 2024	Transpower requirements
	Yes	Yes	AS/NZS 4777.2 2020, Volt-Watt, Volt-VAR	AS/NZS 4777.1 2024	Transpower requirements
>5 MVA	No	Yes	AS/NZS 4777.2 2020, Volt-Watt, Volt-VAR	AS/NZS 4777.1 2024	Vector harmonic & protection study; Transpower requirements
	Yes	Yes	AS/NZS 4777.2 2020, Volt-Watt, Volt-VAR	AS/NZS 4777.1 2024	Vector harmonic & protection study; Transpower requirements

Installations of 1MVA or more require a Power Quality Meter (PQM)

Installations with export greater than 200kVA require installing export curtailment functionality

vector electricity

Appendix B Table of Minimum Requirements (Transition switching & Rotating machines)

Installed rated capacity	Feeder Characteristic	RMU & CB Required	Generator Protection	Interface protection	Vector Studies / Transpower
Transition Switch connected less than 100milli seconds	UG	No	>V, <V,>F, <F,>I		No
	OH	No	>V, <V,>F, <F,>I	AS/NZS 4777.1:2024, 11kV NVD	No
	Liven LV network only	No	>V, <V,>F, <F,>I	AS/NZS 4777.1:2024	No
Transition Switch connected up to 3 seconds	UG or OH	Yes	>V, <V,>F, <F,>I		No
Connected Rotating (Less than or equal to 30kVA)	UG	No	>V, <V,>F, <F,>I, ROCOF/Vector Shift, Volt-Watt, Volt-VAR	>V, <V,>F, <F,>I, ROCOF/Vector Shift	No
	OH	No	>V, <V,>F, <F,>I, ROCOF/Vector Shift, Volt-Watt, Volt-VAR	>V, <V,>F, <F,>I, ROCOF/Vector Shift, 11kV NVD, Vector SCADA	No
Connected Rotating (more than 30kVA)	UG or OH	Yes	>V, F, I, ROCOF/Vector Shift, >V unbalance, >I unbalance, Volt-Watt, Volt-VAR		No
Connected Rotating more than or equal to 1000kVA	UG or OH	Yes	>V, F, I, ROCOF/Vector Shift, >V unbalance, >I unbalance, Volt-Watt, Volt-VAR		Vector harmonic & protection study; Transpower requirements