High Voltage Embedded Generation Network Access Standard

UE-ST-2008.3

united energy

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Document Control

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Version	Amendment Overview	Author
1	Supersedes UE-ST-2008 Incorporates ENA National DER Grid Connection Guidelines – Technical Guidelines for LV EG Connections	Sarah Lim Technical Consultant 20th February 2020 Kaisui Tnay Engineer Complex Customer Connections 20th February 2020
1.1	Updated the following sections: Section 1.3 (7), Section 5.3.2, Section 5.7.2.2 Remote Trip Scheme, Section 5.7.3, Section 6 Table 11, Section 8.3.1, Section 8.3.1.1, Section 8.3.2, Section 8.6.2.1, Section 8.6.2.2 Remote Trip Scheme, Section 8.6.3, Section 9 Table 18	Kaisui Tnay Senior Engineer Complex Customer Connections
1.2	Updated the following sections: Section 1.1 (added requirements to comply to Chapter 5A of NER), Section 1.1.1 (reference to MSO added and removed reference to >5MVA as this will be chapter 5 regardless of exemption), Section 1.1.2 (removed reference to >5MVA as this will be chapter 5 regardless of exemption), Section 1.2 (updated bullet point a) and e)), Section 1.4 (removed reference to communication infrastructure and reference to Chapter 5), Section 2.1 (updated reference to new standard AS/NZS 4777.2:2020), Section 3.1 (updated reference to new AS standards for instrument transformers), Section 3.2 (removed reference to Chapter 5), Section 5.1 (corrected reference to AS/NZS 4777.1:2016), Section 5.3.1 (corrected reference to AS/NZS 4777.1:2016), Section 5.7.2 (updated reference to new standard AS/NZS 4777.2:2020), Section 5.7.2.1 (updated inverter settings for Australia A), Section 5.7.2.2 (updated reference to new standard AS/NZS 4777.2:2020 and added ROCOF and Vector Shift requirements), Section 5.8 (sustained operation for frequency variations clause reference added).	Anil Khushalani Senior Engineer Complex Customer Connections 9th November 2021
1.3	Section 5.7.2.1 (Table 6) and Section 5.7.2.2 (Table 9) updated to align protection relay settings with inverter settings as per AS/NZS 4777.2:2020.	Anil Khushalani Senior Engineer Complex Customer Connections 26 May 2022

1.4	Additions and amendments to Sections 2.1, 2.3.1, Part A Sections 5.3.2, 5.5, 5.7.2.1, 5.7.2.2, 5.7.2.2.1, 5.7.2.2.2, 5.7.5, 5.11, 5.12, 6, 7, Part B Sections 8.6.2.2, 8.6.3, 8.6.5, 8.10, 8.11, 9, 10. Added new Section 11 and associated appendices for generator monitoring meter requirements.	Darshana Paranagama Principal Engineer Complex Customer Connections Darshana Paranagama Darshana Paranagama (Sep 4, 2023 13:14 GMT+10) Sep 4, 2023

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1. Introduction

This document provides the technical requirements for the equipment and installation of low voltage (LV) embedded generation (EG) connections to United Energy's (UE) low voltage distribution networks. This document has been prepared based on present network conditions and is subject to change. This document complies with the ENA National Distributed Energy Resources (DER) Connection Guidelines for LV EG Connections, with the exception of UE specific requirements with deviations presented in Appendix A: Deviations from the National DER Connection Guidelines.

This document shall be read in conjunction with UE-PR-2008 EG Customer Connection Procedure. UE-PR-2008 EG Customer Connection Procedure details the EG connection services offered and the application process.

1.1 Purpose of Document

The purpose of this document is to provide proponents of EG connections information about their obligations for connection to and interfacing with the UE HV distribution network.

A HV EG connection type is defined in Table 1 and Table 2 and subject to the following:

a) point of customer connection to UE's network is at high voltage (HV)

b) capacity < 5MVA and complies to Chapter 5A of NER

Any person who owns, controls, or operates a generating system connected to a transmission or distribution network in the NEM must register with Australian Energy Market Operator (AEMO) as a generator, except where they meet the exemption criteria as stipulated in the National Electricity Rules (NER). UE distribution network is part of the NEM. Generators with total installed capacity of less than 5MVA are automatically exempted from registration and required to comply with Chapter 5A of NER. Generators with total installed capacity greater than 5MVA (unless exempted by AEMO) are required to comply with the generator performance standards stipulated in Chapter 5 of the National Electricity Rules which is available on the AEMC website.

c) it is intended to be connected to and is capable of operating in parallel with any part of the HV distribution network.

d) it meets all other technical requirements set out in this document.

e) a Certificate of Electrical Safety (CES) is issued for the installation and provided to UE.

f) it consists of either Inverter Energy System (IES) or non-IES (synchronous or asynchronous EGs), and/or Energy Storage System (ESS) with a total system capacity shown in Table 1 and Table 2

1.1.1 HV EG IES Connection Limits

Only proponents with IES installations greater than 30kVA can apply for HV EG connections. Please refer to Model Standing Offer (MSO) for IES installations less than 30kVA.

Table 1: HV EG IES capacity and export limits[1, 2, 3, 4]

Network Connection Type	Three Phase Connections automatically exempted from registration
Minimum total installed capacity (based on maximum continuous inverter rating)	> 30kVA
Maximum total installed capacity (based on maximum continuous inverter rating)	< 5MVA
Maximum export	< 5MVA

Notes:

1. The figures shown in Table 1 for total installed capacity and export is subject to change depending on site specific constraints such as
- network constraints
- location of connection point to the UE network
- generator protection and control schemes and compliance to technical requirements in this document
2. The capacity limits in Table 1 is the aggregate maximum continuous inverter rating installed behind the meter.
3. The maximum installed HV EG capacity shall not exceed the thermal rating of the UE's HV connection assets.

4. The above table is subject to the technical requirements as set out in Section 5, in particular if single phase or two phase IES are installed, the current/voltage unbalance at the POC shall not exceed the values in Section 5.7.2.

1.1.2 HV non-IES EG Connection Limits

Only proponents with three phase non-IES installations can apply for HV EG connections. UE does not permit single phase or two phase non-IES installation to operate in parallel with the network.

Table 2: HV non-IES EG capacity and export limits[1, 2, 3]

Network Connection Type	Three Phase Connections automatically exempted from registration
Maximum total installed capacity (based on maximum continuous inverter rating)	< 5MVA
Maximum export	< 5MVA

Notes:

1. The figures shown in Table 2 for total installed capacity and export may be subject to change depending on site specific constraints such as

a) network constraints

b) location of connection point to UE's distribution network

c) generator protection and control schemes and compliance to technical requirements in this document

2. The above table is subject to technical requirements as set out in section 8.
3. The maximum installed HV EG capacity shall not exceed the thermal rating of the UE's HV connection assets.

1.1.3 Combined HV EG IES and Non-IES System

For HV EG systems consisting of both HV EG IES and HV non-IES EG, the system capacities and export shall satisfy the requirements of both Table 1 and Table 2.

1.2 Scope

This document applies to HV EG systems proposals for connection to the network. It applies to

- new connections of HV EG systems
- modifications to existing HV EG systems
- temporarily connected HV EG systems

This document sets out the common requirements for both HV EG IES and HV non-IES EG systems in sections 1 to 4. HV EG IES specific technical, testing and commissioning, and operation and maintenance requirements are set out in Part A of this document. HV non-IES EG specific technical, testing and commissioning, and operation and maintenance requirements are set out in Part B of this document.

It excludes the following:

a) Basic Micro EG Connections with capacity less than or equal to 30KVA

b) EG units covered by *UE-ST-2008.2 Low Voltage Embedded Generation Network Access Standards*

c) Electric vehicles, unless the on-board battery storage system is capable of exporting to the network (in which case the requirements in this document shall apply)

d) DER systems that do not generate electricity, including demand response / demand management systems, unless they impact on the ability of the HV EG system to meet the technical requirements

e) EG systems that are registered within the NEM or capacity ≥ 5MVA

f) EG systems that are directly connected to the transmission network

1.3 Obligations

UE has developed this standard to meet its obligations to ensure the safe and reliable operation of the distribution network for operating personnel, proponents, customers and the general public.

The obligations of proponents are to:

1. comply with the technical requirements as well as relevant national standards, industry codes, legislation and regulations. In the event of inconsistency, legislation and regulations shall prevail, followed by this technical requirements, followed by national standards and industry codes
2. not connect additional HV EG units, make modifications or install additional HV EG units, including ESS, without prior written agreement from UE
3. comply with the UE's connection agreement
4. meet the requirements in the design, installation, operation and maintenance of the HV EG system
5. meet the connection, commissioning, operations and maintenance requirements of UE's HV distribution network
6. the obligation to ensure that the HV EG installation complies with the current Service and Installation Rules
7. submit an application form UE-FM-2930.4 to UE for all new HV installations and alterations and ensuring that all UE requirements are complied with. This form can be found on UE's website.
8. comply with the requirements of the current Electricity Distribution Code

1.4 UE HV EG Assessment Considerations

The following factors are considered at each stage of the Connection Enquiry and Application to Connect process:

- Network safety, security and stability
- Network infrastructure availability, capability and capacity to facilitate the proposal
- Any need to refer the proposal to AEMO or another DNSP potentially impacted by the proposal
- Infrastructure and commercial demarcation and crossover, especially when multiple jurisdictions are involved
- Consideration for non-network support opportunities (especially in areas of network constraints identified under UE's Distribution Annual Planning Report)
- Embedded generation network impact (and nearby proponents)
- Network and proposal interconnection protection
- Network infrastructure thermal capacity
- Network voltage control
- HV EG fault level contribution
- Power factor of HV EG IES
- Power quality of supply generated
- HV EG operations (modus operandi: renewables, base, peaking etc.)
- Network augmentation (i.e. infrastructure upgrade) likely to be required to facilitate the proposal and commercial model such as contestability, construction, ownership, the classification of services provided and associated cost
- Network scope of work delivery timeframe
- All other suitable considerations unique to the proposal
- Compliance to Victorian Service and Installation Rules Compliance to Victorian Electricity Distribution Code
- Compliance to Chapter 5A of the NER
- Existing and in-progress EG applications at the relevant network location

2. Definitions & Acronyms

2.1 Definitions

Table 3: Terms and Definitions

Term	Definition
Backup Protections	Backup protection is the protection contemplated by *AS/NZS 4777* (grid connection of energy systems via inverters) as central protection and installed to perform the functions of: coordinating multiple inverter energy system installations at one site, providing protection for the entire inverter energy system installation and islanding protection to the connected grid as well as preserving safety of grid personnel and the general public
Connection Agreement	A legally binding document between the distributor and the proponent stipulating the commercial and technical terms of the LV EG connection.
Embedded Generating Unit	A generating unit connected within a distribution network and not having direct access to the transmission network
Distributed Energy Resources	Power generation or storage units that are connected directly to the distribution network
Distributor	Distributed Network Service Provider: United Energy (UE)
Embedded Generating Unit	The plant used in the production of electricity and all related equipment essential to its functioning as a single entity
Generating Unit	The plant used in the production of electricity and all related equipment essential to its functioning as a single entity.
Generation	The production of electrical power by converting another form of energy in a generating unit
Inverter Energy System	A system comprising of one or more inverters together with one or more energy sources (which may include batteries for energy storage), and controls, which satisfies the requirements of *AS/NZS 4777.1:2016* and *AS/NZS 4777.2:2020*.
High Voltage	Any voltage greater than 1kV AC
HV Customer	A customer, who has a high voltage supply, with the following agreements in place: • an electricity supply contract with a Retailer • an agreement with a Metering Coordinator • an electricity distribution connection agreement, contract or deemed electricity distribution contract
HV embedded generation connection	A connection between a distribution network and a retail proponent's premises for an embedded generating unit, for which an offer in accordance to Chapter 5A of the National Electricity Rules
HV incomer	The final span or section of UE high voltage aerial or underground network that is connected to the consumer's incoming switchboard.
Inverter Energy System	A system comprising of one or more inverters together with one or more energy sources (which may include batteries for energy storage), and controls, which satisfies the requirements of *AS/NZS 4777.1:2016* and *AS/NZS 4777.2:2020*.
Low voltage	The mains voltage as most commonly used in any given network by domestic and light industrial and commercial consumers (typically 230V)
Market Generating Unit	A generating unit whose generation is not purchased in its entirety by a retailer (and receives payment for generation through the National Electricity Market or Wholesale Electricity Market)

Term	Definition
Micro embedded generation connection	Means a connection between an embedded generating unit and a distribution network of the kind contemplated by *Australian Standard AS 4777* (Grid connection of energy systems via inverters) currently up to or equal to 30kVA
Proponent	A person proposing to become a LV EG (the relevant owner, operator or controller of the embedded generating unit (or their agent))
Site Generation Limit	The generation export threshold that the embedded generation system cannot exceed, measured downstream of the connection point
Small Generation Aggregator	A person who has classified one or more small generating units as a market generating unit
Small Registered LV EG	A LV EG who elects to register a LV EG with the Australian Energy Market Operator as a market generating unit who would otherwise be entitled to an exemption to register based on size
Standard Connection	A connection service (other than a LV embedded generation connection service) for a particular class (or sub-class) of connection applicant and for which an Australian Energy Regulator approved offer in accordance to Chapter 5A of the National Electricity Rules
Single Wire Earth Return	Parts of the PAL and CP electrical distribution networks that use a single live high voltage conductor to supply single-phase or split-phase electric power with higher network impedances, and with distribution supplying low voltages to premises
Technical Requirements Document	The document produced by each Distribution Network Service Provider setting out their requirements for proponents to enable a grid connection, to which these guidelines apply (this document).

2.2 Acronyms

Table 4: Acronyms

Acronym	Definition
AEMC	Australian Energy Market Commission
AEMO	Australian Energy Market Operator
AER	Australian Energy Regulator
AS/NZS	A jointly developed Australian and New Zealand Standard
CBD	Central Business District
CEC	Clean Energy Council
DER	Distributed Energy Resources
DNSP	Distribution Network Service Provider
EG	Embedded Generation
ESS	Energy Storage System
HV	High Voltage
IEC	International Electrotechnical Commission
IES	Inverter Energy System
LV	Low Voltage
NCC	Network Control Center
NEM	National Electricity Market
NER	National Electricity Rules

Acronym	Definition
NMI	National Metering Identifier
ROCOF	Rate of Change of Frequency
SCADA	Supervisory Control And Data Acquisition
SWER	Single Wire Earth Return

2.3 Terminology

The following terminology has been used in this document:

- The word "shall" indicates a mandatory requirement to comply with this document
- The word "may" indicates a recommendation that will not be mandatorily imposed on the proponent
- The word "should" indicates a requirement that may be mandatorily imposed on the proponent based on connection specific safety or operational requirements

2.3.1 Subcategories

This document applies to all the following subcategories of HV EG connections unless otherwise specified:

1. HV EG IES capacity > 30 kVA – Any HV EG system, that is not a LV EG system, with total system capacity as set out in Table 1 for three phase network connection, meeting all relevant technical requirements for HV EG connections set out in this technical requirement document. Further subcategorised by:

a) Exporting

b) Non-exporting

2. HV non-IES EG connection – Any HV EG system that is not an IES, with a total system capacity as set out in Table 2 for three phase network connections, meeting all relevant technical requirements for HV EG connections set out in this technical requirement document. Further subcategorised by:

c) Exporting

d) Non-exporting

Where:

1. Exporting systems shall be considered to be HV EG systems operating in parallel with the HV distribution network and exporting electricity either via partial-export or full-export into the HV distribution network, where:

a) Partial-export HV EG systems limit the amount of export into the HV distribution network to an agreed export threshold defined in the connection agreement

b) Full-export HV EG systems can export into the HV distribution network to the full HV EG nameplate capacity (full AC rating).

2. Non-exporting systems shall be considered to be HV EG systems operating in parallel with the HV distribution network that are not approved and limited to ensure they cannot export electricity into the HV distribution network. It should be noted that non-exporting EG can still contribute to fault levels.

3. Relevant Rules, Regulations, Standards and Codes

3.1 Standards and Codes

This section lists the Australian and international standards and industry codes which shall apply to the design, manufacture, installation, testing and commissioning, and operation and maintenance of all plant and equipment for HV EG connections to the UE HV distribution network. The latest version of the Australian and international standards and industry codes shall be used.

In the event of any inconsistency between Australian and international standards and industry codes and UE's technical requirements, UE technical requirements shall prevail.

Table 5: Applicable Standards and Codes

Standard	Title
AS 2067	Substations and high voltage installations exceeding 1kV a.c.
AS/NZS 3000	Electrical installations (known as the Australian/ New Zealand Wiring Rules)

Standard	Title
AS/NZS 3010	Electrical installations – Generating Sets
AS/NZS 3011	Electrical installations – Secondary batteries installed in buildings
AS/NZS 4777	Grid connection of energy systems via inverters (multiple parts)
AS/NZS 5033	Installation and safety requirements for photovoltaic (PV) arrays
AS/NZS 5139	Electrical installation – Safety of battery systems for use with power conversion equipment
AS 60034	Rotating electrical machines
AS/NZS 60479	Effects of current on human beings and livestock
SA/SNZ TR IEC 61000	Electromagnetic compatibility (EMC)
IEC 62116	Utility-interconnected photovoltaic inverters – Test procedure of islanding prevention measures
IEEE Standard 1547	IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems
AS/NZS 1026	Electric Cables – Impregnated Paper Insulated – For Working Voltages up to and including 19/33 (36) kV
AS/NZS 1429.1	Electric Cables – Polymeric Insulated – For Working Voltages 1.9/3.3 (3.6) kV up to and including 19/33 (36) kV
AS/NZS 61000 series	Electromagnetic Compatibility
AS 61869 (multiple parts)	Instrument Transformers
AS/NZS 60076	Power Transformers
AS/NZS 60898	Electrical accessories – Circuit Breakers for overcurrent protection for household and similar installations
AS/NZS IEC 60947	Low-voltage switchgear and control gear
IEC 60255	Measuring relays and protection equipment
IEC 62271	High voltage switchgear and control gear
UL 508	Standard for Industrial Control Equipment

3.2 Legislation and Regulation

This section lists all the relevant legislation and regulations which shall apply to the design, manufacture, installation, testing and commissioning, and operations and maintenance of all plant and equipment for HV EG connections to the distribution network. The latest version of the legislation and regulations shall be applicable.

In the event of any inconsistency between legislation and regulations and UE's technical requirements, the legislation and regulation shall prevail.

Table 6: Applicable Legislation and Regulations

Document Title	Description
National Electricity Rules Chapter 5A	Electricity Connection for Retail Customers
Electricity Distribution Code[1]	Regulates the distribution of electricity, connections to distribution networks, and the transfer of electricity between distribution systems so that they are undertaken in a safe, efficient, and reliable manner
Electricity Industry Guideline 15 - Connection of Embedded Generation	Provides arrangements for connecting embedded generating units to distribution systems
Victorian Service and Installation Rules[1]	Provides industry agreed technical requirements that meet all legislative and code requirements for the supply and metering related aspects of any connection to the Victorian electricity supply networks.
Electrical Safety (Installation) Regulations	Provides details on regulatory obligations for electricity installation works in Victoria

Note:

1. Where the HV EG system is installed in areas with rapid earth fault current limiter (REFCL) deployment, the HV EG system shall also comply with the REFCL related requirements stipulated in the Electricity Distribution Code and Victorian Service and Installation Rules. REFCLs are currently installed in UE's Frankston South, Dromana and Mornington substations. Proponents shall confirm with UE the applicability of REFCL related requirements to the HV EG system.

4. Fees and Charges

Refer to UE's website for type of connection fees applicable to HV EG connections and how these fees are determined. Where network augmentation works are required to accommodate the HV EG connection, a separate quote will be provided to the proponent. This is in addition to the application fees and charges

Part A – IES Requirements

5. Technical Requirements for HV EG IES

This section details the technical requirements for HV EG IES connections.

5.1 Labelling and Signage

The labels and signs on the installation, including cables, shall be as per *AS 2067*, *AS/NZS 4777.1:2016*, AS/NZS 3000 and *AS/NZS 5033*. If the EG output is at LV and connects to the UE HV network, relevant labelling shall be as per Energy Safe Victoria (ESV) application requirements of *AS/NZS 5033*, *AS/NZS 3000* and any other relevant regulatory requirements.

Site specific labelling for additional energy sources and operating procedure for the energy sources shall be installed at each isolation point that has a possibility of energy feedback from the IES.

5.2 Maximum System Capacity

Refer to Table 1 for details of maximum system capacity.

5.3 Generation Control

5.3.1 Export Limits at Connection Point

The maximum export limit of HV EG IES connections is as per Table 1.

The export limit where required will be negotiated with the proponent as part of the application process. The export limit imposed may be a “hard” or “soft” limit, consistent with the definitions within *AS4777.1:2016* and *AS/NZS 4777.2:2020*.

The ability of the proponent’s HV EG system to export at the export limit is not guaranteed, but rather, it will depend upon network characteristics which change over time. UE reserves the right to revise the export limit of the proponent’s HV EG system if the system adversely affects the network safety and/or performance.

5.3.2 Anti-Islanding Considerations

- IES systems with total capacity ≥ 30kVA but < 1,000kVA - To ensure unintentional island does not form following an electricity distribution network outage, anti-islanding protection functions shall be implemented. Refer to Section 5.7 for detailed protection requirements.
- IES systems with total capacity ≥ 1,000kVA - To ensure an unintentional island does not form following an electricity distribution network outage, IES systems will require reliable and immediate disconnection from the network. Remote trip schemes or alternative NVD based anti-islanding schemes are considered to be reliable and robust and this is the distributors preferred option for large IES systems when ROCOF and vector shift are not considered to be reliable. Alternative schemes or export restrictions may be considered on a case-by-case basis. However, for all schemes, operation restrictions may apply and the distributor will not be able to guarantee the perpetuity of such schemes due to network changes over time. Refer to Section 5.7.2.3 for remote trip scheme requirements and section 5.7.2.4 for NVD based anti-islanding scheme requirements. Note generation capacities >500kVA may also be subject to these additional protection requirements on a case-by-case basis.

5.3.3 Network Asset Constraints Considerations

Introduction of HV IES EG may result in the limits of network assets being exceeded (e.g. thermal limits, reverse power flow, fault current contribution, protection grading issues, protection grading with adjacent feeder faults, etc.) and hence, require network augmentation. If the proponent does not wish to pay for the network augmentation, an export limit may be imposed as an alternative.

5.3.4 Site Generation Limit Downstream of Connection Point

The Victorian Service and Installation Rules stipulated that HV EG electrical characteristics shall be compatible with the relevant distributor’s network, in this case UE’s distribution network. The HV EG output shall not exceed the capability (e.g. thermal limits, harmonics etc.) of the network assets at, or upstream of the network connection point.

5.4 Inverter Energy System

The IES shall comply with the following requirements:

1. type tested and certified as being compliant with an accreditation number or certificate of suitability as evidence of compliance to *IEC 62116* for anti-islanding protection
2. IES EG units should comprise of inverters that have the following inverter power quality response modes available:

a) Reactive power control mode
b) Central control mode via a master/slave system
c) Volt response modes (i.e. volt-var and volt-watt)
d) Fixed power factor or reactive power mode
e) Power rate limit (i.e. ramp rate control)

5.5 Network Connection and Isolation

Network connection and isolation requirements shall be as per the following:

- Complies with the Electricity Distribution Code
- Complies with the current Victorian Service and Installation Rules
- Protection and control system of the installation at POC and downstream of the POC as agreed with UE
- Operation, ownership and responsibility for protection and control schemes downstream of the POC shall lie with the customer and the generator nominated in the Distribution Connection EG agreement

All assets upstream of the POC in UE's distribution network are owned and operated by UE.

5.6 Earthing

The earthing requirements shall be:

1. For installations with IES operating at greater than 1kV a.c., earthing requirements shall comply with *AS 2067*, *AS/NZS 60479.1* and *AS/NZS 3000*.
2. For ESS, additional requirements shall be as per *AS/NZS 5139* and *AS 3011.2*.

5.7 Protection

5.7.1 Protection Requirements at HV Point of Connection (POC)

- Overcurrent
- Earth Fault
- Sensitive Earth Fault

The purpose of this protection is to ensure that any faults within the customer's premises will be cleared via operation of this protection.

These protection settings shall be site specific. Examples of site specific factors include circuit rating, loading, fault level, device grading etc. Operation of overcurrent/earth fault protection shall immediately trip a suitably fault rated circuit breaker. Self-powered relays are not permitted.

The fault clearance time for a solid phase-to-phase or phase-to-ground short circuit at the network connection point must be less than 150ms. Where this fault clearance time cannot be achieved, the proponent should consult with UE to determine the maximum permissible fault clearance time to be adopted.

It is necessary to undertake a grading study and to grade with the upstream network protection. If the immediate upstream network protection device is a circuit breaker, the minimum grading margin shall be 0.3s.

5.7.2 IES Protection

The intention of this section is to ensure the safe and reliable operation of the distribution network for operating personnel, proponents, customer (i.e. electricity consumers) and the general public. The HV EG IES intending to connect to the network shall not adversely affect the operation and safety of other existing network users. UE may impose limitations and/or conditions of operation on the new HV EG IES connection in order to mitigate these issues.

Table 7: HV EG IES Protection Requirements

IES protection	Three Phase Connection
Inverter integrated protection according to *AS/NZS 4777.2:2020*	Yes
IES Backup Protection	Yes

5.7.2.1 Inverter Integrated Protection

AS/NZS 4777.2:2020 and *AS/NZS 4777.1:2016* inverter protection settings for HV EG IES connections are tabulated below. Please note that the proponent is responsible for ensuring that these settings are suitable for their application. Where there is a need to deviate from the settings below, this shall be negotiated with UE as part of the application.

Table 8: Inverter Integrated Protection Settings

Protection function	Setting (per unit)	Trip delay time	Maximum disconnection time
Under voltage 1 (V <)	0.78	10s	11s
Under voltage 2 (V<<)	0.30	1s	2s
Over voltage 1 (V>)	1.15	1s	2s
Over voltage 2 (V>>)	1.2	-	0.2s
Under frequency	47Hz	1s	2s
Over frequency	52Hz	1s	0.2s
Minimum reconnection delay following a protection trip	60s		

Notes:

1. Sustained over voltage setting for the inverter is optional as voltage regulation within the HV customer electrical reticulation is the responsibility of the customer.
2. Active anti islanding shall comply to *AS/NZS 4777.2:2020* or *IEC 62116*
3. Generation with total capacity between 2MW and 5MW may be required to deviate from the settings in Table 8 and comply to generator performance standards.

5.7.2.2 IES Backup Protection

Backup protection requirements shall apply to HV EG IES connections as per Table 7. The protection functions for each HV EG IES connection subcategory is shown in Table 9. The protection relay shall be compliant with *IEC 60255*.

Table 9: Backup Protection Requirements

Protection function	Exporting to UE Network[1]	Non-exporting to UE Network[1,2]
Network reverse power protection	–	✓
Phase balance protection • Current unbalance protection • Voltage unbalance protection	✓	–
Passive anti-islanding protection	✓	✓
Reconnection Time Delay	✓	✓
Remote tripping	–	–
Synchronisation check (for EG systems configured to operate in island mode when disconnected from UE network)	✓	✓
Symbols are used to denote protection requirements, where: ✓ Represents that the protection shall be required – Represents that the protection may be required × Represents that the protection shall not be required		

Notes:

1. For customers exporting to the HV reticulation, the voltage and current sensing devices of the protection relay are to be located at HV and upstream of all IES. The protection relay shall be capable of disconnecting the contribution from all IES when a fault is detected.
2. For customers who are exporting only to their LV reticulation, the voltage and current sensing devices of the protection relay are to be located at LV and upstream of all IES. The protection relay shall be capable of disconnecting the contribution from all IES when a fault is detected.

- The protection schemes shall be designed such that:
- Voltage sensing shall be located as close to the main Incomer Circuit Breaker as practicable
- All protection elements initiate tripping of a suitably rated circuit breaker (tripping of CB isolates the IES); or
- Current based protection elements (e.g. overcurrent, earth fault) shall initiate tripping of a suitably rated circuit breaker while voltage based protection elements (e.g. over voltage, under voltage, over frequency, under frequency) may initiate opening of a suitably rated contactor.
- The protection scheme shall be fail-safe such that in the event of any component failure (e.g. device fault, loss of auxiliary supply, etc.), the HV EG IES shall be automatically disconnected from the network within 2s.

For voltage-based protection elements, if the trip/open signal is not hard wired to the disconnection device (i.e. circuit breaker or contactor), a dedicated wireless trip scheme may be used. The trip/open signal shall be initiated by a protection grade device (IEC 60255 compliant). The wireless trip scheme shall incorporate control equipment (i.e. devices that utilise digital input and output functions) compliant to AS/NZS IEC 60947 or equivalent. The communication used shall be compliant with internationally recognised standards (e.g. IEC, AS/NZS or IEEE).

The receipt of the trip/open signal shall operate the disconnection device directly. This is illustrated in Figure 1 below:

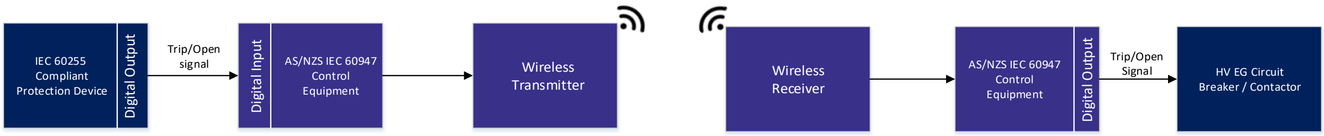

Figure 1: Typical Wireless Protection Trip Scheme

End to end supervision of the wireless communication shall be enabled and failure of the connection shall disconnect the HV EG in less than the auto reclose dead time of the upstream UE feeder CB or ACR. At present, the auto reclose dead time on UE's network is 8s. The time delay for the supervision function shall be negotiated with UE as part of the application.

- **Network Reverse Power Protection**

Where required, the reverse power protection is configured to look towards the network. The setting shall be set as per agreement with UE and use a trip delay of 2s. Delays of greater than 2s shall be negotiated with UE.

- **Current unbalance protection**

As per the NER requirements in S5.3.6, the current in any phase shall not be greater than 105% or less than 95% of the average of the currents in the three phases. Any deviations to these limits shall be negotiated with UE.

- **Voltage unbalance protection**

The impact of the HV EG system on the UE network voltage shall not exceed the limits stipulated in Table S5.1a.1 of the NER S5.1a.7 replicated in Table 10 below. Voltage unbalance is measured as negative sequence voltage.

However, in recognition of the challenges in complying with this NER requirement, UE may allow the connection if the proponent is able to demonstrate that the introduction of the HV EG does not adversely affect the voltage at the POC.

Table 10: Voltage Unbalance Requirements

Table S5.1a.1

Nominal supply voltage (kV)	Maximum negative sequence voltage (% of nominal voltage)			
Column 1	Column 2	Column 3	Column 4	Column 5
	no contingency event	credible contingency event or protected event	general	once per hour
	30 minute average	30 minute average	10 minute average	1 minute average
more than 100	0.5	0.7	1.0	2.0
more than 10 but not more than 100	1.3	1.3	2.0	2.5
10 or less	2.0	2.0	2.5	3.0

- **Passive Anti-Islanding Protection**

Voltage measurement for anti-islanding protection shall be located upstream of both the HV EG connection and any power quality improvement devices (i.e. active filters etc.). The passive anti-islanding protection shall be as per Table 11.

Table 11: Passive Anti-islanding Protection

Protection function	Setting (per unit)	Trip delay time	Maximum disconnection time
Under voltage 1 (V <) (V_{L-N})	0.78	10s	11s
Under voltage 2 (V<<) (V_{L-N})	0.3	1s	2s
Over voltage 1 (V>) (V_{L-N})	1.15	1s	2s
Over voltage 2 (V>>) (V_{L-N})	1.2	-	0.2s
Under frequency	47Hz	1s	2s
Over frequency	52Hz	1s	2s
Neutral voltage displacement[1,2]	10% of line to line voltage (V_{L-L})	-	3s

Notes:

1. Not required for customers who are exporting only to their LV reticulation.
2. Where the HV EG system is installed in areas with REFCL deployment, the setting for neutral voltage displacement will be subject to negotiation based on site specific condition.
3. ROCOF and Vector Shift settings are required to be set according to the limitations of the inverters.

a) Vector Shift – As per *AS/NZS 4777.2:2020*, inverters shall remain in continuous operation for a single phase vector shift of 60º and three phase vector shift of 20º. Therefore, the proposed Vector Shift setting for the Central Protection device is required to be outside these boundaries and also set within safety limitations of the equipment (e.g. 21º for 3 phase vector shift). However, inverter withstand limits are required to be considered for inverters that are not compliant to *AS/NZS 4777.2:2020*.

b) ROCOF – As per NER, generators shall maintain continuous operation for ROCOF that do not exceed 4Hz/s r a duration of 0.25s. Therefore, the proposed ROCOF setting for the Central Protection device is required to be outside these boundaries and also set within safety limitations of the equipment (e.g. 4.1Hz/s, t= 0.27s).

4. Generation with total capacity between 2MW and 5MW may be required to deviate from the settings in Table 11 and comply to generator performance standards.

- **Reconnection Time Delay**

The backup protection is required to have a reconnection time delay of greater than 60s post voltage-based protection operation (e.g. under voltage, over voltage etc.). Once the protection has operated and tripped the relevant circuit breaker or contactor, the network parameters must be within the limits set out in Table 11 for at least 60s before the HV EG IES can reconnect with the network.

If the HV EG circuit breaker is tripped via UE remote trip scheme, the proponent shall contact NCC prior to reconnecting the HV EG IES with the network.

5.7.2.3 Remote Trip Scheme

To ensure an unintentional island does not form following an electricity distribution network outage, a remote trip scheme may be required. The requirement for a remote trip scheme is dependent on the network connection point and the HV EG capacity.

The purpose of the remote trip scheme is to immediately and automatically transmit a trip command to the proponent's HV EG CB in response to a UE protection trip resulting in the loss of the relevant UE HV feeder. Figure 2 below illustrates a typical remote trip scheme.

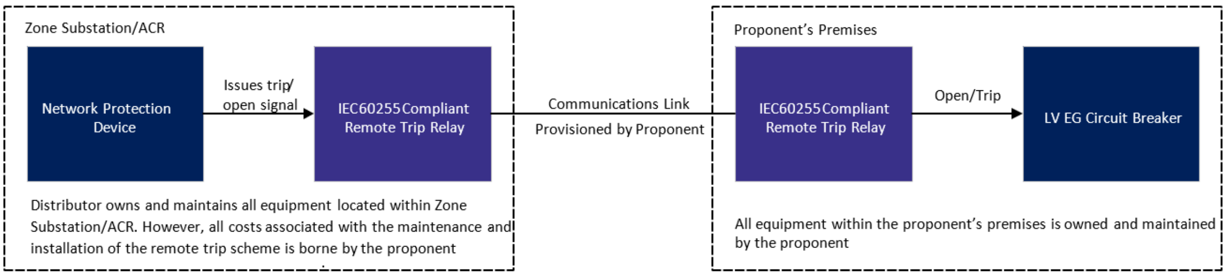

Figure 2: Typical Remote Trip Scheme

The minimum requirements for the proponent's remote trip scheme are as follows:

- Backup protection (including voltage and current sensors) that forms part of the customer HV protection scheme shall be installed at the HV incomer of the installation. Any changes to the location of the backup protection, including voltage and current sensors, shall be negotiated with UE.
- Send a remote trip signal to the proponent's HV EG CB for any relevant UE protection operation, "loss of mains" network scenarios on the HV supply feeder including overcurrent, earth fault and sensitive earth fault protection.
- UE Network Control Centre (NCC) operators shall have the facility to trip the proponent's HV EG CB via UE NCC SCADA. This trip shall be latched until NCC resets the trip signal. This trip signal shall result in the proponent's HV EG CB closing to be blocked as well.
- Send a remote trip signal to the proponent's HV EG CB for any manual initiated open command on the UE HV supply feeder/ACR (both via UE operator on site at the supply zone substation or controller in the UE NCC).
- Tripping of the proponent's HV EG CB shall be completed within a maximum of 200ms from the time of the UE protection operation or manually initiated command. Any deviation of the disconnection time shall be negotiated with UE.
- The scheme shall be configured so that the proponent's HV EG CB is automatically tripped in the event the integrity of the scheme is compromised, including equipment failure associated with the scheme. The proponent's HV EG CB shall trip if the integrity of the scheme is not restored (e.g. equipment failure, loss of auxiliary supply) within 2s to ensure the scheme is fail safe.
- End to end supervision of the communication shall be enabled and failure of the connection shall disconnect the HV EG in less than the auto reclose dead time of the upstream UE isolation device. The time delay for the supervision function shall be negotiated with UE.
- At a minimum the following information shall be telemetered to the UE NCC via SCADA for each proponent's remote trip scheme:

  - Equipment fail alarm for both ends

- Health of communications link
- Remote trip received by proponent
- Proponent HV EG CB fail to open (after receipt of remote trip signal)
- Proponent HV EG CB status (open/closed)
- Loss of mains (loss of network) protection operated
- Proponent generation (kW) with measurement accuracy within ±2%
- Proponent reactive power output (kvar) with measurement accuracy within ±2%
- Proponent net load (kW) with measurement accuracy within ±2%
- Proponent net reactive power consumption (kvar) with measurement accuracy within ±2%
- Additional voltage, current or power quality parameters such as harmonics, flicker, voltage dips and swells may be required. These will be negotiated as part of the application process.

5.7.2.4 NVD Based Anti-Islanding Scheme

Refer *UE-ST-5003 NVD Based Anti-Islanding Scheme* for technical requirements when connecting to the UE network.

5.7.3 Special Operations Conditions

The following HV EG protection is required for special UE network operational conditions:

- **Live line work by UE**

When works are undertaken near or on live HV distribution feeders, UE enables a live line operating mode which disables automatic reclose and enables low set instantaneous overcurrent and earth fault protection. With live line mode enabled, grading may be compromised with downstream protection (including the protection associated with the HV EG installation). If the proponent wishes to operate their HV EG when live line mode is enabled, the HV EG protection will also need to act much more quickly to disconnect from the network for phase-phase faults on the HV feeder while live line sequence is enabled. As such, additional requirements may be required and shall be negotiated with UE as part of the application.

- **Total Fire Ban (TFB) Days**

For HV EG installed in HBRA may experience TFB restrictions, if the proponent chooses to operate their HV EG on TFB days, the HV EG will be required to disconnect instantaneously to avoid contribution to a fault. As such, additional requirements may be required and shall be negotiated with UE as part of the application.

5.7.4 Switchgear and control gear requirements

The switchgear and control gear associated with the HV EG IES connection shall be:

- Compliant to all relevant standards, codes legislations and regulations listed in Section 3.
- Switchgear – appropriate breaking and thermal capacities based on the fault level at the switchgear location. Refer to Figure 3 below (this is extracted from the Electricity Distribution Code) for the maximum HV fault level. Site specific fault level at HV customer POC can be obtained from UE.

DISTRIBUTION SYSTEM FAULT LEVELS		
Voltage Level kV	**System Fault Level MVA**	**Short Circuit Level kA**
66	2500	21.9
22	500	13.1
11	350	18.4
6.6	250	21.9
<1	36	50.0

Figure 3: Fault levels extracted from the Electricity Distribution Code[1]

- EG isolation – All EG shall have a lockable isolating device owned and operable by the proponent.

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1 https://www.esc.vic.gov.au/electricity-and-gas/codes-guidelines-and-policies/electricity-distribution-code

5.7.5 Interlocking

The interaction, interlocking and safe operation of different types of generation downstream of the point of connection shall be the responsibility of the Customer.

When connecting an islanded HV EG system to the network, synchronisation check protection shall be implemented.

5.8 Operating Voltage and Frequency

UE has an obligation to maintain the network voltage in compliance to the Distribution Code. Introduction of HV EG IES to the network may impact the network voltage and deviate it beyond the limits of the Distribution Code. The EG shall not adversely affect the voltage at the point of connection (POC) such that the voltage deviates beyond the limits of the Electricity Distribution Code.

The HV EG system should operate at the frequency ranges in compliance with AEMC's Frequency Operating Standard. Where the HV EG systems are unable to operate within the AEMC Frequency Operating Standard, this shall be negotiated with UE.

It is the responsibility of the proponent to maintain the voltage of the HV and LV electrical reticulation within the proponent's premises.

Sustained operation for frequency variations will be in accordance with Clause 4.5.3 of *AS/NZS 4777.2:2020* or to be negotiated with UE.

5.9 Metering

Metering shall be installed as per Victorian Service and Installation Rules[2].

5.10 Power Quality

HV EG IES shall comply with the applicable power quality requirements of the AS/NZS 61000 series as well as relevant Victorian regulations and licence conditions, including but not limited to:

- Network voltage control
- Voltage fluctuations
- Harmonics
- Voltage balance

5.10.1 IES Volt Response Modes

IES may be equipped with power quality response modes to either maintain the power quality at its point of connection or provide support to the network. Site specific requirements are to be negotiated with UE during the technical assessment. This encompasses the use of inverter volt response modes, power factor control modes, etc.

5.10.2 Network Ancillary Services

AEMO is responsible for maintaining the network frequency close to 50Hz in accordance with the NEM frequency standards and for keeping the voltage within an acceptable range at particular nodes on the transmission network and for scheduling power flow between regions while maintaining power flows within the capability of plant. AEMO achieves these objectives by dispatching scheduled generation to match the load and via ancillary services.

Ancillary services can be one of the following:

- Frequency Control Ancillary Services (FCAS)
- Network Control Ancillary Services (NCAS)

In practice FCAS and NCAS are offered by HV EGs by providing either real power or reactive power reserves that may be required in response to a network fluctuation, disturbance or event or based on load flows to provide local network support. Any HV EG has the option to provide ancillary services.

HV EG participating in network ancillary services (potentially IES with ESS) has the potential to rapidly change network load, resulting in significant voltage impact on the local network. Hence, the HV EG shall adopt necessary controls to prevent adverse impacts on the power quality at the point of connection while generating to provide ancillary services.

[2] https://www.victoriansir.org.au/

5.11 HV Embedded Network

A HV embedded network operator is exclusively responsible for the management of the embedded network including any EG within the embedded network. The Distributor does not have a direct relationship with the EG and/or the proponent in this case. Hence, the HV embedded network operator shall make available to the Distributor, all necessary documentation to demonstrate compliance to this document and other applicable standards and regulations.

5.12 Communications Requirements for Monitoring Systems

For HV EG IES systems requiring remote trip schemes, the communication requirements are outlined in Section 5.7.2.3.

Communication requirements for alternate control schemes as mentioned in Section 5.7.2.4 shall be negotiated with UE as part of the application process.

Proponents shall also install remote monitoring of their HV EG IES systems to ensure that the proponent is promptly notified of issues on their HV EG IES systems. Remote monitoring of HV EG IES systems by the proponent may be achieved via use of IES manufacturer's software applications.

A generator monitoring meter is required for systems ≥200kVA. This scheme will provide remote monitoring capability as well as the ability for UE to trip the generation if required by AEMO. Refer to section 11 for further for details.

5.13 Data and Information

5.13.1 Static Data and Information

The static data and information shall be provided by the proponent to UE as listed in Appendix F: Static Data and Information. UE will provide this data to AEMO's Distributed Energy Resource Register (DERR) on behalf of the proponent.

5.13.2 Dynamic Data and Information

For HV EG IES systems requiring remote trip schemes, the dynamic data requirements are outlined in Section 5.7.2.3. Dynamic data requirements for HV EG IES systems implementing alternate control schemes as mentioned in Section 5.7.2.4.shall be negotiated with UE as part of the application process.

5.14 Cybersecurity

All devices and equipment settings associated with the HV EG system shall be secured against inadvertent or unauthorised tampering. Changes to the HV EG settings shall require the use of tools (e.g. special interface devices and passwords) and special instructions which shall not be provided to unauthorised personnel.

5.15 Technical Studies

Technical studies shall be completed as part of the connection application as per Table 12.

Table 12: Technical Studies Required for HV EG IES Connections

Technical Studies	HV EG IES
Power Flow Study	–
Fault Level Contribution Study	✓
Protection Study	✓
Power Quality Impact Study (including harmonics, flicker, voltage step change, unbalance)	–
Earthing Study	–
Dynamic System Studies (see Section 5.15.5)	–
Symbols are used to denote technical studies requirements, where: ✓ Represents that technical studies shall be required – Represents that technical studies may be required	

As part of the application process, UE shall provide the following network data to enable the proponent to complete the required technical studies:

- network fault levels up to the point of common coupling
- network model
- network protection information for UE assets (e.g. protection settings)
- network equipment information for UE assets (e.g. line and conductor ratings)

Where one or more of the technical studies does not meet the assessment criteria, UE shall provide the proponent feedback on components of the submission that require further work. The proponent has the option to discuss with UE:

- Alternative configurations of the HV EG IES systems
- Network augmentation (and associated cost of network augmentation)

5.15.1 Power Flow Study

The requirement for a power flow study shall be negotiated with UE as part of the application process. Typically this is required for larger installations where there may be thermal impacts to UE's distribution network or where there are impacts on the proponent's maximum demand.

5.15.2 Power Quality Impact Studies

The requirement for this study shall be negotiated with UE as part of the application process.

5.15.3 Fault Level Contribution Study and Protection Settings Report

A comprehensive protection study is required for all HV EG installations. The fault level contribution and protection settings shall be included in this study.

Please refer to https://myenergy.ue.com.au for additional information. This form can be found on UE's website.

5.15.4 Earthing Study

An earthing study is required if alterations or additions are made to the proponent's HV network.

5.15.5 System Studies

5.15.5.1 Steady state study

The following steady state studies may be required for HV EG applications:

- Power Flow Study (including network contingency analysis where applicable)
- Fault Level Contribution Study (including network contingency analysis where applicable)

- Protection Study (including network contingency analysis where applicable)
- Power Quality Impact Study (including harmonics, flicker, voltage step change, unbalance, network contingency analysis where applicable)

The proponent shall negotiate with UE to determine the required steady state studies for their application,

5.15.5.2 Dynamic study

Dynamic studies may be required depending on the following:

- outcome of steady state studies,
- presence of non-standard design features as part of the HV EG connection (e.g. STATCOM)
- location of the HV EG on the network

The studies may include:

- Transient/step frequency disturbance
- Transient/step voltage fluctuation
- Generator stability
- Generator governor control/excitation control
- Frequency response
- Fault ride through

The dynamic study requirements shall be negotiated with UE as part of the application process

6. Testing and Commissioning for HV EG IES

Testing and commissioning of the HV EG IES installation shall be undertaken by the proponent in accordance with *AS 2067*, *AS/NZS 3000* and *AS/NZS 5033*, the CEC approved test regime (if applicable), and the equipment manufacturer's specifications and to the technical requirements stipulated in this document. The testing and commissioning results shall demonstrate that the installed HV EG IES system meets the requirements of the connection agreement.

Note these tests shall be installation tests and not type tests of the equipment. Equipment type tests shall be as per *IEC 62116* for inverters.

In addition, the following requirements for network connection of HV EG IES systems shall be met:

- Testing and commissioning plan shall be produced by the proponent covering all newly installed equipment, interfaces with existing equipment and end to end testing of remote trip scheme (if installed). The plan shall be produced based on the sequence of testing on site.
- All tests shall be provided in a test report format or ITP format with reference made to the commissioning plan. The test report shall clearly indicate pass/fail criteria for each test.
- Pre-commissioning shall be undertaken to prove the functionality of the complete scheme.
- The results of all testing and commissioning activities shall be thoroughly documented and shall align with the commissioning plan.
- Testing and commissioning acceptance shall be signed off by a suitably qualified and authorised person.
- Testing and commissioning acceptance may require UE to carry out witnessing at the proponent's expense.

Table 13: Testing and Commissioning Requirements for HV EG IES Connections

Testing and commissioning submission	HV EG IES	
	Exporting	Non-exporting
Protection settings and performance[1]	✓	✓
HV switchgear integrity and performance	✓	✓
CTs and VTs performance test results	✓	✓
Power quality settings and performance	–	–
Export limits settings and performance	–	✓
Earth grid in compliance to AS 2067:2016	–	–
Communications performance for monitoring system[2]	✓	✓

Testing and commissioning submission	HV EG IES	
	Exporting	Non-exporting
Site Maintenance Procedure	✓	✓
Safety and Operating Procedure	✓	✓
Confirm system is as per specifications	✓	✓
Confirm single line diagram is located on site	✓	✓
As-built documentation and drawings	✓	✓
Certificate of Electrical Safety (CES)	✓	✓
UE HV EG Commissioning forms (see Appendix F:)	✓	✓
Symbols are used to denote testing and commissioning requirements, where: ✓ Represents that testing and commissioning shall be required – Represents that testing and commissioning may be required		

Notes:

1. Protection Settings and Performance

- The HV EG IES protection relay shall be tested by secondary injection. All necessary functional tests shall be carried out to prove that the protection and control schemes operate as per the design.

2. Power Quality Settings and Performance

- On-load tests shall be undertaken after protection settings and performance tests have been completed. During these on-load tests, the value of electrical parameters shall be recorded such as HV EG voltage, current, active power, power factor and frequency. On-load tests shall confirm the HV EG regulates active power and power factor within a certain tolerance of the applied settings when synchronised with UE's network.

3. Communications schemes for monitoring

- End to end testing of monitoring data points are required.
- Where remote tripping is required, full end-to-end testing of the remote trip scheme is required.

7. Operations and Maintenance

The operation and maintenance requirements for HV EG IES connections to the UE network, includes:

1. The HV EG IES system shall be operated and maintained by the proponent to ensure compliance with their connection agreement and all legislation, codes, and/or other regulatory instruments at all times
2. As a function of the routine maintenance checks, a record of inspection activities undertaken at the site demonstrating that the installation has been tested and is safe to remain connected to the network is required. Record of inspections shall be retained by the customer and made available to UE upon request.

The following documentation is to be kept at the HV EG IES installation in compliance with relevant codes and is to be readily accessible by UE's representatives and other authorised parties:

- A single line diagram showing all electrical metering points, protection functions and zones of coverage.
- A record of all approved protection settings.
- A copy of the approved operating procedures.
- Maintenance plan and all subsequent maintenance records.

In addition, the proponent shall:

1. Maintain and operate the HV EG IES installation in a safe condition
2. Ensure that any changes to the HV EG IES installation are performed by an electrician lawfully permitted to do the work and that the proponent holds a Certificate of Electrical Safety (COES) issued in respect of any of the changes
3. Seek UE approval prior to altering the connection in terms of an addition, upgrade, extension, expansion, augmentation or any other kind of alteration, including any changes to firmware and protection functions or settings.

4. If any breach of this technical standard is suspected, UE may undertake an investigation. If the investigation reveals a breach, the proponent shall be required to rectify this breach and pay UE for the costs associated with the investigation and associated works undertaken by UE.

Part B – Non-IES Requirements

8. Technical Requirements for HV non-IES EG

This section details the technical requirements for HV non-IES EG connections.

8.1 Labelling and Signage

The labels and signs on the installation, including cables, shall be as per *AS 2067* and *AS/NZS 3000*. Site specific labelling for additional energy sources and operating procedure for the energy sources shall be installed at each isolation point that has a possibility of energy feedback from the HV non-IES EG.

8.2 Maximum System Capacity

Refer to Table 2 for details of maximum system capacity.

8.3 Generation Control

8.3.1 Export Constraints at Connection Point

The maximum export limit of HV non-IES EG connections is as per Table 2.

The export constraints where required will be negotiated with the proponent as part of the application process.

The ability of the proponent's HV EG system to export at the export limit is not guaranteed, but rather, it will depend upon network characteristics which changes over time. UE reserves the right to revise the export limit of the proponent's HV EG system if the system adversely affects the network safety and/or performance.

Anti-Islanding Considerations

- HV non-IES EG systems with total capacity < 1,000kVA – To ensure an unintentional island does not form following an electricity distribution network outage, HV non-IES EG shall incorporate anti-islanding protection functions such as ROCOF, vector shift, NVD etc. to reliably and automatically disconnect from the network. Refer to Section 8.6 and Table 18 for detailed protection requirements. If there is insufficient load on the network to implement a reliable ROCOF and vector shift setting, minimum import may be considered or alternatively remote trip scheme may be required.
- HV non-IES EG systems with total capacity ≥ 1,000kVA - To ensure an unintentional island does not form following an electricity distribution network outage, HV non-IES EG systems will require reliable and immediate disconnection from the network. Remote trip schemes are considered to be reliable and robust and this is UE's preferred option for large HV non-IES EG systems. Alternatively, minimum import depending on the connection point will avoid the requirement for such schemes. Refer to Section 8.6.2.3 for remote trip scheme requirements.

Network Asset Constraints Considerations

Introduction of HV non-IES EG may result in the limits of network assets being exceeded (e.g. thermal limits, reverse power flow, fault current contribution, protection grading issues, protection grading with adjacent feeder faults, etc.) and hence, require network augmentation. If the proponent does not wish to pay for the network augmentation, an export limit may be imposed as an alternative.

8.3.2 Site Generation Limit Downstream of Connection Point

The Victorian Service and Installation Rules stipulated that HV EG electrical characteristics shall be compatible with the relevant distributor's network, in this case UE's network. The HV EG output shall not exceed the capability (e.g. thermal limits, harmonics etc.) of the network assets at, or upstream of the network connection point.

8.4 Network Connection an Isolation

Network connection and isolation requirements shall be as per the following:

- Complies with the Electricity Distribution Code
- Complies with the Victorian Service and Installation Rules
- Protection and control system of the installation at POC and downstream of the POC as agreed with UE
- Operation, ownership and responsibility for protection and control schemes downstream of the POC shall lie with the proponent and the generator nominated in the Distribution Connection EG agreement

All assets upstream of the POC in UE network is owned and operated by UE.

8.5 Earthing

For installations with non-IES operating at greater than 1kV a.c., earthing requirements shall comply with *AS 2067, AS/NZS 60479.1* and *AS/NZS 3000*. The earthing system for the HV non-IES EG system must provide satisfactory earthing independent of UE's earthing system.

8.6 Protection

8.6.1 Protection Requirements at HV Point of Connection (POC)

As per the current Victorian SIR, the proponent is required to have the following protection at their POC:

- Overcurrent
- Earth Fault
- Sensitive Earth Fault

The purpose of this protection is to ensure that any faults within the customer's premises will be cleared via operation of this protection.

These protection settings shall be site specific. Examples of site specific factors include circuit rating, loading, fault level, device grading etc. Operation of overcurrent/earth fault protection shall immediately trip a suitably fault rated circuit breaker. Self-powered relays are not permitted. Where possible, the protection trip output shall be latched.

The fault clearance time for a solid phase-to-phase or phase-to-ground short circuit at the network connection point must be less than 150ms. Where this fault clearance time cannot be achieved, the proponent should consult with UE to determine the maximum permissible fault clearance time to be adopted.

It is necessary to undertake a grading study and to grade with the upstream network protection. If the immediate upstream network protection device is a circuit breaker, the minimum grading margin shall be 0.3s.

8.6.2 HV non-IES EG Protection

The intention of this section is to ensure the safe and reliable operation of UE's network for operating personnel, proponents and the general public. The HV non-IES EG intending to connect to the network shall not adversely affect the operation and safety of other existing network users. UE may impose limitations and/or conditions of operation on the new HV non-IES EG connection in order to mitigate these issues.

Table 14: Protection requirements for HV non-IES EG

EG integrated protection	Yes
Backup protection	Yes – located as close as possible to the HV incoming supply

8.6.2.1 HV non-IES EG Integrated Protection

HV non-IES EG integrated protection refers to protection configured directly on the non-IES EG. For example, for a diesel generator, this is the protection directly programmed on the diesel generator controller. Table 15 below indicates UE preferred protection settings. Any deviations will need to be negotiated with UE during the application process.

Table 15: HV EG integrated protection requirements

Protection function	Setting (per unit)	Maximum disconnection time
Under voltage	0.78	2s
Over voltage 1	1.13	2s
Over voltage 2	1.15	0.2s
Under frequency	47Hz	2s
Over frequency	52Hz	0.2s
ROCOF	Calculated based on HV non-IES EG inertia and characteristics	≥ 0.2s
Vector Shift		Instantaneous

Protection function	Setting (per unit)	Maximum disconnection time
Reverse power towards HV EG	Typically, 5% of HV non-IES EG power rating	To be determined by proponent
Synchronisation Check	As per HV non-IES EG characteristics	To be calculated based on manufacturer's specifications and synchronising method
Reconnection Time Delay	> 60s	

Note: UE may request for an additional synchronisation check relay upstream of the generator synchroniser if the integrated synchronisation check cannot be tested by secondary injection. This will be based on the EG system design and capacity.

8.6.2.2 Backup Protection

Backup protection shall be required for all HV non-IES EG connections that has a total capacity greater than 30kVA. For HV non-IES EG connections with a total capacity of less than 30kVA, backup protection shall be required when:

- the integrated protection does not comply with *IEC 60255*, and/or
- secondary injection testing of the integrated protection is not possible

The backup protection relay shall be compliant with *IEC 60255*. It shall trip a circuit breaker for all current-based and voltage-based faults.

The back-up protection shall scheme consist of a battery backup or UPS backed supply with adequate alarm and monitoring. A failsafe wiring for the trip circuit is required to disconnect the generator on DC supply failure. The generator shall disconnect within 2s when the DC voltage drops below DC under voltage threshold or a total loss of DC supply.

In the event of the backup protection relay failure, the protection scheme shall disconnect the HV non-IES EG within a maximum of 2s. Where duplicated protection schemes have been implemented, this may not be required and will be assessed as part of the application process.

Trip signal shall be hard wired to the relevant circuit breaker for protection based on fault current. Where hard wired schemes are not possible for passive anti-islanding protection, alternative schemes may be considered and shall be negotiated with UE.

Table 16: HV non-IES EG Backup Protection Requirements

Backup protection function	Requirements
Directional overcurrent	May be required if the overcurrent protection at HV POC is not sensitive enough to detect fault contribution from the HV non-IES EG for faults on the network. The directional overcurrent shall trip within 150ms for a solid phase-to-phase and phase-to-ground short circuit at the network connection point. Where this fault clearance time cannot be achieved, the proponent should consult with UE to determine the maximum permissible fault clearance time to be adopted. Where possible, the protection trip output shall be latched.
Current unbalance protection e.g. negative sequence current protection	Current in each phase shall not deviate from the average of the three phase currents by more than 5% for periods greater than 2 minutes.
Passive anti-islanding protection	See section below for more details.
Synchronisation check	• Δφ< ±15°; to be negotiated with UE based on manufacturer specifications • Frequency and voltage deviation limits to be negotiated with UE • Time delay to be calculated based on manufacturer's specifications and synchronising method
Power export protection	This is site specific and shall be negotiated with UE based on network constraints with a maximum trip delay of 2s.
Remote Tripping	This is site specific and shall be negotiated with UE based on network constraints. See section below for remote trip scheme requirements.
Reconnection Time Delay	The backup protection is required to have a reconnection time delay of greater than 60s post voltage-based protection operation (e.g. under voltage, over voltage etc.). In other words, once the protection has

Backup protection function	Requirements
	operated and tripped the relevant circuit breaker or contactor, the network parameters must be within the limits set out in Table 17 for at least 60s before the HV non-IES EG can reconnect with the network. For HV non-IES EG systems greater than 1MVA, the proponent shall contact NCC prior to reconnecting the HV non-IES EG system to the network.

- **Passive Anti-Island Protection**

Voltage sensing for anti-islanding protection of the HV non-IES EG shall be connected at point of connection which is upstream of both the HV non-IES EG connection and any power quality improvement devices (i.e. active filters etc.). The protection relay shall be compliant with *IEC 60255*.

Table 17: HV non-IES EG anti-islanding protection requirements below indicates UE preferred anti-islanding protection settings.

Table 17: HV non-IES EG anti-islanding protection requirements may not apply to HV non-IES EG with total capacity between 2MW and 5MW or providing network services/ancillary services, which may operate with wider protection settings while supplemented with a reliable anti-islanding protection (e.g. remote trip scheme with UE). Any deviations shall be negotiated with UE during the application process.

Table 17: HV non-IES EG anti-islanding protection requirements

Under voltage (V_{L-N})	0.78	2s
Over voltage 1 (V_{L-N})	1.13	2s
Over voltage 2 (V_{L-N})	1.15	0.2s
Under frequency	47Hz	2s
Over frequency	52Hz	2s
ROCOF[1]	Calculated based on HV EG inertia and characteristics	Decided based on ROCOF setting
Vector Shift[1]		Instantaneous
Neutral voltage displacement[2]	10% of line to line voltage (V_{L-L})	3s

Notes:

1. The suitability of ROCOF and Vector Shift for anti-islanding protection of the HV non-IES EG is summarised in Table 18. The suitability of ROCOF and Vector Shift for anti-islanding protection depends on the loading on the UE HV supply feeder. As the feeder loading may vary with time, the effectiveness of ROCOF and vector shift may be compromised. Hence, the proponent shall undertake periodic review of ROCOF and vector shift at an agreed interval with UE. The proponent will be required to modify the design of their HV EG installation if the anti-islanding protection is found to be inadequate.
2. Where the HV EG system is installed in areas with REFCL deployment, the setting for neutral voltage displacement will be subject to negotiation based on site specific condition.

Table 18: Suitability of ROCOF and vector shift for HV non-IES EG

Type of HV EG	Suitability of ROCOF and Vector Shift for Passive Anti-Islanding
Synchronous generator with 30kVA < Capacity < 1000kVA	If the generator rating is more than 80% of the minimum load on the HV feeder protection zone and network sectionalisation, a minimum import or a dedicated remote trip scheme between the feeder circuit breaker and/or ACR and the non-IES EG's circuit breaker may be required. Refer to the section below for remote trip scheme requirements.
Asynchronous generator	An induction machine draws reactive energy for excitation from the electricity network and therefore cannot sustain operation and island. It is noted however that asynchronous non-IES EGs may self-excite from power factor correction capacitors and/or adjacent capacitance within the electricity network. For large non-IES EGs, studies will need to be undertaken to confirm that the output from such a non-IES EG will decay rapidly when network connection is lost. Anti-islanding protection in the form of ROCOF and voltage vector shift protection must be installed regardless of the outcome of such studies.

8.6.2.3 Remote Trip Scheme

The purpose of the remote trip scheme is to immediately and automatically transmit a trip command to the proponent's HV EG CB in response to a UE protection trip resulting in the loss of the relevant UE HV feeder. Figure 4 below illustrates a typical remote trip scheme.

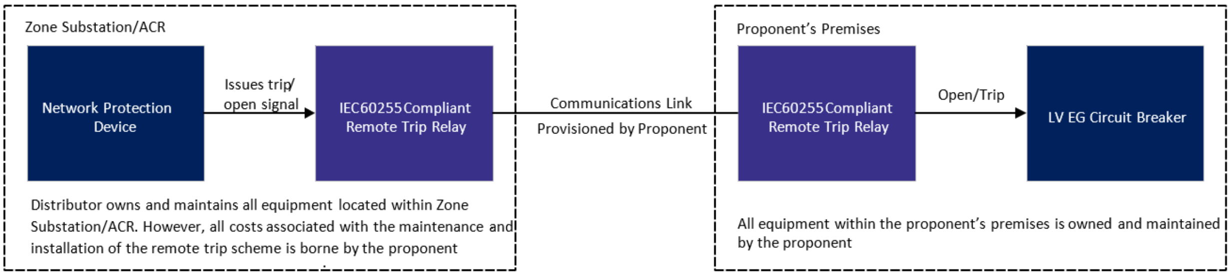

Figure 4: Typical Remote Trip Scheme

The minimum requirements for the proponent's remote trip scheme are as follows:

- Backup protection (including voltage and current sensors) that forms part of the proponent HV protection scheme shall be installed at the HV incomer of the installation. Any changes to the location of the backup protection, including voltage and current sensors, shall be negotiated with UE.
- Send a remote trip signal to the proponent's HV EG CB for any relevant UE protection operation, "loss of mains"
- network scenarios on the HV supply feeder including overcurrent, earth fault and sensitive earth fault protection.
- UE Network Control Centre (NCC) operators shall have the facility to trip the proponent's HV EG CB via UE NCC SCADA. This trip shall be latched until NCC resets the trip signal. This trip signal shall result in the proponent's HV EG CB closing to be blocked as well.
- Send a remote trip signal to the proponent's HV EG CB for any manual initiated open command on the HV supply feeder /ACR (both via UE operator on site at the supply zone substation or controller in the UE NCC).
- Tripping of the proponent's HV EG CB shall be completed within a maximum of 200ms from the time of the UE protection operation or manually initiated command. Any deviation of the disconnection time shall be negotiated with UE.
- The scheme shall be configured so that the proponent's HV EG CB is automatically tripped in the event the integrity of the scheme is compromised, including equipment failure associated with the scheme. The proponent HV EG CB shall trip if the integrity of the scheme is not restored (e.g. equipment failure, loss of auxiliary supply etc.) within 2s to ensure the scheme is fail safe.
- End to end supervision of the communication shall be enabled and failure of the connection shall disconnect the HV EG in less than the auto reclose dead time of the upstream UE isolation device. The time delay for the supervision function shall be negotiated with UE.
- At a minimum the following information shall be telemetered to the UE NCC via SCADA for each proponent's remote trip scheme:
  - Equipment fail alarm for both ends

- Health of communications link
- Remote trip received by proponent
- Proponent HV EG CB fail to open (after receipt of remote trip signal)
- Proponent HV EG CB status (open/closed)
- Loss of mains (loss of network) protection operated
- Proponent generation (kW) with measurement accuracy within ±2%
- Proponent reactive power output (kvar) with measurement accuracy within ±2%
- Proponent net load (kW) with measurement accuracy within ±2%
- Proponent net reactive power consumption (kvar) with measurement accuracy within ±2%
- Additional voltage, current or power quality parameters such as harmonics, flicker, voltage dips and swells may be required. These will be negotiated as part of the application process.

8.6.3 Special Operational Conditions

The following HV EG protection is required for special UE network operational conditions:

- **Live line work by UE**

When works are undertaken near or on live HV distribution feeders, UE enables a live line operating mode which disables automatic reclose and enables low set instantaneous overcurrent and earth fault protection. With live line mode enabled, grading may be compromised with downstream protection (including the protection associated with the HV EG installation). If the proponent wishes to operate their HV non-IES EG when live line mode is enabled, the HV EG protection will also need to act much more quickly to disconnect from the network for phase-phase faults on the HV feeder while live line sequence is enabled. As such, additional requirements may be required and shall be negotiated with UE as part of the application.

- **Total Fire Ban (TFB) Days**

For HV EG installed in areas that may experience TFB restrictions, if the proponent chooses to operate their HV EG on TFB days, the HV EG will be required to disconnect instantaneously to avoid contribution to a fault. As such, additional requirements may be required and shall be negotiated with UE as part of the application.

- **Short Term Parallel**

UE requires the same analysis for both short term paralleling with the UE network as it does for continuous parallel operation of a HV EG. This is because the consequences of mal-operation are the same for short term parallel operation as with continuous operation. HV EG shall include a backup system to automatically disconnect the HV EG during a short term parallel in the event of a failure paralleling control scheme (i.e. extended parallel protection). HV EG will require protection as per above Table 16 if the maximum parallel time is≥ 1s. Note that where the fault level limit is compromised, paralleling for any time may not be allowed.

- **Portable HV EG parallel operation**

It is necessary to have critical protection and control systems as part of the permanent installation. See sections 8.6.2.1 and 8.6.2.2 for the required protection.

8.6.4 Switchgear and Control Gear Requirements

The switchgear and control gear associated with the HV non-IES EG connection shall be:

- Compliant to all relevant standards, codes legislations and regulations listed in section 3
- Switchgear – appropriate breaking and thermal capacities based on the fault level at the switchgear location. Refer to Figure 5 below (this is extracted from the Electricity Distribution Code) for the maximum HV fault level. Site specific fault level at proponent POC can be obtained from UE.

DISTRIBUTION SYSTEM FAULT LEVELS		
Voltage Level kV	**System Fault Level MVA**	**Short Circuit Level kA**
66	2500	21.9
22	500	13.1
11	350	18.4
6.6	250	21.9
<1	36	50.0

Figure 5: Fault Levels Extracted from the electricity Distribution Code

- EG isolation – All EG shall have a lockable isolating device owned and operable by the proponent.

8.6.5 Interlocking

The interaction, interlocking and safe operation of different types of generation downstream of the point of connection shall be the responsibility of the Customer.

When connecting an islanded HV non-IES EG system to the network, synchronisation check protection shall be implemented.

8.7 Operating Voltage and Frequency

UE has an obligation to maintain the network voltage in compliance to the Distribution Code. Introduction of HV non-IES EG to the network may impact the network voltage and deviate it beyond the limits of the Distribution Code. The EG shall not adversely affect the voltage at the point of connection (POC) such that the voltage deviates beyond the limits of the Electricity Distribution Code.

The HV EG system shall operate at the frequency ranges in compliance with AEMC's Frequency Operating Standard.

It is the responsibility of the proponent to maintain the voltage of the HV and LV electrical reticulation within the proponent premises.

8.8 Metering

Metering shall be installed as per Victorian Service and Installation Rules[3].

8.9 Power Quality

HV non-IES EG have power quality response capability to either maintain the power quality at the point of connection or provide support to the network. HV non-IES EG shall comply with the applicable power quality requirements of the *AS/NZS 61000* series as well as relevant Victoria regulations (e.g. Victorian Distribution Code) and licence conditions, including but not limited to:

- Network voltage control
- Voltage fluctuations
- Harmonics
- Voltage balance

8.9.1 HV Non-IES Voltage Response Modes

HV non-IES EG can be configured with either of the following modes:

- Fixed power factor control mode
- Voltage control mode
- Reactive control mode

The voltage response mode configured for HV non-IES EG shall be negotiated with UE as part of the application process as it is dependent on network characteristics at the point of connection.

8.9.2 Network Ancillary Services

AEMO is responsible for maintaining the network frequency close to 50Hz in accordance with the NEM frequency standards and for keeping the voltage within an acceptable range at particular nodes on the transmission network and for scheduling power flow between regions while maintaining power flows within the capability of plant. AEMO achieves these objectives by dispatching scheduled generation to match the load and via ancillary services.

Ancillary services can be one of the following:

- Frequency Control Ancillary Services (FCAS)
- Network Control Ancillary Services (NCAS)
- System Restart Ancillary Services (SRAS)

In practice FCAS and NCAS are offered by HV EGs by providing either real power or reactive power reserves that may be required in response to a network fluctuation, disturbance or event or based on load flows to provide local network support. Any HV EG has the option to provide ancillary services.

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3 http://www.victoriansir.org.au/

HV non-IES EG participating in network ancillary services has the potential to rapidly change network load, resulting in significant voltage impact on the local network. Hence, the HV non-IES EG shall adopt necessary controls to prevent adverse impacts on the power quality at the point of connection while generating to provide ancillary services.

8.10 Embedded Network

HV embedded network operator is exclusively responsible for the management of the embedded network including any EG within the embedded network as the Distributor does not have direct relationship with the EG and/or the proponent. Hence, the HV embedded network operator shall provide all materials which demonstrates compliance to this document and other applicable standards and regulations.

The Distributor however may require remote tripping of the EG. This will be defined in response to the connection application.

8.11 Communications Systems

For HV non-IES EG systems requiring remote trip schemes, the communication requirements are outlined in Section 8.6.2.3.

Proponents shall also install remote monitoring of their HV non-IES EG systems to ensure that the proponent is promptly notified of issues with their HV non-IES EG systems. Remote monitoring of HV non-IES EG systems by the proponent may be achieved via use of the HV non-IES EG manufacturer's software applications.

A generator monitoring meter is required for systems ≥200kVA. This scheme will provide remote monitoring capability as well as the ability to UE to remotely trip the generation if required by AEMO. Refer to section 11 for further details.

8.12 Data and Information

8.12.1 Static Data and Information

The static data and information shall be provided by the proponent to UE as listed in Appendix F: Static Data and Information UE will provide this data to AEMO's Distributed Energy Resource Register (DERR) on behalf of the proponent.

8.12.2 Dynamic Data and Information

For HV non-IES EG systems requiring remote trip schemes, the dynamic data requirements are outlined in Section 8.6.2.3.

8.13 Cybersecurity

The HV EG settings shall be secured against inadvertent or unauthorised tampering. Changes to the HV EG settings shall require the use of tools (e.g. special interface devices and passwords) and special instructions not provided to unauthorised personnel.

8.14 Technical Studies

Technical studies shall be completed as part of the connection application as per Table 19.

Table 19: Technical Studies Required for HV EG IES Connections

Technical Studies	HV EG IES
Power Flow Study	–
Fault Level Contribution Study	✓
Protection Study	✓
Power Quality Impact Study (including harmonics, flicker, voltage step change, unbalance)	–
Earthing Study	–
Dynamic System Studies (see Section 8.14.5)	–
Symbols are used to denote technical studies requirements, where: ✓ Represents that technical studies shall be required – Represents that technical studies may be required	

As part of the application process, UE shall provide the following network data to enable the proponent to complete the required technical studies:

- network fault levels up to the point of common coupling
- network model
- network protection information for UE assets (e.g. protection settings)
- network equipment information for UE assets (e.g. line and conductor ratings)

Where one or more of the technical studies does not meet the assessment criteria, UE shall provide the proponent feedback on components of the submission that require further work. The proponent has the option to discuss with UE:

- Alternative configurations of the HV EG IES systems
- Network augmentation (and associated cost of network augmentation)

8.14.1 Power Flow Study

The requirement for a power flow study shall be negotiated with UE as part of the application process. Typically this is required for larger installations where there may be thermal impacts to UE's distribution network or where there are impacts on the proponent's maximum demand.

8.14.2 Power Quality Impact Studies

The requirement for this study shall be negotiated with UE as part of the application process.

8.14.3 Fault Level Contribution Study and Protection Settings Report

A comprehensive protection study is required for all HV EG installations. The fault level contribution and protection settings shall be included in this study. Please refer to https://myenergy.ue.com.au for additional information. This form can be found on UE's website.

8.14.4 Earthing Study

An earthing study is required if alterations or additions are made to the proponent's HV network.

8.14.5 System Studies

Steady State Study

The following steady state studies may be required for HV EG applications:

- Power Flow Study (including network contingency analysis where applicable)
- Fault Level Contribution Study (including network contingency analysis where applicable)

- Protection Study (including network contingency analysis where applicable)
- Power Quality Impact Study (including harmonics, flicker, voltage step change, unbalance, network contingency analysis where applicable)

The proponent shall negotiate with UE to determine the required steady state studies for their application,

Dynamic Study

Dynamic studies may be required depending on the following:

- outcome of steady state studies,
- presence of non-standard design features as part of the HV EG connection (e.g. STATCOM)
- location of the HV EG on the network

The studies may include:

- Transient/step frequency disturbance
- Transient/step voltage fluctuation
- Generator stability
- Generator governor control/excitation control
- Frequency response
- Fault ride through

The dynamic study requirements shall be negotiated with UE as part of the application process.

9. Testing and Commissioning for HV non-IES EG

Testing and commissioning of the HV non-IES EG installation shall be undertaken by the proponent in accordance with *AS 2067*, *AS/NZS 3000*, the equipment manufacturer's specifications and to the technical requirements stipulated in this document. The testing and commissioning results shall demonstrate that the installed HV non-IES EG system meets the requirements of the connection agreement.

Note these tests shall be installation tests and not type tests of the equipment.

In addition, the following requirements for network connection of HV non-IES EG systems shall be met:

1. Testing and commissioning plan shall be produced by the proponent covering all newly installed equipment, interfaces with existing equipment and end to end testing of remote trip scheme (if installed). The plan shall be produced based on the sequence of testing on site.
2. All tests shall be provided in a test report format or ITP format with reference made to the commissioning plan. The test report shall clearly indicate pass/fail criteria for each test.
3. Pre-commissioning shall be undertaken to prove the functionality of the complete scheme.
4. The results of all testing and commissioning activities shall be thoroughly documented and shall align with the commissioning plan.
5. Testing and commissioning acceptance shall be signed off by a suitably qualified and authorised person.
6. Testing and commissioning acceptance may require UE to carry out witnessing at the proponent's expense.

Table 20: Testing and Commissioning for HV non-IES EG

Testing and Commissioning Submission	HV non-IES EG	
	Exporting	Non-exporting
Protection settings and performance[1]	✓	✓
HV switchgear integrity and performance	✓	✓
CTs and VTs performance test results	✓	✓
Power quality settings and performance	–	–
Export limits settings and performance	–	✓
Earth grid in compliance to AS 2067:2016	–	–
Communications performance for monitoring system[2]	✓	✓
Site Maintenance Procedure	✓	✓

Testing and Commissioning Submission	HV non-IES EG	
	Exporting	Non-exporting
Safety and Operating Procedure	✓	✓
Confirm system is as per specifications	✓	✓
Confirm single line diagram is located on site	✓	✓
As-built documentation and drawings	✓	✓
Certificate of Electrical Safety (CES)	✓	✓
UE HV EG Commissioning Form (see Appendix F)	✓	✓
Symbols are used to denote testing and commissioning requirements, where: ✓ Represents that testing and commissioning shall be required – Represents that testing and commissioning may be required		

Notes:

1. Protection Settings and Performance

The HV non-IES EG protection relay shall be tested by secondary injection. All necessary functional tests shall be carried out to prove that the protection and control schemes operate as per the design.

2. Power Quality Settings and Performance

On-load tests shall be undertaken after protection settings and performance tests have been completed. During these onload tests, the value of electrical parameters shall be recorded such as HV EG voltage, current, active power, power factor and frequency. On-load tests shall confirm the HV EG regulates active power and power factor within a certain tolerance of the applied settings when synchronised with UE's network

3. Communications schemes for monitoring

- End to end testing of monitoring data points are required.
- Where remote tripping is required, full end-to-end testing of the remote trip scheme is required.

10. Operations and Maintenance

HV EG systems shall be operated and maintained to ensure compliance with their connection agreement and all legislation, codes, and/or other regulatory instruments at all times. The operations and maintenance requirements for HV EG connections, includes:

1. The HV EG system shall be operated and maintained to ensure compliance with the connection agreement and all legislation, codes, and/or other regulatory instruments at all times
2. As a function of the routine maintenance checks, a record of inspection activities undertaken at the site demonstrating that the installation has been tested and is safe to remain connected to the network is required. Record of inspections shall be retained by the customer and made available to the Distributor upon request

The following documentation is to be kept at the HV EG installation in compliance with relevant codes and is to be readily accessible by UE's representatives:

- A single line diagram showing all electrical metering points, protection functions and zone of coverage.
- A record of all approved protection settings.
- A copy of the approved operating procedures.
- Maintenance plan and records.

In addition, the proponent shall:

1. Maintain and operate the HV EG installation in a safe condition
2. Ensure that any changes to the HV EG installation are performed by an electrician lawfully permitted to do the work and that the proponent holds a Certificate of Electrical Safety (CES) issued in respect of any of the changes
3. Seek UE approval prior to altering the connection in terms of an addition, upgrade, extension, expansion, augmentation or any other kind of alteration, including any changes to protection functions or settings.

If any breach of this technical standard is suspected, UE may undertake an investigation. If the investigation reveals a breach, the proponent shall be required to rectify this breach and pay UE for the costs associated with the investigation and associated works undertaken by UE.

11. Generator Remote Disconnect (Network Device)

The Victorian Government has introduced a mandatory emergency backstop mechanism (remote disconnection functionality) requirement for new and replacement embedded generation systems hosted on the distribution network. Generators are required to disconnect during minimum demand events upon receiving a disconnection signal from the Distributor. This requirement shall apply to new or replacement HV EG generation (except like for like replacement) installed on or after 01/10/2023.

The following generation types with a total capacity ≥200kVA shall comply to the disconnection command:

- Inverter based generation such as solar PV and BESS
- Synchronous generation

The HV EG installation shall be required to have a Generator Monitoring Meter (GMM). This is a Network Device (as defined under *NER* chapter 7, clause 7.8.6) and shall be installed and wired to a design similar to Revenue or NEM metering. However, it shall not be utilised in any Market Settlements or Retail / Network billing.

The GMM shall provide the following functions.

- Operate a trip output contact that shall be used to disconnect HV EG from the distribution network.
- Measure HV EG generation data: Voltage (R,W,B), Current (R,W,B), kW, kVar

Multiple GMMs may be installed depending on the configuration of the installation. Refer Appendix C: Typical GMM Configuration for typical generation and GMM installations.

11.1 GMM Installation Requirements

11.1.1 Current Transformer and CT Chamber

The GMM, as a Network Device, remains under the ongoing control of the Distributor.

The installation is to be undertaken in accordance with the requirements of Chapter 8 of the *Victorian Service and Installation Rules (VSIR)*, and in particular with the section 8.11 LV "Current Transformer Metering". A typical wiring diagram is shown in Appendix D: GMM Wiring Diagrams.

UE will supply 3 x LV current transformers and associated wiring loom up to 10 metres long for installation by the HV Customer in accordance with the *VSIR* clause 8.11.5, 8.11.6 and 8.11.7. The CTs shall be Type S, Type T or Type W as per *VSIR* clause 8.11.3.2 and figure 8.11-E. The HV Customer shall provide the CT chamber in accordance with *VSIR* clause 8.11.5 and be labelled "Generator Monitor Metering Transformers" complying with clause 5.4. The HV Customer shall supply and install LV 32A fuse bases and cartridges, and 4mm2 single core double insulated wiring from the busbar to the 32A fuse bases as per *VSIR* clause 8.11.7.1.

11.1.2 Installation

The HV Customer shall supply the meter panel to UE for fit out as per *VSIR* clause 8.11.2.4. UE shall install the meter panel with test block, fuses and the GMM and any specific communications equipment such as aerials. The HV Customer shall provide a suitable location for the meter panel installation. Any site-specific mounting equipment to secure the meter panel shall be provided by the HV Customer. The HV customer shall ensure that the integrity of the meter panel, and associated equipment are not compromised after installation.

Where the GMM is to be located within a basement or internal switch room, a remote antenna (outside of the building) may be required for communications. The HV Customer shall consult UE and provide suitable conduit for installation of the antenna cabling. This conduit, draw wire or antenna cabling installation and any wall penetrations shall be provided by the HV Customer as per *VSIR* clause 8.12.2.1.

UE shall commission the GMM into service.

11.1.3 Control Signal Wiring

The voltage connection to the GMM shall be such that the GMM supply is not interrupted following operation of the EG disconnection function (e.g. voltage supply to the GMM shall be connected upstream of the disconnection device). The voltage supply to the GMM shall be nominal 230/400V AC.

The GMM control wiring shall be in accordance with Appendix D: GMM Wiring Diagrams, and shall consist of one output contact. This output contact shall be for control purposes only and may be used to drive an auxiliary relay or digital input. However, it may not be used for direct tripping of circuit breakers. To allow for different installations with varied control voltages the GMM output is provided as a voltage free contact. The HV Customer shall provide an appropriate extra low DC control voltage for switching by the GMM output. This voltage is to be limited to a maximum of 50V DC with suitable fusing at the source end of the wiring. The GMM output contact shall not exceed the maximum contact rating of 2A.

The HV Customer shall provide the GMM control wiring to the meter board location. The GMM, associated fusing and test block in the meter panel will be sealed by UE and shall not be accessed by others.

This GMM and associated equipment shall be independent to, and segregated from, all revenue metering equipment.

11.1.4 Access

The meter panel shall be located such that it provides safe and easy access. The HV Customer shall also ensure that a safe environment, required isolations, safe and easy access to the work area is provided to UE during GMM installation, commissioning, and future maintenance works.

11.1.5 Configurations with Multiple GMM

For installations that have multiple generators connected to different distribution boards, the GMM shall be installed at the relevant upstream generation bus. Where there are multiple inverter based generators intended to be directly connected to a switchboard, it is expected that the generation will be connected via a dedicated switch to a generation bus in accordance with *AS 4777.1* section 5.5. The GMM disconnect signal shall disconnect the main generation CB (e.g. main switch-inverter supply as per *AS4777.1*) via a suitable control scheme (i.e. slave relay operation).

11.1.6 Essential or Critical Services

For critical customers, exemptions to the minimum demand disconnect requirement may be sought and will be reviewed by UE. Critical customers are deemed as those where the disconnection and isolation of generating equipment will have significant detrimental impacts to the operation of the HV Customer. These include, but are not limited to, hospitals and emergency health providers, data centres etc. These HV Customer's will need to provide justification and proof of adverse operational impact to their operation caused by the disconnection.

11.1.7 Off Grid Operation

HV Customers intending to operate the generation while disconnected from the distribution network (i.e. during loss of mains supply or UE network outage) have the option to design the generation system such that the generation disconnection signal is interlocked with the incoming main CB status.

- Main incoming CB is closed – GMM shall disconnect the generation once the GMM output operates.
- Main incoming CB is opened – GMM is not required to disconnect the generation.

11.1.8 Equipment Replacement

Where works occur at an existing site with generation capacity ≥200kVA, that is not a like for like warranty replacement, the site shall be brought up to the latest standard in terms of GMM requirements.

11.1.9 Alternative Disconnection Capability

Where the installation has either a remote trip scheme or NVD based anti-islanding scheme as described in *UE-ST-5003 NVD Based Anti-Islanding Scheme*, a GMM may not be required if the emergency disconnection command can be implemented via UE SCADA to trip the relevant generation.

11.2 Test and Commissioning

The following pre commissioning tests shall be undertaken as a minimum. The HV Customer shall provide the required access, isolations and information to UE.

- CT connection, accuracy, burden, polarity test up to the test links of the metering panel.
- Point to point test of voltage supply wiring up to the test links of the metering panel.
- Analogue measurement verification inclusive of polarity of kW and kVar readings.
- Functional EG disconnect test.

The HV Customer shall provide UE with a copy of the COES for the installation prior to commencement of commissioning. The "Sanction to Connect" will be granted upon satisfactory completion of the GMM commissioning tests and generation system commissioning tests.

11.3 Labelling

Labels to be attached to meter panel and CT chamber to read as per sample below.

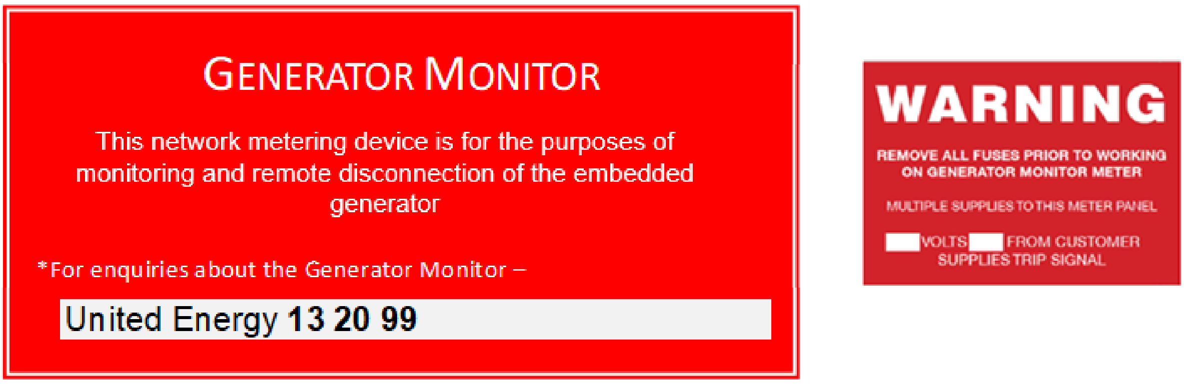


Figure 6: Labelling

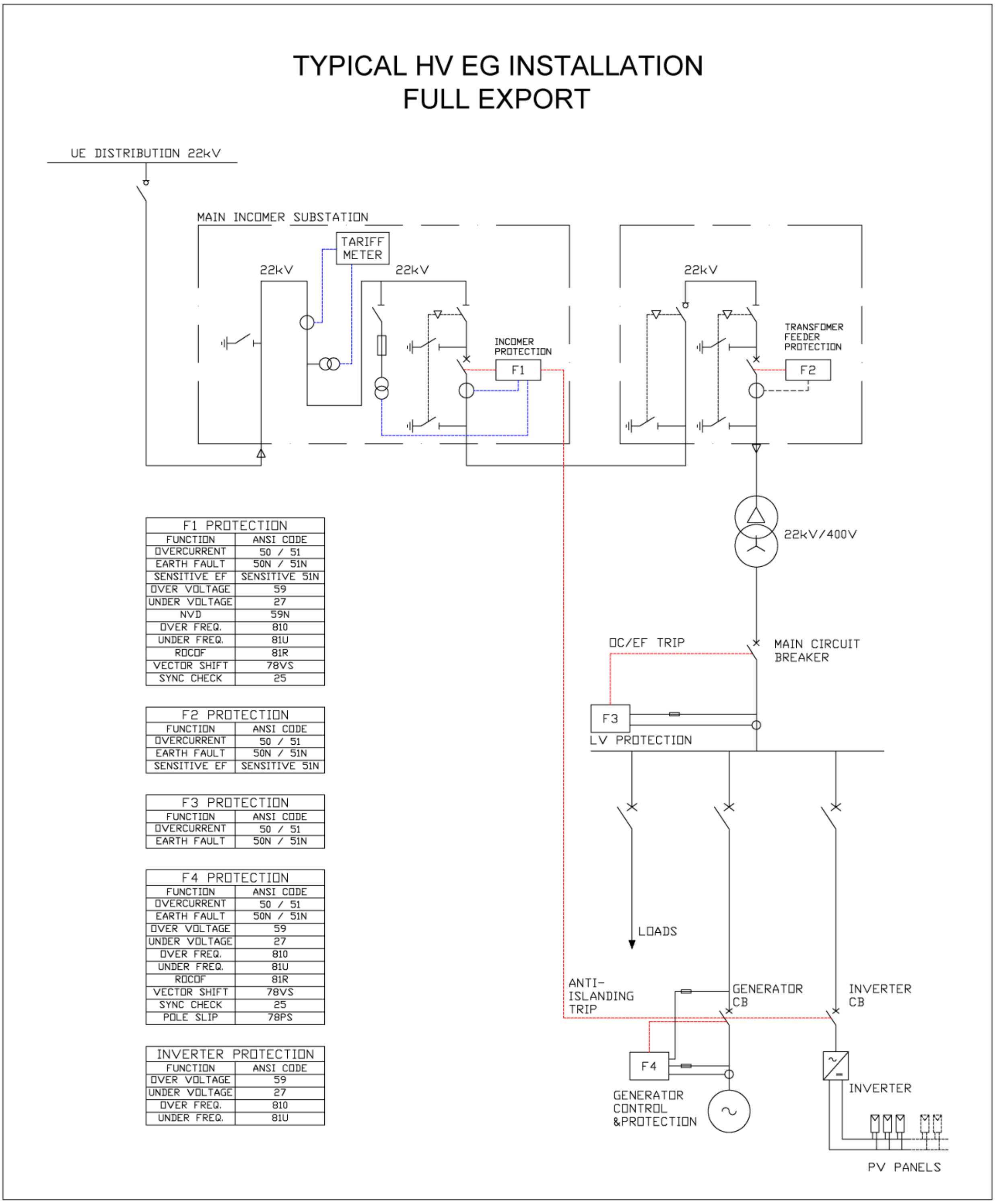
Appendix A: Deviations from the National DER Connection Guidelines

Table 21: Table of Deviations from National DER Connection Guidelines

Section	Description of Deviation	Type of deviation	Justification
1.1	All HV EG connections are to be three phase. In addition, the minimum system capacity for HV non-IES EG system is to be greater than 30kVA. There requirements are not stipulated in the National DER MV and HV EG Connection Guideline.	Promote improved benefits to Australia's electricity system	Promotes clarity on HV EG connection by differentiating requirements from the LV EG connection
1.3	Added additional obligations f to h	To meet jurisdictional requirement	To ensure the proponents meets the jurisdictional requirements
2.1	Definition of IES is different from the National DER LV EG Connection Guideline	To meet jurisdictional requirement	The definition was amended to align with AS/NZS 4777.1:2016
2.1	Added definition of a HV customer	Promote improved benefits to Australia's electricity system	c who is considered a HV customer
2.3	Terminology of the word 'may' and 'should' were swapped as described in the National DER MV and HV EG Connection Guideline	Promote improved benefits to Australia's electricity system	Clarifies requirements for proponents
3.2	Added additional requirements for HV EG installed in REFCL protected network areas	To meet jurisdictional requirement	To ensure the proponents meets the jurisdictional requirements
4 (5 in ENA guide)	Moved Fees and Charges section from section 5 as shown in ENA Guideline to section 4	Promote improved benefits to Australia's electricity system	Promotes readability and easier reference with sections 1 – 4 being common to both IES and non-IES EG
5 – 10 (4, 6 and 7 in ENA guide)	Created Part A for IES specific requirements and Part B for non-IES specific requirements. This is different to the approach from ENA guideline where IES and non-IES requirements were combined in the various sections	Promote improved benefits to Australia's electricity system	Promotes readability and easier reference with dedicated sections for IES and non-IES EG specific requirements
5.3.1, 8.3.1 (4.3.1 in ENA guide)	Specific export limit was stipulated instead of export limit to be determined at the time of application as stated in the National DER MV and HV EG Connection Guideline.	Promote improved benefits to Australia's electricity system	To facilitate HV EG connections by streamlining the assessment process whilst not adversely impacting the network
5.4 (4.4 in ENA guide)	Excluded items 3b – 3d as the National DER MV and HV EG Connection Guideline stated preferably instead of a requirement	To meet jurisdictional requirement	To ensure the proponents meets the jurisdictional requirements

5.7.2, 8.6.2 (4.7.2 in ENA guide)	Replaced central protection terminology used in National DER MV and HV EG Connection Guideline with backup protection	Promote improved benefits to Australia's electricity system	Promotes clarity on protection requirements
5.7.3, 8.6.4	Added an additional section on switchgear and control gear requirements	To meet jurisdictional requirement	To ensure associated equipment with HV EG are compliant with AS and international standards
5.10.2, 8.11.2	Added an additional section on network ancillary services requirements	Promote improved benefits to Australia's electricity system	To ensure system stability when the HV EG provides network ancillary services
5.11, 8.12	Added an additional section on HV connections with multiple tenancies / EG downstream of HV POC	Promote improved benefits to Australia's electricity system	To ensure EG downstream of HV POC will not adversely impact the network
5.12, 8.13 (4.11 in ENA guide)	Communication requirements are not based on export level as in the National DER MV and HV EG Connection Guideline. It is based on remote trip requirement.	Promote improved benefits to Australia's electricity system	Promotes clarity on communication requirements to only systems that require remote trip

Appendix B: Connection Arrangement Requirements



F1 PROTECTION	
FUNCTION	ANSI CODE
OVERCURRENT	50 / 51
EARTH FAULT	50N / 51N
SENSITIVE EF	SENSITIVE 51N
OVER VOLTAGE	59
UNDER VOLTAGE	27
NVD	59N
OVER FREQ.	81O
UNDER FREQ.	81U
ROCOF	81R
VECTOR SHIFT	78VS
SYNC CHECK	25

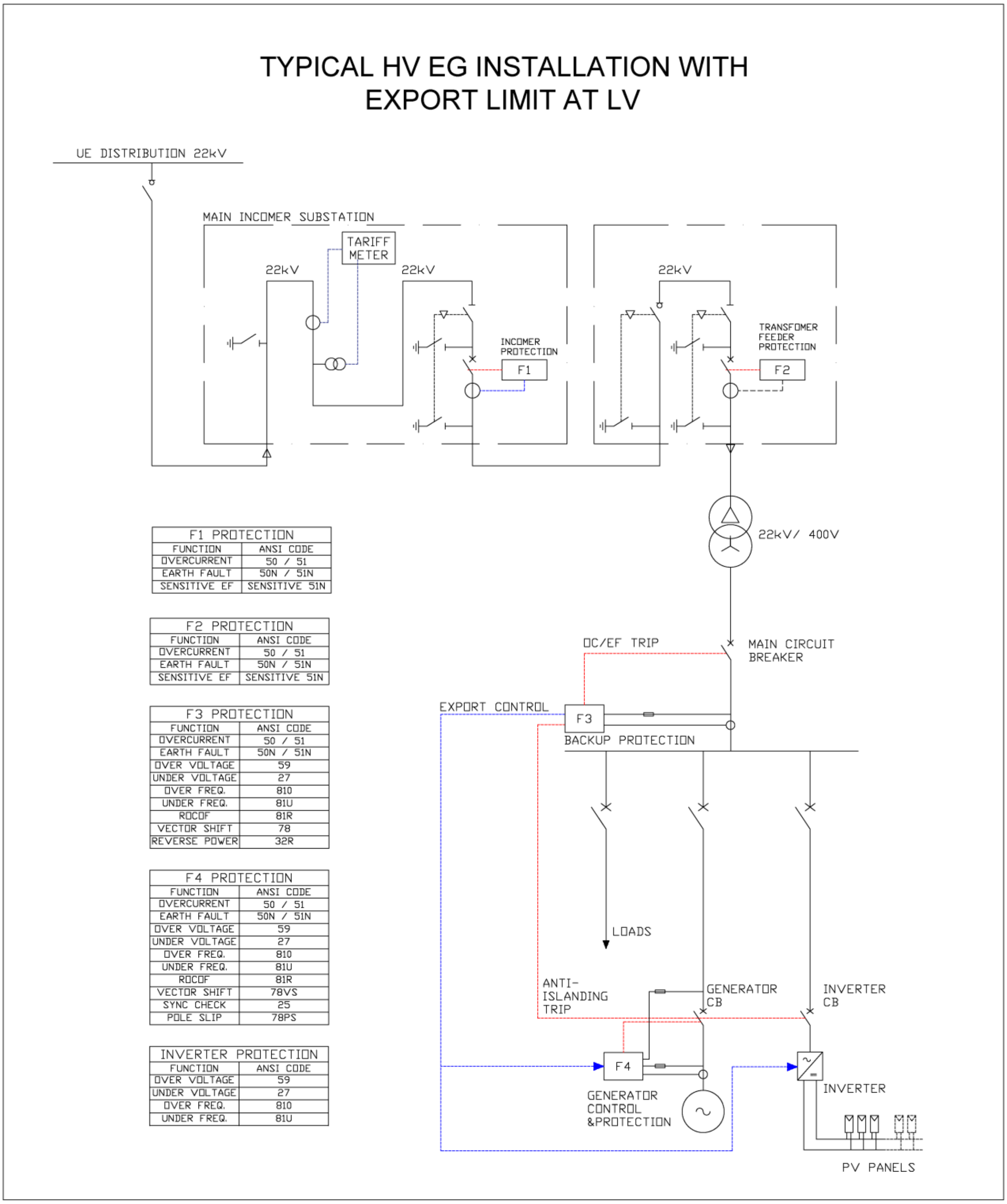
F2 PROTECTION	
FUNCTION	ANSI CODE
OVERCURRENT	50 / 51
EARTH FAULT	50N / 51N
SENSITIVE EF	SENSITIVE 51N

F3 PROTECTION	
FUNCTION	ANSI CODE
OVERCURRENT	50 / 51
EARTH FAULT	50N / 51N

F4 PROTECTION	
FUNCTION	ANSI CODE
OVERCURRENT	50 / 51
EARTH FAULT	50N / 51N
OVER VOLTAGE	59
UNDER VOLTAGE	27
OVER FREQ.	81O
UNDER FREQ.	81U
ROCOF	81R
VECTOR SHIFT	78VS
SYNC CHECK	25
POLE SLIP	78PS

INVERTER PROTECTION	
FUNCTION	ANSI CODE
OVER VOLTAGE	59
UNDER VOLTAGE	27
OVER FREQ.	81O
UNDER FREQ.	81U

Figure 7: Typical HV EG Installation with no export limit conditions Imposed



F1 PROTECTION	
FUNCTION	ANSI CODE
OVERCURRENT	50 / 51
EARTH FAULT	50N / 51N
SENSITIVE EF	SENSITIVE 51N

F2 PROTECTION	
FUNCTION	ANSI CODE
OVERCURRENT	50 / 51
EARTH FAULT	50N / 51N
SENSITIVE EF	SENSITIVE 51N

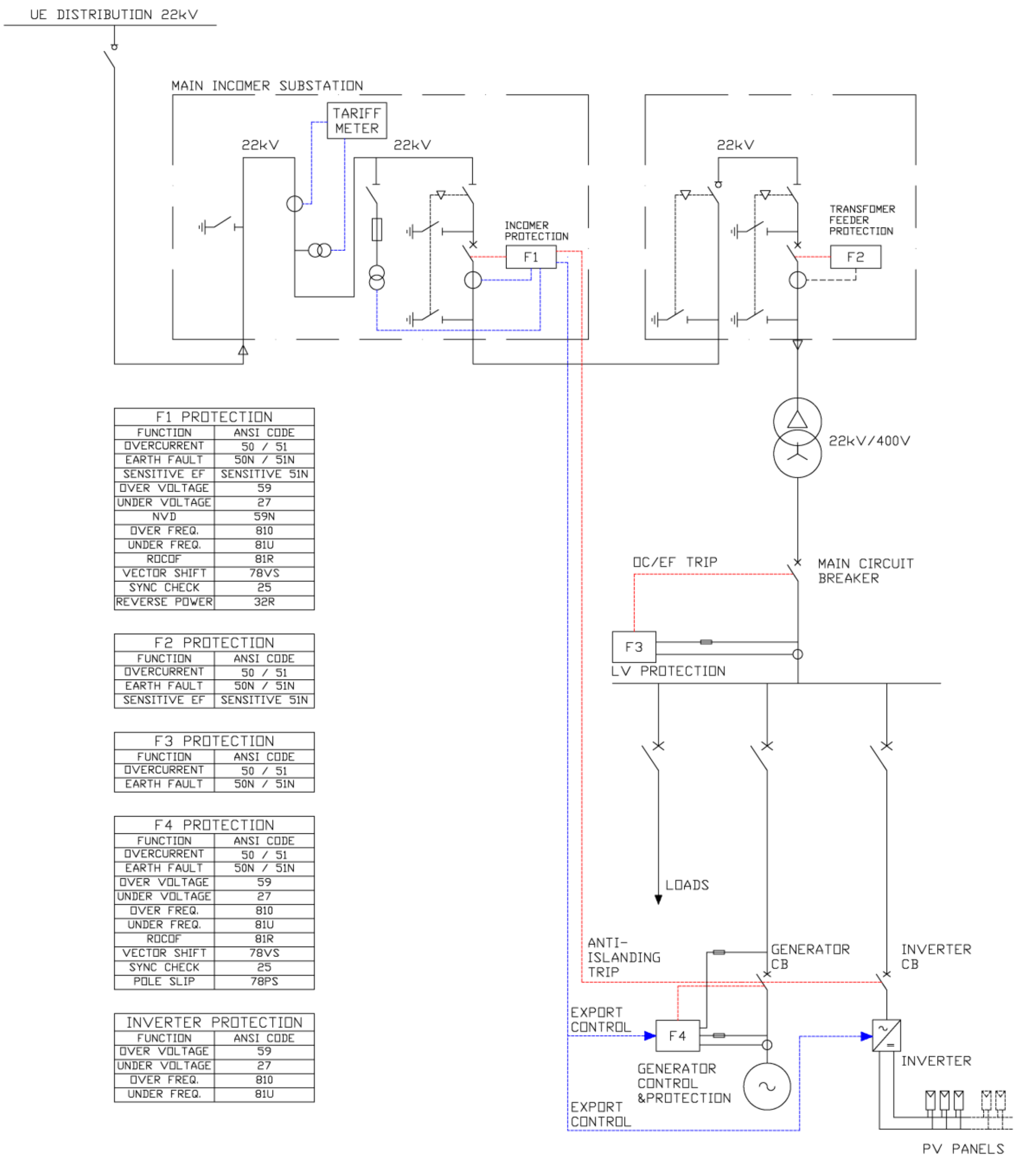
F3 PROTECTION	
FUNCTION	ANSI CODE
OVERCURRENT	50 / 51
EARTH FAULT	50N / 51N
OVER VOLTAGE	59
UNDER VOLTAGE	27
OVER FREQ.	81O
UNDER FREQ.	81U
ROCOF	81R
VECTOR SHIFT	78
REVERSE POWER	32R

F4 PROTECTION	
FUNCTION	ANSI CODE
OVERCURRENT	50 / 51
EARTH FAULT	50N / 51N
OVER VOLTAGE	59
UNDER VOLTAGE	27
OVER FREQ.	81O
UNDER FREQ.	81U
ROCOF	81R
VECTOR SHIFT	78VS
SYNC CHECK	25
POLE SLIP	78PS

INVERTER PROTECTION	
FUNCTION	ANSI CODE
OVER VOLTAGE	59
UNDER VOLTAGE	27
OVER FREQ.	81O
UNDER FREQ.	81U

Figure 8: Typical HV EG installation with export limit conditions imposed at LV

TYPICAL HV EG INSTALLATION WITH EXPORT LIMIT AT HV



F1 PROTECTION	
FUNCTION	ANSI CODE
OVERCURRENT	50 / 51
EARTH FAULT	50N / 51N
SENSITIVE EF	SENSITIVE 51N
OVER VOLTAGE	59
UNDER VOLTAGE	27
NVD	59N
OVER FREQ.	81O
UNDER FREQ.	81U
ROCOF	81R
VECTOR SHIFT	78VS
SYNC CHECK	25
REVERSE POWER	32R

F2 PROTECTION	
FUNCTION	ANSI CODE
OVERCURRENT	50 / 51
EARTH FAULT	50N / 51N
SENSITIVE EF	SENSITIVE 51N

F3 PROTECTION	
FUNCTION	ANSI CODE
OVERCURRENT	50 / 51
EARTH FAULT	50N / 51N

F4 PROTECTION	
FUNCTION	ANSI CODE
OVERCURRENT	50 / 51
EARTH FAULT	50N / 51N
OVER VOLTAGE	59
UNDER VOLTAGE	27
OVER FREQ.	81O
UNDER FREQ.	81U
ROCOF	81R
VECTOR SHIFT	78VS
SYNC CHECK	25
POLE SLIP	78PS

INVERTER PROTECTION	
FUNCTION	ANSI CODE
OVER VOLTAGE	59
UNDER VOLTAGE	27
OVER FREQ.	81O
UNDER FREQ.	81U

Figure 9: Typical HV EG installation with export limit conditions imposed at HV

Appendix C: Typical GMM Configuration

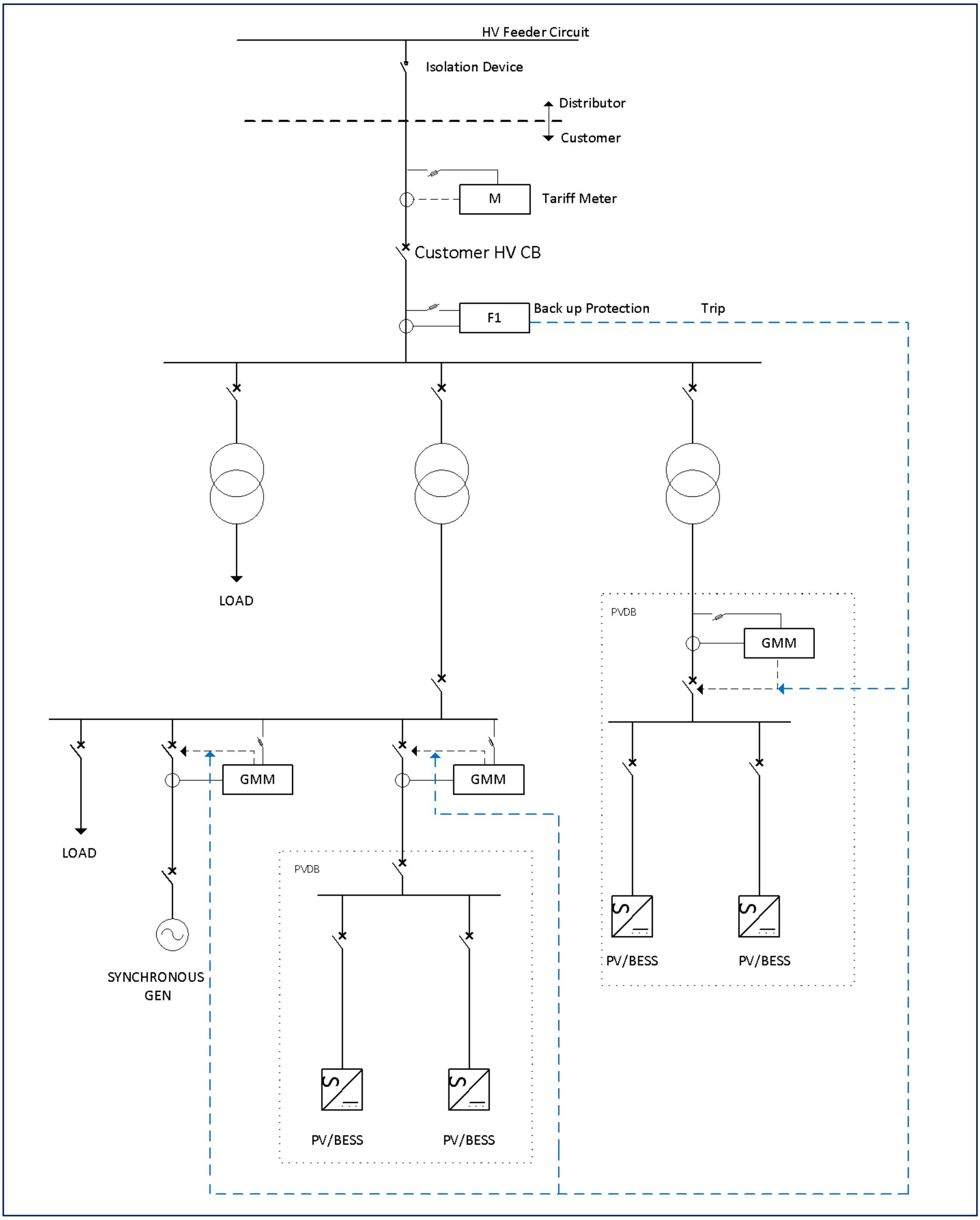


Figure 10: Typical GMM configuration

Appendix D: GMM Wiring Diagrams

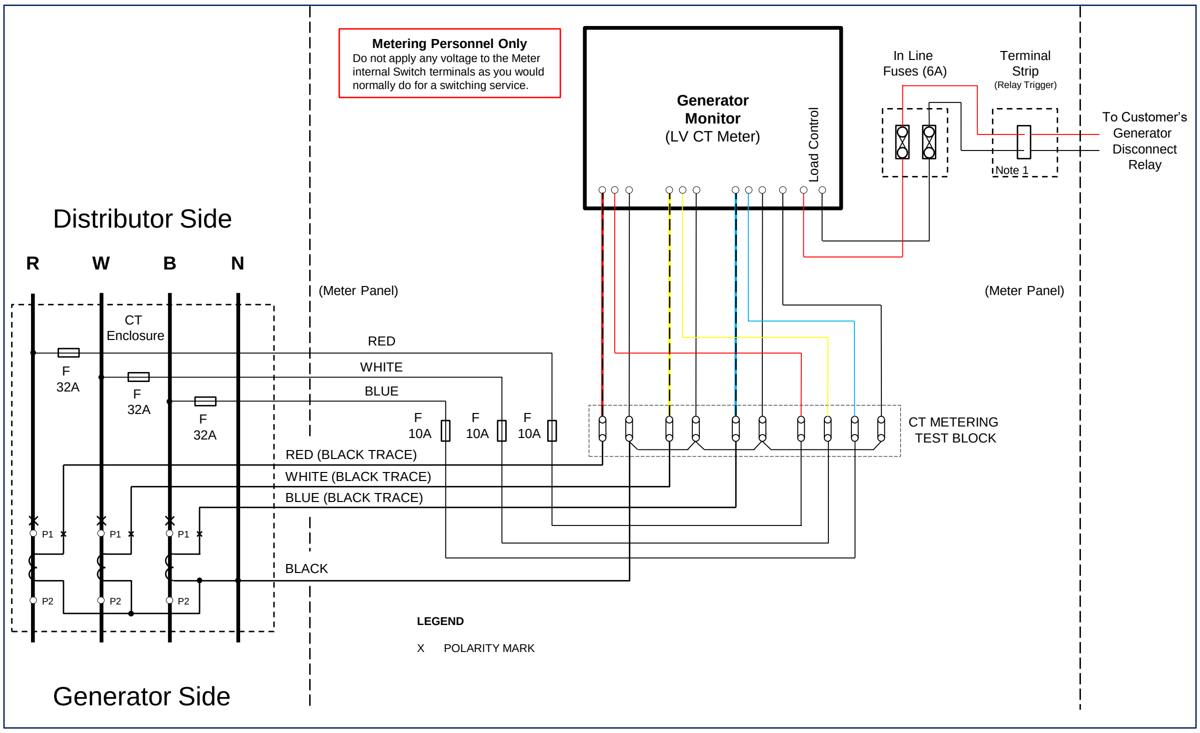


Figure 11: Typical Wiring Diagram for Generator Monitoring Meter

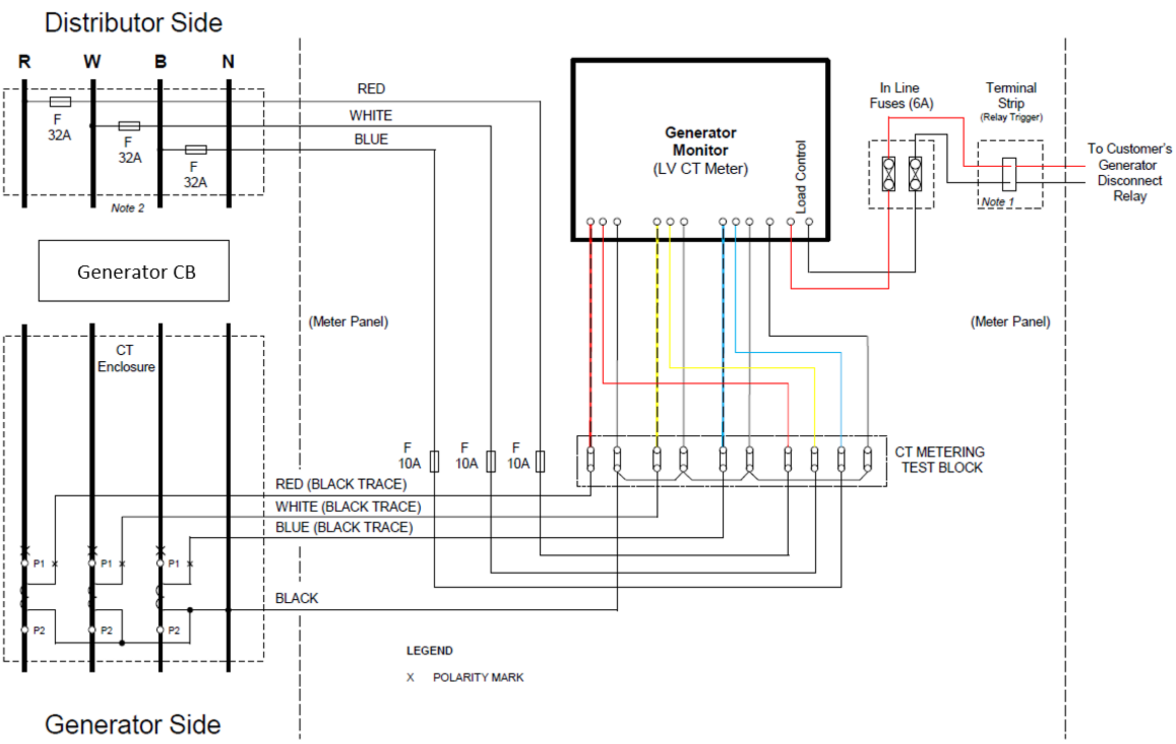


Figure 12: Typical Wiring Diagram for Generator Monitor

Notes:

1. In line fuses and terminal strip required.
2. Generator Monitoring Meter voltage supply to be sourced from a point upstream of the generator circuit breaker.

Appendix E: Sample Offer to Connect

A sample offer to connect can be found on UE's website[4].
For non-registered HV EG customers, please refer to the document titled:
Chapter 5A Distribution Connection Embedded Generator Agreement – Sample

[4] https://www.unitedenergy.com.au/partners/renewable-generators/negotiated-eg-connections/

Appendix F: Static Data and Information

Static data and information to be provided by the proponent on the HV EG connection can be found on UE's website[5].

For HV EG IES connections, please refer to the form titled:
UE-FM-5003 IES Commissioning Form

For HV non-IES EG connections, please refer to the form titled:
UE-FM-5004 Non-IES Commissioning Form

For HV connections with both IES and non-IES EG, please refer to the form titled:
UE-FM-5005 Combined Commissioning Form

[5] https://www.unitedenergy.com.au/partners/renewable-generators/negotiated-eg-connections/