



ESP009 Technical Requirements for Small-Scale Inverter Connected Distributed Generation (DG)

Standard

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I. DOCUMENT CONTROL

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1.0	November 2021	First Release. This standard is issued to replace ENS4009 first published in May 2013
2.0	May 2026	This standard is updated to include: <ul style="list-style-type: none"> • 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. ROLES AND RESPONSIBILITIES

Roles	Responsibility
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Document Author	Determining and ensuring: <ul style="list-style-type: none"> • Document layout and formatting (using a standardised template) • Accurate, complete and up-to-date content
Document Contributors	People responsible for content/sections within a controlled document
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IV.RELATED DOCUMENTS

Internal Documents	Document Title and Description
ESP005	Technical requirements for connecting distributed generation
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's Approved Inverter List	Clean Energy Council 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 connections of small-scale inverter-based distributed generation systems up to 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 at residential dwellings.

Distributed generation satisfying the requirements of this standard may apply for connection to the Vector distribution network using the Part 1A process (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:

- a) Connections for small-scale inverter-based distributed generation with capacity less than or equal to 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.
 - 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 following are excluded from the scope of this standard:

- a) The connection of distributed generation via inverters with capacities more than 30kVA. The requirements for connection of these distributed generators are addressed in the Vector Standard ESP005.
- b) Connection of distributed generation (all sizes) directly (without inverters) connected to Vector's distribution network. This is addressed in the Vector Standard ESP005.

- c) Connection of standby (or backup) generation, as this type of generation does not normally operate in parallel with Vector’s distribution network. The Code excludes generation that is only momentarily synchronised with Vector’s distribution network from the definition of distributed generation.

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.
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)	<p>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.</p> <p>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.</p>
Export limits assessment methodology (ELAM)	Export limits assessment methodology (ELAM) required for export limit assessments set out by the Electricity Authority (EA)
Export Management System	The management system will dynamically curtail export of individual distributed generators connected via Common Smart Inverter Profile (CSIP) when the condition of the network permits.
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.
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.
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 supply (POS), 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.
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.
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

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.

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.

All Inverter-based distributed generation systems must be installed in adherence to AS/NZS 4777.1 2024

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:

- a) Public safety (downed conductor) risk for distributed generation connected to Vector's overhead network (includes upstream overhead, and likely back-feed overhead).
- b) 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.
- c) 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.

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 supply circuit breaker.	Section 4.3
			Ensure residual voltage protection	Section 4.4
			Ensure robust commissioning and ongoing maintenance of the Protection and Control systems.	Section 6 and 7
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 4.4 Section 6 and 7
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 complaints.	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 4.4 Section 4.8

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 4.3
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3. COMPLIANCE

The design, installation and operation shall comply with the latest editions of the standards and guides listed in iv Related Documents.

4. TECHNICAL REQUIREMENTS

All inverter-based distributed generation of capacities $\leq 30\text{kVA}$ 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 Standards.

Inverter-based distributed generation of capacities $>30\text{kVA}$ connected to or proposed to be connected to Vector's distribution network shall comply with Vector's standard "ESP005 Technical Requirements for the connection of distributed generation." This standard is published on the Vector official website.

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 distributed generation. As a minimum, the following criteria must be met: Maximum network design fault ratings are not exceeded.

- a) Equipment fault ratings are not exceeded.
- b) Equipment thermal ratings are not exceeded.
- c) 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.

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 Dynamic Distributed Generation Export Connection

A dynamic export connection allows for an export limit of up to 10kVA for single phase connections and up to 30kVA for three phase connections. The dynamic export limit will be set to the maximum export at most times and will only be dynamically adjusted based on the conditions of the network. Anytime the export limit of a DG connection is reduced below its maximum, it will be based on the Vector Congestion Management Policy which 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). Dynamic adjustment of export limits will only be made to mitigate the following network conditions but are not limited to:

- a) Exceeding equipment thermal ratings.
- b) Sustained over-voltage to the Vector distribution network and its customers.
- c) Non-compliance with power quality requirements defined in the relevant NZ Electricity Regulations, NZ Electrical Codes of Practice and AS/NZS 61000 series of Standards and Technical Reports.

Vector will communicate a dynamic export limit directly to compatible AS/NZS 4777.2 2020 and Common Smart Inverter Profile (CSIP) compliant inverters over Wi-Fi. If there is a loss of communication between the distributed generator and Vector's CSIP export management server, the export limit will drop to a default fall back limit of 2.5kW.

4.3 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 be CSIP capable. Only installations meeting the inverter CSIP capability requirement will be accepted and processed under Part 1A of The Code.

CSIP capable inverters on the [Clean Energy Council's Approved Inverter List](#) are pre-approved for use on Vector's network. Listed inverters with *Software Communication Client* field populated are approved as CSIP capable.

Inverters that do not meet the requirement of CSIP capability will be processed using the Part 1 process (Schedule 6.1 of the Code).

4.3.1 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" was published on the 23 August 2024. This standard 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.

4.3.2 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" was published on the 18 December 2020. This standard 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 will meet Vector’s requirements

4.3.3 Common Smart Inverter Profile (CSIP)

All inverters should be capable of CSIP communication in compliance with Australian standard, SA TS5573:2025 Common Smart Inverter Profile (CSIP-AUS) Test Standard.

4.4 Voltage and Frequency Settings

The inverter voltage and frequency protection settings should comply with the Australia A (AUS A) settings set out in the standard, AS/NZS 4777.2 2020. 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 settings (s)
Under voltage 2 (V<<)	0.304 p.u.	70 V	122 V	2 s
Under voltage 1 (V<)	0.783 p.u.	180 V	313 V	11 s
Over voltage 1 (V>)	1.152 p.u.	265 V	461 V	2 s
Over voltage 2 (V>>)	1.196 p.u.	275 V	478 V	0.2 s

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

Frequency Setting Parameters	Frequency Settings (Hz)	Trip settings
Under Frequency (F<)	47 Hz	2 seconds
Over Frequency (F>)	52 Hz	0.2 seconds

4.5 Network Islanding

To ensure the distributed generator does not energise any part of the Vector distribution network which is disconnected from the rest of the Vector distribution network or is disconnected from Transpower grid, the inverter **must** disconnect the distributed generator. 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

and remain disconnected for the duration when the customer's installation is operated in an island mode. The distributed generator shall cease to energise the Vector distribution network within maximum of two (2) seconds of the formation of an island.

4.6 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.

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 (I_{THD}) to the 50th harmonic shall be less than 5%.

4.7 Phase Imbalance for three phase connections

To ensure any voltage imbalance that may be introduced into the Vector distribution network is kept to an acceptable level, single phase inverters installed within a three phase connection need to adhere to table C.1 in AS/NZS 4777.1:2024.

Distributed generator installations that do not satisfy the requirements are not eligible to apply for connection using the Part1A process (Schedule 6.1 of the Code).

4.8 Distributed Generator Active Power and Reactive Power Control

The risk of the low voltage (LV) network voltage exceeding the statutory maximum limit of 10% above nominal voltage levels is increasingly likely as additional distributed generation is connected to Vector's distributed network.

For inverter connected distributed generation, implementing Volt-VAR and Volt-Watt response modes provide a means of mitigating excessive voltages in localised areas of the network during periods where the network experiences high volumes of export and low network demand. This facilitates increasing penetration of generation without compromising the upper voltage limits.

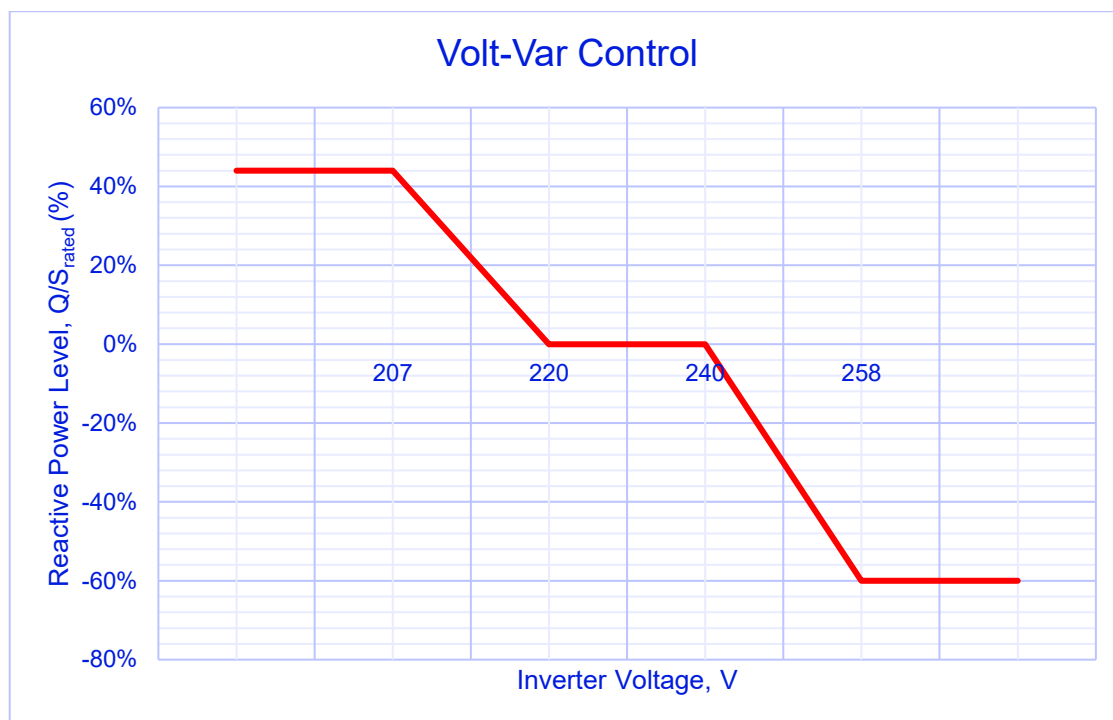
Volt-Watt response mode for charging is additionally required for all inverter based energy storage systems to mitigate lowering the voltage below regulatory voltage requirements of -10% during periods the network experiences high network demand. This facilitates increasing levels of battery charging without compromising the lower voltage limits.

Volt-Watt and Volt-VAR response modes for exporting generation and charging must be set on inverters of distributed generators connected to the Vector distribution network as described in in this section. The settings are described in section 3.3 and 3.4 of AS/NZS 4777.2 2020 and summarised in sections 4.8.1, 4.8.2, and 5.1.1.

4.8.1 Volt-VAR Control

Volt-VAR response modes shall be sufficiently smooth so as not to cause voltage fluctuations or voltage flicker. During increasing voltage events distributed generators shall endeavour to suppress the high voltage by absorbing reactive power (VAR), this will enable increased generation capacity to be connected to Vector’s network whilst maintaining voltage within the regulatory limits.

Graph 1 demonstrates an example of the Volt-VAR response setting settings in accordance with AS/NZS 4777.2:2020 Australia A for LV (230V/400V) connected generation:



Graph 1: Curve for the Volt-Var response mode

The following table defines the required Volt-VAR response settings in accordance with AS/NZS 4777.2:2020 Australia A for LV (230V/400V) connected generation:

Table 3: Volt-Var response set-point values.

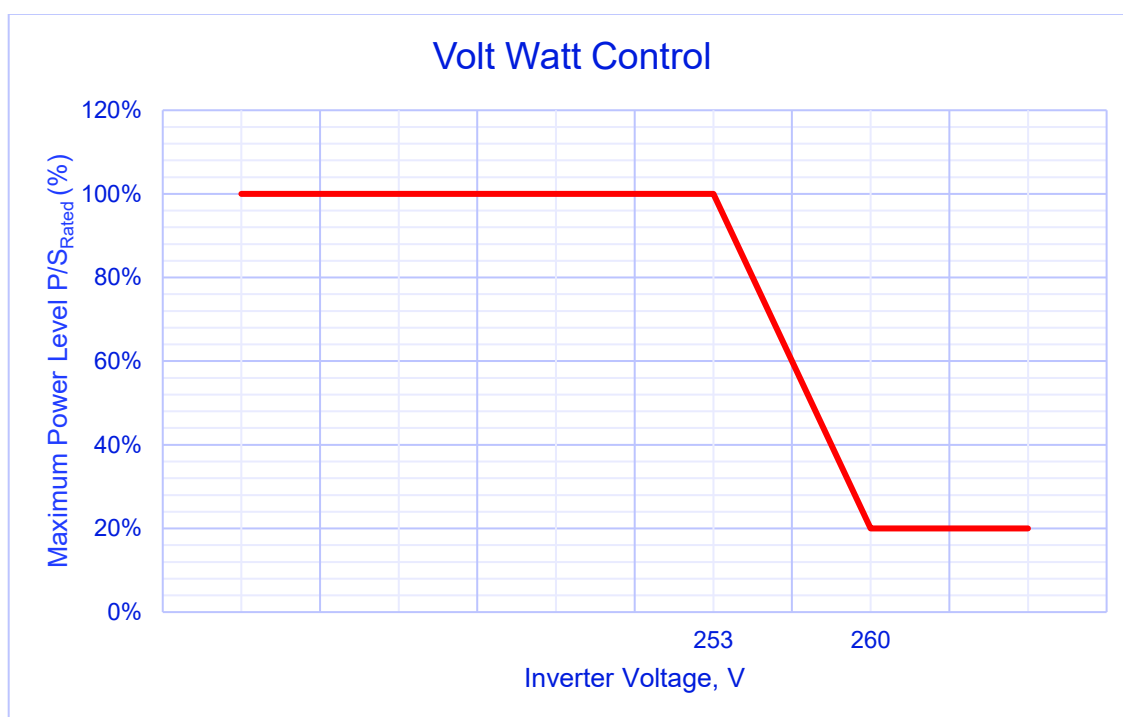
Reference	Inverter Reactive Power Level (Q) % of S _{Rated}	1-ph Voltage (LV)	3-ph Voltage (LV)
V1	44% Supplying (capacitive)	207	360
V2	0%	220	383
V3	0%	240	417

V4	60% Absorbing (inductive)	258	449
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4.8.2 Volt-Watt Control

For LV (400V/230V) connected distributed generation if the point of connection at the inverter exceeds 253V, the generator will begin to curtail generation down to a maximum of 20% when voltage reaches 260V.

Graph 2 demonstrates an example of the Volt-Watt response setting for LV (230V/400V):



Graph 2: Curve for the Volt-Watt response mode for inverters exporting

The following table defines the required Volt-Watt response setting for LV (230V/400V):

Table 4: Volt-Watt response set-point values for inverters exporting.

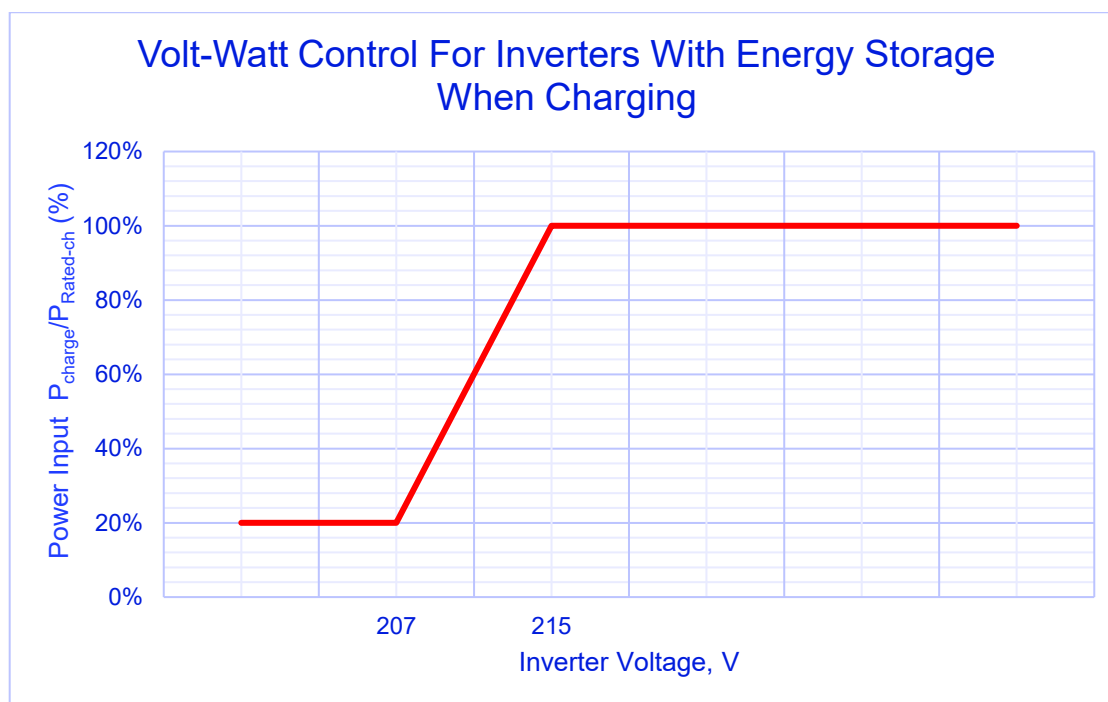
Reference	Inverter Maximum Output Power (P) % of S_{Rated}	1-ph Voltage (LV)	3-ph Voltage (LV)
V1	100%	253	360
V2	20%	260	383

5. Inverter connected energy storage systems

5.1.1 Volt-Watt Control for energy storage systems

For LV (400V/230V) connected inverter-based energy storage systems if the voltage at the inverter falls below 215V, the inverter will begin to curtail its rate of charging down to a maximum of 20% when voltage reaches 207V.

Graph 3 and Table 5 demonstrates an example of the Volt-Watt response setting for charging at LV (230V/400V):



Graph 3: Curve for the Volt-Watt response mode for inverters charging.

Table 5: Volt-Watt response set-point values for inverters charging.

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

6. PRE-COMMISSIONING (PRE-CONNECTION) REQUIREMENTS

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

The distributed generator owner shall provide Vector full details of the protection settings to be applied to the inverter system in the application form.

All testing and associated costs are the responsibility of the distribution generator owner.

Vector or Vector's representative reserves the right to witness the testing.

The distributed generator shall use a contractor who is experienced and qualified in installation and commissioning of distributed generation systems.

7. POST-COMMISSIONING AND ONGOING MAINTENANCE REQUIREMENTS

Within 10 working days of commissioning of the distributed generation system, copies of the following documentation must be provided to Vector:

Certificate of Compliance (CoC) and Record of Inspection (RoI) for the installation of the distributed generation system shall be sent to Vector for records.

A photo of the nameplate of each inverter in your DG system showing its model details and serial number shall be sent to Vector.

No changes (including setting changes) shall be made to the generator or protection without Vector's prior written approval.