SA Power Networks

Technical Standard - TS131

Inverter Energy System (IES) Above 200kW or Any Size Rotating Generating System

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1. Purpose

This technical standard provides designers, contractors and consultants with an understanding of the technical connection requirements for Inverter Energy Systems (IES) with a nameplate capacity above 200kW or all rotating generating systems, which are to be connected to SA Power Networks' distribution network.

The South Australian electricity distribution network has limited capacity in both directions. With an increase in the amount of generation systems being connected to the distribution network, the reverse demand (generation) is growing at a much faster rate than the forward demand. This technical standard includes additional monitoring requirements to enable SA Power Networks to manage the high voltage network within the thermal capacity of the network and assist in meeting our quality of supply obligations.

2. Scope

This standard outlines the equipment and installation requirements for Inverter Energy Systems (IES) above 200kW or all rotating generating systems, that are intended to be connected to and capable of operating in parallel with SA Power Networks' distribution network. Battery energy storage systems connected via Inverters are also classified as generating units and shall comply with the requirements specified within this document.

This document shall be read in conjunction with NICC270: 'Connection Requirements of Embedded Generation' and SA Power Networks' Service and Installation Rules (S&IR), which are available at (www.sapowernetworks.com.au), and shall be in accordance with the relevant AS/NZS standards (eg AS/NZS 4777 series, AS/NZS 3000, AS/NZS 5033).

For small IES system capacity not exceeding 30kW, refer to TS129 and for IES system above 30kW and up to or equal to 200kW, refer to TS130.

This document also incorporates SA Power Networks' requirements for 'Closed Transition Transfer Switches - (CTTS)'. The technical requirements outlined in this technical standard, other than those detailed in **Section 16**, does not apply to embedded generating systems that do not operate in parallel with the network and are connected via compliant 'CTTS'.

This standard does not include SA Power Networks' or the generator's obligatory requirements to comply with 'Essential Services Commission of SA (ESCOSA) - Electricity Distribution Code (EDC)', Electricity Metering Code (EMTC), Licensing, AEMO and 'National Electricity Rules (NER)'.

It is the responsibility of the proponent, to ensure that their installation is compliant with the EDC and NER requirements, and to ensure all required third party approvals and/or licenses are obtained.

3. Effective Date of Standard

The requirements set out in this technical standard are effective from the date of issue. If you are unable to meet certain requirements of this standard an exemption may be granted by Manager Network Standards & Performance.

4. Inverter Energy Systems

Whilst AS/NZS 4777 only covers LV connected Inverters less than (≤) 200kVA, all generating systems connected to SA Power Networks' distribution network irrespective of their size or connection voltage will be expected to operate in accordance with the principles detailed in AS/NZS 4777.

All references to and requirements of Inverter Energy Systems (IES) within this document, assumes the principles of AS/NZS 4777 will be met. Any Inverter not compliant with AS/NZS 4777 will be required to demonstrate compliance with these principles as part of their commissioning and witnessing tests.

5. Installation Requirements

All generating systems connected to SA Power Networks' distribution network irrespective of their size must comply with the installation requirements set out in AS/NZS 4777.

SA Power Networks requires that the switchboard, either the main switchboard or a sub switchboard, which contains SA Power Networks' devices must have a main switch/main isolator that isolates the complete board. Refer **Figure 1** below.

The main switch must be manually operated with no motorised controls and no connections to any monitoring or measurement equipment.

Where there are multiple IES directly connected to an individual switchboard there shall be only one main switch/main isolator (inverter supply).

Where a network monitoring unit is required it must be in a safe accessible location (ie not on roof).

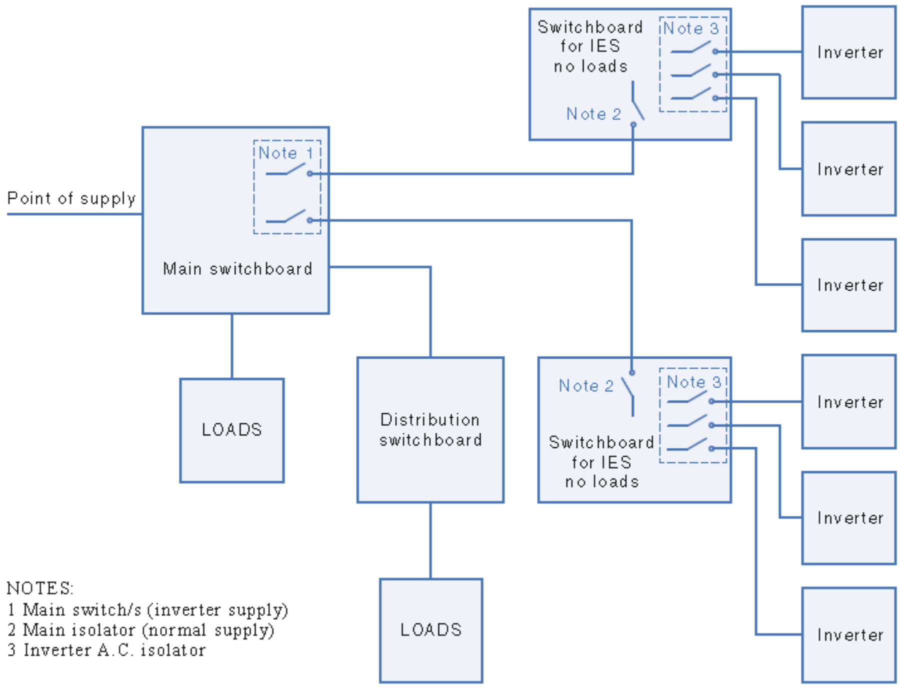


Figure 1

Typical Multiple Distribution Board Used as Marshalling Points for the IES Then Connected to Main Switchboard **(source AS/NZS4777.1:2016)**

6. Protection Systems

The protection scheme shall be designed in accordance with the applicable regulations and SA Power Networks' standards, which require a protection system that detects all credible fault types.

No less than three months prior to the commencement of commissioning, the proponent must submit to SA Power Networks for review and agreement, any protection system details that have not been provided at the connection application stage. This may include but not be limited to provision of the proposed protection and control system settings for SA Power Networks' review and approval.

Protection design at the connection point (ie between the generating system and SA Power Networks' distribution network) shall be capable of achieving reliable discrimination of faults within the generating system installation and those on the network.

In addition, the dispatch of embedded generation must not cause cycling of network protection or control systems, and consideration shall be given to the co-ordination of plant and equipment settings.

Most of SA Power Networks' distribution lines and feeders are programmed for automatic re-closing within 1.5 to 5s after successful clearance of a line or feeder fault. Therefore, failure of the proponent's equipment to rapidly disconnect during a SA Power Networks' loss of supply event may result in damage to the generating system's equipment or pose a health safety risk to the public and SA Power Networks' personnel.

The size and characteristics of the proposed generating system determines the type of protection systems that must be installed. Refer to **Table 1** and refer to **Appendix A** for various examples, showing typical requirements for different types of generation sizes, connection arrangements and protection schemes.

Table 1 - Generating System Protection Requirements

Protection Scheme	Non-Export		Export	
	≤ 1MW	> 1MW	≤ 1MW	> 1MW
Minimum Import	Yes	Yes	No	No
Inter-Tripping	No	No	Yes (See Note 2)	Yes (See Note 2)
Permissive Signalling	No (See Note 4)	No (See Notes 1 & 4)	Yes (See Notes 2 & 4)	Yes (See Notes 2 & 4)
ROCOF	Yes	Yes	Yes	Yes
Under/Over Frequency	Yes	Yes	Yes	Yes
Under/Over Voltage	Yes	Yes	Yes	Yes
Feeder / Line Protection	No	No	No	No (See Note 5)
Synchronisation (See Note 3)	Yes	Yes	Yes	Yes
Generator Over-current	Yes	Yes	Yes	Yes
Generator Earth Fault	Yes	Yes	Yes	Yes
Voltage Unbalance	Yes	Yes	Yes	Yes
Customer CBF	HV only	Yes	HV only	Yes
Pole Slip	No	Yes (See Note 3)	No	Yes (See Note 3)
Set 1 & 2 Protection	No	No	No	No (See Note 1)

Notes:

1. May be required depending on generating system's size and location.
2. Typically, not required for generating systems less than 5MW where all generating units are inverter connected.

3. Synchronising facilities are not required for asynchronous generating systems, including inverter connected generating systems.
4. Permissive signalling facilities and fault current limiting equipment will be required for all rotating generating systems connected to the 11kV network within Adelaide CBD.
5. For export generating systems requiring connection via a dedicated 11kV feeder or 33kV or 66kV line, these connection assets will be required to be fitted with protection systems provided by SA Power Networks. The proponent will need to make available space within their control room for the installation of SA Power Networks' relays and associated infrastructure.

6.1 Anti-Islanding

The extent and type of anti-islanding protection will depend on the size and characteristics of the proposed generating system, refer to Table 1.

The embedded generating system must be disconnected whenever the distribution network is de-energised. For an example, whenever SA Power Networks' substation circuit breaker and/or recloser controlling the line or feeder that supplies the embedded generating system's connection point operates either for a fault or switching operation, then the embedded generating system must automatically be disconnected from the distribution network.

Anti-islanding protection schemes are required to operate within the reclose time of the applicable SA Power Networks' protection device. Generation installations shall not be reconnected to the network after the restoration of the grid supply without verification that normal conditions have been restored for a minimum of two minutes (except for inverter connected systems, which shall comply with AS/NZS 4777 requirements).

The anti-islanding protection settings must be designed to ensure generator fault ride through capability for remote network faults and reliable operation for islanding events. Anti-islanding protection must not trip for fault ride through events unless agreed otherwise with SA Power Networks.

It should be noted that unscheduled tripping of generation capacity following system fault events can produce significant voltage variations and may impact on SA Power Networks' quality of supply to other proponents or the stability and security of the Transmission Network.

6.1.1 Minimum Import Protection

Non-export generating systems are those never intended to export power to the distribution network and are designed to ensure all generated electricity is consumed within the proponent's premises.

Unless an inter-trip protection scheme is installed, all non-export embedded generating systems must include minimum import power protection to detect an islanding event and to prevent the inadvertent export of electricity into the distribution network at all times. The minimum import protection scheme is in addition to other SA Power Networks' embedded generating system network protection requirements.

The minimum import power protection must include three phase power monitoring relays installed at the connection point, or other agreed location, to ensure a minimum level of demand is continuously supplied by the network.

This power monitoring protection is typically set to a threshold of 10% of the Agreed Maximum Demand (AMD) of the proponent's installation. Whenever the electricity import level from the distribution network drops below this threshold for more than 0.4s, the embedded generating system must be automatically disconnected from the distribution network.

The minimum import protection circuit must be of fail-safe design such that in the event of failure, the generating system is disconnected.

Minimum Import Protection and Seamless Transfer

Where a proponent proposes to utilise minimum import protection and plans to return to SA Power Networks' supply with a seamless or 'bumpless' transfer, special consideration must be given to the minimum import protection arrangement.

Under this scenario, and if determined feasible by SA Power Networks, the minimum import protection may be temporarily inhibited for a short duration to allow the seamless transfer of the proponent's facility to SA Power Networks' supply.

This temporary inhibit will ensure the generating system is able to be unloaded to a level that ensures correct operation of the uninhibited minimum import protection scheme. The inhibit must be of fail-safe design.

Where SA Power Networks has agreed to allow a temporary inhibit of the minimum import protection, reverse power protection must be installed to detect and prevent islanding operation. The reverse power protection must be set as low as practical, considering the protection relay, CT accuracy and generating system synchronisation characteristics. Typically, such protection will be set at 5% of the agreed connection point capacity with a 1s delay. The design of control systems will need to minimise reverse power flow immediately following synchronisation.

6.1.2 Inter-Trip Protection

Inter-trip protection is required for any exporting embedded generating system that does not comply with AS/NZS 4777 or the principles therein (ie rotating generating systems).

Inter-trip protection may also be required in cases where the combined generation capacity represents a significant portion of the total area load, implementation of a minimum import protection scheme is not feasible or where deemed necessary by SA Power Networks.

The inter-trip protection scheme shall be installed so that the embedded generating system is disconnected from the network when the distribution network is de-energised via SA Power Networks' network protection. The inter-trip scheme is in addition to other SA Power Networks' Embedded Generating System network protection requirements.

Where an intertrip protection scheme has been deemed necessary, SA Power Networks will, at the proponent's expense, install a communication link between the embedded generating system and the relevant SA Power Networks' substation. Alternatively, the proponent may provide this communication link according to SA Power Networks' specification. Under some circumstances, depending on the location and connection voltage, SA Power Networks may require diversity or duplication of these communications links.

The SA Power Networks' communication links will be continuously monitored for integrity. If the communication links fails, the embedded generating system will be automatically disconnected from the distribution network until the communications links are restored.

SA Power Networks will provide the inter-trip signal to an agreed interface panel installed at an agreed location on the proponent's site. It will be the responsibility of the proponent to trip the agreed circuit breakers on receipt of the inter-trip signal. The intertrip signal from the interface panel to the agreed circuit breaker, including the communications link, must be of fail-safe design.

The proponent must also include tripping of the generating system, if DC supply to the protection scheme is lost.

Refer to **Section 14** in this document, for more details on interface requirements.

6.1.3 Permissive Signaling

Permissive signalling provides a method for SA Power Networks to indicate those times when a generating system may or may not connect to and operate in parallel with the network.

Permissive signalling is required for all exporting rotating generating systems and exporting IES generating systems greater than or equal to 200kW in capacity.

SA Power Networks reserves the right to request the installation of permissive signalling on exporting IES generating systems below this level if SA Power Networks deems it necessary (eg where fault current limiting methods are employed within the generating system).

For all rotating generating systems connected to the CBD's 11kV network, irrespective of whether they are export or non-export, a permissive signalling scheme shall be installed.

The permissive signalling scheme shall be installed such that the embedded generating system is disconnected from the network whenever a "permission denied" signal is issued by SA Power Networks. The permissive signalling scheme is in addition to other SA Power Networks' embedded generating system protection requirements.

Where a permissive signalling scheme has been deemed necessary, SA Power Networks will, at the proponent's expense, install a communication link between the embedded generating system and the relevant SA Power Networks' substation. Alternatively, the proponent may provide this communication link according to SA Power Networks' specification. Under some circumstances, depending on the location and connection voltage, SA Power Networks may require diversity or duplication of these communications links.

The SA Power Networks' communication links will be continuously monitored for integrity. If the communication links fails, the embedded generating system will be automatically disconnected from the distribution network until the communications links are restored.

SA Power Networks will provide the permissive signalling signal to an agreed interface panel installed at an agreed location on the proponent's site. On receipt of a "permission denied" signal it will be the responsibility of the proponent to ramp down the generating units before tripping the generating unit's circuit breakers. The permissive signalling signal from the interface panel to the generating unit's circuit breakers, including the communications link, must be of fail-safe design.

The proponent must also include shut down of the generating system, if DC supply to the scheme is lost.

6.1.4 Rate of Change of Frequency

'Rate of Change of Frequency' (ROCOF) protection may be required to detect islanding operation. If deemed required, ROCOF protection elements must be included in the protection scheme.

The generating system must be capable of continuous uninterrupted operation for the following rate of change of frequencies:

1. ± 4Hz/s for 250ms
2. ± 3Hz/s for 1s

The ROCOF protection settings must be based on the proponent's proposed distribution network connection arrangement and operating requirements. The protection settings will be determined by SA Power Networks at the design stage and subject to the results of the network study and subsequent engineering report.

The proponent shall submit details of their proposed ROCOF settings to SA Power Networks for approval prior to commissioning.

6.1.5 Under/Over Frequency

Main and back-up under/over frequency protection must be installed to ensure the generating system is disconnected from the network when the system frequency varies outside the nominated range. The frequency protection settings must be based on the proponent's proposed distribution network connection arrangement and operating requirements.

Inverter Connected Generating Systems

The inverter must be disconnected from the network for the following settings:

1. Under-frequency (f) = 47Hz with 1s delay
2. Over-frequency (F) = 52Hz with 0.2s delay

Where the generating system uses inverter, that have internal under/over frequency protection, this inverter can be used as the main protection and a single back-up under/over frequency protection scheme applied as the back-up protection. The back-up Under/Over frequency protection shall be set to trip for the following settings:

1. Under-frequency (f) = 47Hz with 2s delay
2. Over-frequency (F) = 52Hz with 2s delay

Rotating Generating Systems

Under/Over frequency protection must be installed at the main switchboard. If the frequency at the supply point exceeds +4% or -6% of nominal frequency (50Hz) for more than 0.4s, the generating system or all generating units must be disconnected from the network.

6.1.6 Under/Over Voltage

Main and back-up under/over voltage protection must be installed to monitor all three phases at the connection point. This protection is set to ensure the generating system is disconnected from the network when the voltage at the connection point varies outside predetermined values.

If the generating system is located remote from the connection point, SA Power Networks may accept use of a local voltage reference source for use with under/over voltage protection.

The proponent's protection relays must be capable of at least a two-stage protection scheme.

Inverter Connected Generating Systems

For LV Inverters compliant with AS/NZS 4777, the Inverter must be disconnected from the network for the following settings:

1. Under-voltage (V) = 180V with 1s delay
2. Over-voltage 1 (V) = 260V with 1s delay
3. Over-voltage 2 (V) = 265V with 0.2s delay

Where the generating system uses inverters, that have internal under/over voltage protection, these inverters can be used as the main protection and a single back-up under/over voltage protection scheme applied as the back-up protection. The back-up under/over voltage protection shall be set to trip for the following settings:

1. Under-voltage (V) = 180V with 2s delay
2. Over-voltage (V) = 260V with 2s delay
3. Sustained over-voltage (V) based on average value over a period of 10min = 255V with 15s delay

For HV Inverters, SA Power Networks will advise the under/over voltage protection requirements within the engineering report after receipt of an application to connect.

Rotating Generating Systems

Under/Over voltage protection must be installed to monitor all three phases at the connection point. SA Power Networks' default position on these protection settings is that, for LV connected rotating generating systems, if the phase to earth voltage on any phase at this point exceeds +10% or -6% of nominal voltage for more than 0.4s the generating system must be disconnected from the network.

For HV connected rotating generating systems, if the phase to earth voltage on any phase at this point exceeds +10% or -10% of nominal voltage for more than 0.4s the generating system must be disconnected from the network. The proponent may submit under/over voltage settings outside this range for SA Power Networks' review and consideration.

6.2 Synchronising Facilities

Synchronisation is the act of matching, within allowable limits, the 'Voltage Magnitude', the 'Phase Angle', and the 'Frequency' of an embedded generating system, prior to closing the circuit breaker connecting it to the network. To minimise disturbances to adjoining customers, all three parameters must be closely matched across the connecting/synchronising circuit breaker before closure.

In the case of synchronous generating units, automatic synchronising facilities must be installed at the circuit breaker that interfaces with the distribution network and/or elsewhere, that is proposed to synchronise the embedded generating system with the distribution network.

Synchronising facilities are to include a dead bus check system, to prevent the proponent closing the embedded generating unit onto the distribution network, when it is de-energised.

Synchronisation controls must provide for 'clean' connection, without the potential for large reactive power flows in or out of the Embedded generating system, following network connection.

Synchronisation must produce voltage variations less than ± 3% of the prevailing network voltage at the network connection point and comply with the assigned flicker levels (refer to **Section 11**).

Automatic synchronising controls will operate inside the limits shown in **Table 2**:

Table 2
Generation Synchronising Requirements

Aggregated capacity (kVA)	Parameters		
	Frequency difference (Δf, Hz)	Voltage difference (ΔV, %)	Phase angle difference (ΔØ, °)
0 - 500	0.3	10	20
>500 - 1,500	0.2	5	15
>1,500	0.1	3	10

The proponent will undertake tests to demonstrate that when closing the connecting/ synchronising circuit breaker, all three parameters (Refer to **Table 2**) are within the assigned range. Tests should also demonstrate that if any of the parameters are outside the assigned range, the connecting circuit breaker will not close.

The use of manual synchronisation controls is not permitted except during commissioning. Note that SA Power Networks' circuit breakers are not fitted with synchronising facilities.

Asynchronous generating systems, including inverters, do not require the installation of synchronising facilities, as the network electricity supply is required to facilitate starting and running of the generation capacity. However, the start-up (in-rush) current following energisation, must also produce voltage variations less than ± 3% of the prevailing network voltage at the network connection point and comply with the assigned flicker levels (more details in **Section 11**).

6.3 Over-Current and Earth Fault

Unless otherwise agreed, over-current and earth fault protection must be installed on the embedded generating system. This protection is used to detect faults within the proponent's installation and the distribution network.

This protection must coordinate / discriminate with all relevant protection, including the distribution network protection and any other proponents' protection, and must include high speed protection (ie no intentional delay).

The embedded generating system's protection system must be capable of discriminating between a fault that is internal or external to the generating system.

6.4 Feeder/Line Protection

Where a generating system is required to be connected to the network via either a dedicated feeder (eg 11kV) or sub-transmission line (ie 33kV or 66kV) (refer **Section 11**), SA Power Networks will require this dedicated asset to be protected by SA Power Networks' protection systems which will be provided by SA Power Networks at the proponent's expense.

For dedicated distribution feeders, a main / backup protection system consisting of a main set of differential feeder protection and backup over-current protection shall be installed. Communications for protection signalling will be via a single set of either optic fibre or radio. The use of mobile phone networks for protection signalling communications will not be accepted.

For dedicated sub-transmission connections at 33kV or 66kV, the use of a Set 1 & Set 2 differential protection schemes shall be installed. Communications for protection signalling will be via two geographically diverse sets of either optic fibre, radio or a combination thereof. The use of mobile phone networks for protection signalling communications will not be accepted.

The implementation of such protection schemes will require the proponent to make available suitable space within their control room for SA Power Networks to install its protection panel and any associated telecommunication equipment.

6.5 Voltage Unbalance

A voltage unbalance (or negative phase sequence) protection scheme must be installed for all embedded generating systems. These schemes must be designed to protect the generating system against unbalance of system operating conditions and ensure the rapid disconnection of all embedded generating units from the distribution network.

Protection settings will be coordinated with and trip the generating units for voltage unbalance conditions greater than or equal to the values show in **Table 3**.

Table 3
Generating System Voltage Unbalance Requirements
(Source: NER 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	general	once per hour
	30 minute average	30 minute average	10 minute average	1 minute average
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

6.6 Circuit Breaker Fail

Circuit Breaker Failure (CBF) protection is required for LV connected embedded generating systems having a capacity greater than 1MW or any HV connected embedded generating system. The form of CBF protection is subject to agreement with SA Power Networks, but may include one of the following:

1. CB auxiliary switch scheme;
2. current based scheme; and
3. remote back-up coverage via other plant.

Islanded system operation would not be considered suitable in the event of a down-stream CBF event.

6.7 DC System or UPS Integration Protection

The generating system must be automatically disconnected from the network in the event of a failure of the ‘Direct Current’ (DC) supply or ‘Uninterrupted Power Supply’ (UPS) supply to the protection and control systems.

Where the protection scheme for a generating system involves an intertrip and line differential scheme signal from SA Power Networks, duplicate (ie Set 1 and Set 2) DC supplies must be provided irrespective of whether multiple communication links exist or not.

6.8 Protection Equipment Requirements

All protection equipment must comply with the relevant IEC standards.

For all appropriate protection settings, the proponent shall ensure that, the provisions of NER clause S5.2.2 – Application of Settings and the ESCOSA license requirements are complied with, including seeking approval from SA Power Networks (and if required AEMO) of any settings applied or proposed to be altered.

6.8.1 Protection Testing and Commissioning

Prior to connection to the distribution network, all protection equipment must be tested and commissioned by a competent commissioning officer, in line with the requirements of **Section 21**.

The proponent of the embedded generating system must keep a written record of all SA Power Networks' approved protection settings and test results. A copy of this record should be available at the connection point or as required by SA Power Networks and should not be altered without the prior written approval of SA Power Networks.

6.8.2 Protection Redundancy

In the case that the protection and control schemes outlined in this section are already incorporated internally within those schemes employing inverters, the internal inverter protection schemes can be used as the main protection but back-up protection (external to the inverter protection) will also be required.

The overall protection scheme must include sufficient redundancy to ensure that a faulted element within the protection zone is disconnected from the distribution network within the applicable fault clearance time with any single protection element (including communications upon which that protection system depends) failing or being out of service.

6.8.3 Protection Labelling and Security

Protection systems should be clearly labelled and shall be permanent, indelible, legible from viewing levels and suitable for the purpose which it is intended for the life of the installation.

Protection relay labelling is to include a notice "Settings only to be changed with prior approval from the distributor". For general signage/labelling requirements, refer to TS304: 'Substation Design - Signage'

All protection systems must be tamperproof to prevent unscheduled or inadvertent changes of settings. SA Power Networks considers either of the following methods (or a combination thereof) suitable to ensure settings are tamperproof:

1. The fitting of a uniquely identifiable seal in such a manner that protection settings cannot be modified without the removal of the seal.
2. Password protection, where in the presence of SA Power Networks' officer the settings are password protected and the password is only then provided to a responsible person of the proponent.

6.8.4 Inverter Power Quality Response Modes

For all AS/NZS 4777 compliant inverters, the Proponent/Electrical Contractor/Installer must ensure the South Australian power quality response mode has been set in the inverters, be proven through testing and must not be changed without written approval from SA Power Networks.

The South Australian power quality response modes are:

1. Volt-VAr response mode (AS/NZS 4777.2 Table 11) **(Mandatory).**
2. Volt-Watt response mode (AS/NZS 4777.2 Table 10).

Settings for the power quality response modes are shown in **Tables 4, 5 and 6**.

Table 4
Mandatory: Volt-VAr Response Mode for AS/NZS 4777 Compliant Inverters

Reference	Voltage in Volts	VAr % Rated VA
V_1	207 (default)	31% leading (sourcing VAr, 2.4%/Volt)
V_2	220 (default)	0
V_3	248	0
V_4	253	44% lagging (sinking VAr, 8.8%/Volt)

Table 5
Volt-Watt Response Mode for AS/NZS 4777 Compliant Inverters

Reference	Voltage in Volts	Power % rated Power
V_1	207 (default)	100% (default)
V_2	220 (default)	100% (default)
V_3	250 (default)	100% (default)
V_4	265 (default)	20% (default, 5.3%/Volt)

Table 6
Sustained Operation for Voltage Variations

Reference	Voltage
$V_{nom-max}$	258 Volts

Power quality response mode settings shall be the same for all the inverters at site. While all new inverters shall operate with the required South Australian power quality response modes, multiple power quality response mode settings are allowed where the following is satisfied:

1. All inverters installed on or after 1 December 2017 operate with the required South Australian power quality response modes other than those where SA Power Networks has specified a site-specific power factor control system within its engineering report.
2. Inverters installed prior to 1 December 2017 which are not capable of operating with an approved power quality response mode are operating at unity power factor.
3. Replacement inverters, including warranty replacements, shall be configured to operate with the required South Australian power quality response modes.
4. Where quality of supply investigations reveals voltage issues at a proponent's site or the section of the network to which the generating system is connected, SA Power Networks may direct proponents with Inverters having this functionality to enable these response modes.

6.8.5 Soft Ramp Up after Connect or Reconnect

All inverters shall have 'Soft Ramp Up after Connect or Reconnect Mode' as specified in AS/NZS 4777.2.

7. Fault Level

7.1 Generating System Fault Level Contributions

Embedded generating systems may contribute to the fault levels of the distribution network beyond the safe operating level of SA Power Networks' and existing network users' equipment.

Fault level contributions from any proposed generator installation must be determined at the design stage and SA Power Networks can provide source impedance data to assist proponents.

Depending on the network connection location and voltage, the embedded generating system may need to select appropriate generator, step-up transformer and grounding options to mitigate potential fault level issues. Alternatively, fault mitigation equipment approved by SA Power Networks may be utilised by the proponent to reduce fault level contributions.

Any additional short circuit fault current sources are to be accurately defined and carefully managed. The proponent will bear any costs that SA Power Networks may incur in respect of applying or reviewing or approving any fault level control mitigation measures.

7.1.1 Adelaide CBD Specific Requirements

The 11kV distribution network within the Adelaide CBD is approaching the maximum safe fault level of both the customers' and SA Power Networks' existing high voltage equipment. Unless very significant modifications are made to the Adelaide CBD distribution network, no additional short circuit fault sources can be connected to the Adelaide CBD network; this includes any rotating embedded generating unit.

However, with appropriate protection and control equipment, SA Power Networks may permit the installation of such generating units within the Adelaide CBD where the:

1. Embedded generating units operate electrically islanded from the distribution network (and therefore do not contribute to the distribution network's short circuit fault current level). This includes generating units designed for island operation with momentary closed transition of the load between the distribution network and the embedded generating unit and vice versa, in compliance with **Section 16**; or
2. Embedded generating systems designed to limit the fault contribution to the network to their full load current or near zero value. This may be achieved through the incorporation of:
   (a) fault current limiting devices; or
   (b) generating units connected via grid connected inverters, which limit the fault current contribution to their full load current or a near zero value.

It is important to note that these restrictions only apply to connections which impact the 11kV distribution network within the Adelaide CBD.

7.2 SA Power Networks' Ultimate Network Fault Levels

The SA Power Networks system operates using a range of distribution voltages and the associated fault levels may vary significantly depending on the network connection point's nominal voltage. As network fault levels are subject to change, the ultimate fault level for the relevant network connection voltage should be used for sizing any proponent's equipment for the proponent's proposed installation's high voltage and low voltage plant and switchgear.

Where SA Power Networks' equipment is already designed to these ultimate fault levels, SA Power Networks' responsibility will be to ensure fault levels do not exceed these ultimate fault levels, not the adequacy of the proponent's equipment. **Table 7** provides an indication of SA Power Networks' ultimate network fault rating design requirements.

Table 7
Network Ultimate Fault Rating Design Requirements

Supply Voltage	Fault Level
400V	For Prospective Fault Current (kA) values, refer to NICC802: '11kV and 7.6kV to LV Mk7 Padmount Transformers - Information & Requirements for Customers/ Contractors'.
7.6kV or 11kV	20kA
33kV	25kA
66kV	31.5kA

Where the fault rating of SA Power Networks' existing network is less than those levels specified in **Table 7**, SA Power Networks will advise the proponent through the engineering report. Where the connection of any proposed generating system will cause the fault rating of any existing equipment to be exceeded, augmentation may be required to raise the fault rating of SA Power Networks' equipment, or the proponent may elect to install fault current limiting equipment to enable connection of the proposed generating system to the network. The cost of either option will be borne by the proponent.

8. Reactive Power Control

The majority of SA Power Networks' zone substation transformers are fitted with 'On-Load Tap Changing' (OLTC) facilities and will automatically act to restore network voltage levels to compliant levels within one minute. In addition, 'Line Drop Compensation' (LDC) controls may also be used to regulate the network voltage at a location downstream of the zone substation. These controls are commonly used to regulate network voltages and maximise transfer capacity to customers.

The connection of embedded generating systems to the distribution network may impact on SA Power Networks' ability to regulate network voltages. For this reason, SA Power Networks requires embedded generating systems to control reactive power output, within their capability, to maintain the connection point voltage to an agreed target or operate at an agreed power factor such that voltage variations are maintained within prescribed limits.

The generating system's reactive power output must be controlled within an agreed range. A generating system would typically be expected to be capable of continuously supplying or absorbing reactive power to achieve a power factor as stated in SA Power Networks' Service and Installation Rules, measured at the connection point.

All generating systems which require SCADA as per **Section 14.1**, will be fitted with power factor controls to automatically control reactive power absorption or output to assigned levels and maintain security and reliability of customers' supply. SA Power Networks will have the ability to issue a power factor setpoint signal to the embedded generating systems via a SCADA control interface and the sent-out generation reactive capacity must not deviate from this setpoint value.

Subject to the appropriate network studies, generating systems not able to meet these typical reactive power capabilities may still be considered acceptable.

The embedded generating systems may require additional sources of reactive power (eg Statcoms, Capacitors, Reactors) or network augmentations to regulate network voltages within acceptable limits.

The final operating reactive power requirements for the embedded generating system will be identified by the network studies and included within the engineering report.

8.1 Reactive Power Where Generators are also Customers

In cases, where a proposed generating system is connected to a connection point that also supplies electrical load, the reactive power requirements at the connection point will be a combination of the supply and generation requirements.

When the site is exporting electricity, the generating system would typically be expected to be capable of continuously supplying or absorbing reactive power to achieve a power factor as per SA Power Networks' Service and Installation Rules, measured at the connection point.

Subject to the appropriate network studies, a generating system not able to meet the typical reactive power capabilities may still be considered acceptable.

9. Real Power Control

To ensure control over the real power "in feed" to the distribution network, adequate control must be provided over the governor or primary energy source. The embedded generating unit's real power output must comply with NER clause S5.2.5.14 - Active power control technical requirements.

All generating systems which requires SCADA as per **Section 14.1** , will be fitted with 'Generation Dispatch Limiter' (GDL) controls to automatically control real power output to assigned levels and maintain security and reliability of Customers' supply. SA Power Networks will issue a maximum GDL signal to the embedded generating system via a SCADA control interface and sent out generation capacity must not exceed this limit.

Notwithstanding the requirements to install an operational GDL control scheme, any generating system connected to SA Power Networks' distribution network shall have the capability of ramping real power output at an agreed rate in response to an external signal.

Depending on the network connection location, SA Power Networks may also place restrictions on the ramping of real power production to support the management of network voltages and detailed studies may be required assess the impact of dispatch with existing generation capacity.

10. Quality of Supply

Generating system must not impact on the quality of supply to SA Power Networks' distribution networks and their network users/customers. The generating system must comply with all applicable requirements of the NER, ESCOSA's license conditions, AS/NZS 61000 series and SA Power Networks' Service and Installation Rules, including but not limited to:

1. network voltage control;
2. voltage fluctuations;
3. harmonics; and
4. voltage balance.

As part of any application to connect, SA Power Networks will undertake the required network studies to determine compliance or otherwise based on assigned power quality of supply limits. The results of the studies, and any associated operational constraints will be advised within the engineering report.

SA Power Networks' assessment and allocation of power quality limits for generating systems will be in accordance with the AS/NZS 61000 series. Subject to existing power quality limitations at the proposed network connection point, SA Power Networks will consider establishing negotiated access standards in accordance with NER S5.2.5.2 - Quality of Electricity Generated.

The development of negotiated access standards for power quality, are analogous to the AS/NZS 61000 Stage 3 process and reflect acceptance of emissions levels on a conditional basis.

It should be noted, SA Power Networks may rescind the allocation of Stage 3 emission levels because of changes in network configuration or connection of additional customers/generators. If a reallocation of emission levels is required, SA Power Networks will advise the proponent at the earliest possible time.

It is the responsibility of the owner of the embedded generating system to ensure ongoing compliance with their assigned power quality obligations and undertake appropriate tests as required.

Unscheduled or scheduled disconnection of embedded generating system must not result in changes to customer supply voltages (at the end of feeders) in excess of those defined in the NER and EDC technical requirements. Detailed studies may be required to identify the extent of customer voltage variations following tripping of an embedded generating system.

The operation of an embedded generating system must not cause any cycling of network protection or control systems. This dispatch of embedded generating system capacity must not result in a material increase in the number of transformer tap changer operations in the adjoining network.

11. Transfer Capacity and Maximum Allowable Embedded Generation Connections by Voltage

The embedded generating system transfer capacity into the distribution network will depend on many factors including:

1. the network connection voltage;
2. thermal and fault rating of network plant and equipment;
3. characteristics of the network plant and equipment;
4. proximity and capacity of adjoining loads and generating systems; and
5. generation capacity.

Depending on the capacity of the embedded generating system, dynamic stability studies may be required to assess stability issues and identify the maximum generation capacity that can be dispatched under normal and contingency operating conditions.

The thermal rating of the distribution assets must not be exceeded under any of the operational scenarios of the embedded generating system. The distribution plant affected may include the feeder / line conductors (both underground and overhead), line voltage regulators, reclosers, circuit breakers, disconnectors, instrument transformers and power transformers.

Detailed investigations will be required to confirm the binding thermal limits that may constrain generation transfer capacity. Depending on the level of existing embedded generating system, the ability of equipment such as power transformers to manage reverse power flows may be less than the traditional power flows for which they were designed.

Equally, the fault rating of all distribution network assets must not be exceeded under any operational scenario of the embedded generating system. Importantly, embedded generating system must comply with the provisions of NER clause S5.2.5.12 - Impact on network capability, and as a minimum, must not restrict the ability to supply customer load or power transfer capacity to an area by more than the embedded generating system capacity.

Additional control systems may be required to support the management of embedded generating system dispatch under contingency operating conditions.

The sudden disconnection of embedded generating system capacity should not produce network voltage changes that adversely impact on other network users and must be below levels specified under the NER or by SA Power Networks.

Typically, the following maximum embedded generating system connection capacities may be possible under favourable conditions, but may be less depending on the individual distribution network configuration, refer to **Table 8**.

Table 8
Generating System Connection Configuration by Voltage and Maximum Transfer Capacity

Voltage	Maximum Transfer Capacity	
	Up to and below 5MW	5MW and Greater
LV	Only up to 1.5MW via a dedicated transformer, with a 400V connection point. (See Note 1)	--
11kV	via an existing shared 11kV Distribution Network, with a 11kV connection point. (See Note 2)	via a dedicated 11kV feeder.
33kV	via an existing shared 33kV Distribution Network; with a 33kV connection point. (See Note 3)	via a dedicated 33kV line.
66kV	via a dedicated 66kV line.	

Notes, in weak areas:

1. Connection to a dedicated HV feeder / line may be required.
2. A dedicated 11kV Distribution feeder may be required.
3. A dedicated 33kV Distribution line may be required.

It should be acknowledged that there can be significant variation in network characteristics, plant thermal ratings and Customer loads depending on location, and as such an accurate assignment of transfer capacity cannot be made without undertaking the appropriate network studies or calculations.

SA Power Networks does not permit the connection to either the low voltage (LV) or high voltage (HV) distribution networks of single phase embedded generating system installations above the thresholds specified in TS129. Examples showing different types of generation and the connection arrangement for different capacities are shown in **Appendix A**.

12. Fault Ride through Capability

The ability of an embedded generating system to ride through selected network faults may be a requirement for network connection depending on the location and capacity of the embedded generating system.

While it is possible that tripping of a single generating unit due to a system fault may not cause material impact on local Customer supply, SA Power Networks may need to consider the potential for "cascade" or "co-incident" tripping of multiple embedded generating units following a network fault and evaluate their combined impact on system security and reliability of supply to customers.

The above concerns are captured under NER clause S5.2.5.5 - Generating system response to disturbances following contingency events.

SA Power Networks may need to evaluate the impact of both transmission and distribution faults on generating system performance. Depending on the outcome of these studies, embedded generating systems may be required to ensure fault ride through capability in accordance with the NER and ESCOSA's license conditions.

13. Reclosing Co-ordination

SA Power Networks commonly uses automatic reclosing on its distribution network to limit the duration of interruptions to customers for momentary fault events. Reclosers and circuit breakers can be automatically reclosed after an initial fault condition. Typically, 70% to 90% of faults on the overhead distribution network is transient in nature and by de-energising supply for a short time, the arc will extinguish and supply can be restored.

In effect, automatic reclosing allows immediate testing of a previously faulted portion of the network and makes it possible to restore supply if the fault is no longer present. Typically, SA Power Networks' reclose times vary between 1s and 5s and are programmed to attempt to reclose 1 to 3 times before permanently opening (ie locking out).

The connection of an embedded generating system to the distribution network means that the network can potentially be energised after the network recloser or circuit breaker is opened. Unless the embedded generating system is rapidly disconnected, the arc may not extinguish and result in unsuccessful recloser or circuit breaker operations, permanent damage to SA Power Networks' equipment or exposing the public or SA Power Networks' personnel to increased risk. This may lead to an extended supply outage to many customers rather than a short-term supply interruption.

Assuming the arc is extinguished, the "islanded" line or feeder may drift in synchronism from the main grid. If the network recloser or circuit breaker was to reclose, while the "Islanded Network" was still supplied via the embedded generating system, significant voltage transients may be generated. This event will produce out of phase voltages that may result in:

1. damage to the embedded generating system;
2. transient over-voltages on the connecting network resulting in damage to Customer equipment and failure of surge arrestors;
3. transformers and motors may experience high magnetic inrush and cause maloperation of protection systems; or
4. rapid changes in the out of phase voltages may cause damage to Customer equipment over a wide area.

For the above reasons, it is important to co-ordinate the tripping of generating systems with line or feeder reclosing to prevent out of phase supply events. The protection requirements outlined in **Section 6** have been designed to address these issues. It is the responsibility of the proponent to ensure the functional operation of all generation System protection and control systems.

Depending on the capacity of the embedded generating system facility and proximity of other embedded generating systems, SA Power Networks may require the installation of inter-trip protection using a reliable communications medium to automatically disconnect the embedded generating system in the event of a reclose operation. SA Power Networks' inter-trip requirements are listed in **Section 6.1.2**.

Long distribution networks, multiple sources of supply, multiple reclosers and voltage regulators may contribute to the complexity of secure inter-trip protection schemes. It should be noted that the cost of designing, maintaining and installing these inter-trip schemes by SA Power Networks will be borne by the proponent of the embedded generating system. Any disabling of the inter-trip scheme for any reason shall prevent the generating system from exporting to the network.

14. Remote Monitoring and Control

The broad/general remote monitoring and control requirements for embedded generating systems are outlined in this section. The exact requirements will be determined during SA Power Networks' assessment of the proposed embedded generating system's connection to the distribution network.

The nameplate capacity and operational requirements of the proposed embedded generating system in relation to the capacity of the distribution network at the proposed connection point will influence the actual interface and communications requirements**. Table 9** summarises the type of remote monitoring and control applicable to various types of generating systems.

Table 9
Remote Monitoring & Control requirements by Generation type and Capacity

Generation Type	Non-Export			Export		
	<1MW	≥1MW, <5MW	≥5MW	<1MW	≥1MW, <5MW	≥5MW
Inverter	N/A	N/A	N/A	NMU (max export < 200kW) SCADA (Basic) (max export ≥ 200kW)	SCADA (Basic)	SCADA (Inter-trip)
Rotating	SCADA (Basic) Refer Note 1	SCADA (Basic) Refer Note 1	SCADA (Basic)	SCADA (Inter-trip)	SCADA (Inter-trip)	SCADA (Inter-trip)

Notes:

1. Only required if connection is to CBD network.
2. N/A = Not Applicable.
3. NMU = Network Monitoring Unit – refer **Section 14.1.1.**
4. SCADA (Basic) – refer **Section 14.1.2.**
5. SCADA (Inter-trip) – refer **Section 14.1.3.**

14.1 Typical Remote Monitoring and Control Arrangements

This section outlines the typical remote monitoring and control arrangements that SA Power Networks requires to facilitate a connection to the network.

SA Power Networks will receive SCADA and protection inputs (as applicable) as a form of real time monitoring to SA Power Networks' Network Operations Centre (NOC)and is responsible for all equipment at its end. SA Power Networks is also responsible for all associated equipment within SA Power Networks' communications network. This may include the following equipment:

1. protection relays (eg. aux trip relays, directional distance relays, differential protection relays);
2. current and voltage transformers;
3. SCADA RTU;
4. DC power system;

5. discrete digital signalling fibre or radio system (eg tele-protection scheme; multiplexing or router);
6. private or public mobile carrier network equipment; and
7. SA Power Networks' communications cubicle or cabinet.

The augmentation of SA Power Networks' communications network will be at the proponent's expense. The proponent is responsible for:

1. all equipment within the proponent's plant (isolators, circuit breakers, CTs, VTs);
2. the interface for all inputs and outputs required for the protection scheme;
3. the control room;
4. auxiliary supplies; and
5. generating system SCADA monitoring and control.

The proponent is to provide and maintain a public telephone facility for the purposes of backup operational communications between the embedded generating system and the SA Power Networks' network operations centre.

14.1.1 Network Monitoring Unit

This is only applicable for generating systems that are large IES generating systems above 200kW but less than 1MW, with maximum export less than (<) 200kW.

SA Power Networks need to be provided with interval data on the electricity that the IES generating system has produced; however, this data is not required on a real-time basis. This requirement may be met by the installation of a remote read interval meter that provides the required data to SA Power Networks on a weekly or more frequent basis.

As the capacity of the inverter system that is to be continuously connected to the network is not more than 1MW, has a maximum export less than 200kW, and the proposed IES generating system is AS/NZS 4777 compliant, SA Power Networks does not intend to impose any real time remote monitoring and control requirements.

However, as the IES generating system has a nameplate rating greater than (>) 200kW, the proponent must provide a hinged panel for the installation of SA Power Networks' CT monitoring and communications equipment to provide half hourly power and energy readings of the IES generating system.

The proposed monitoring design must be submitted to SA Power Networks for approval prior to the procurement/modification of the switchboards on the site.

Information specific to the required monitoring panel design and its installation is as per the following (refer to **Figure 2**). Monitoring unit surrounds and enclosures construction details:

1. must have sufficient stability and strength to withstand distortion and contain any energy which might be caused in both normal and fault conditions;
2. any hinges or fixings used to support a monitoring panel will be of adequate strength to support the weight of the panel and monitoring unit therein without sag of the panel when in the open position;
3. hinged monitoring panels must be capable of movement through an arc of not less than 60 degrees when SA Power Networks' equipment is fixed and connected. The movement of the panel will not be obstructed in any way and the device used to retain the hinged panel in the closed position must be in correct alignment when all necessary equipment is mounted on the panel;

4. access doors of the hinged type must have the hinges mounted on the vertical side. Access doors of the sliding type must move horizontally;
5. means for securing the panel in the closed position must be accessible to the hand where the means for securing it is removed to open the panel eg a screw or nut;
6. enclosures shall take the form of a box type enclosure that accommodates the monitoring panel;
7. installed in a manner so that the monitoring equipment is completely enclosed;
8. provided with required clearances;
9. SA Power Networks' monitoring equipment must not be exposed to weather, moisture, dust, vibration or mechanical damage;
10. the three phase CT monitoring unit should have a height of 310mm and width of 180mm; and
11. the test block should have a height of 160mm and width of 220mm.

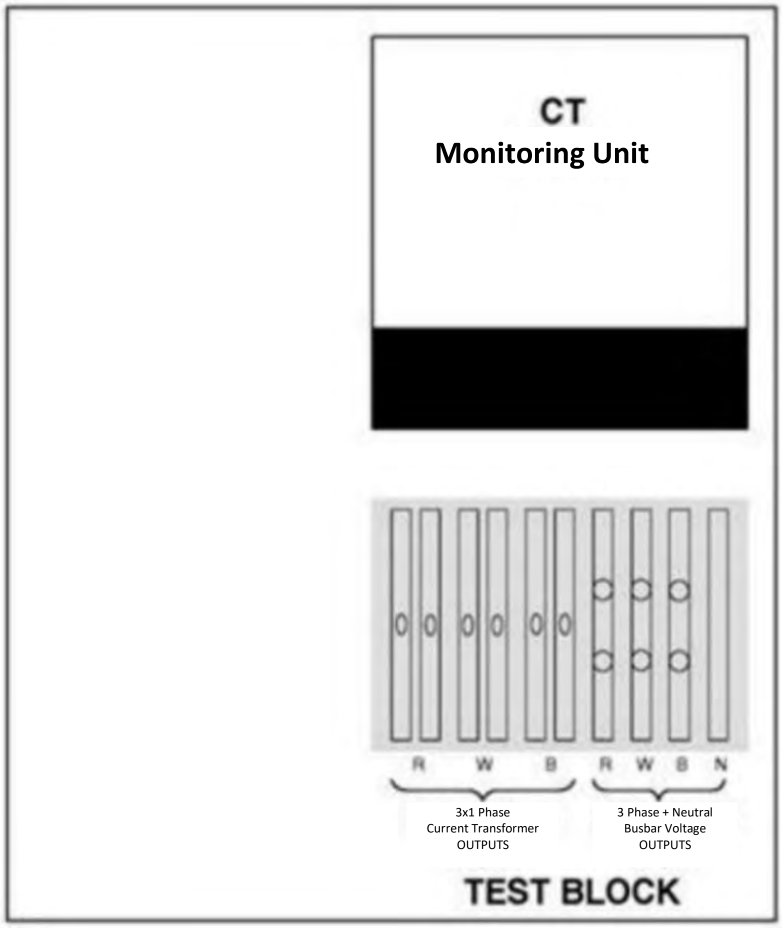


Figure 2
Monitoring Enclosure

14.1.2 SCADA (Basic Telemetry and Control)

The system shown in **Figure 3** is only applicable for the following generating systems:

1. inverter generating system with an installed capacity greater than 200kW but less than 5MW, with maximum export greater than 200kW, at a proponent's site with existing load;
2. inverter generating systems' export greater than 200kW but less than 5MW at a proponent's site purely generating electricity (with auxiliary loads);
3. rotating non-exporting generating systems greater than 5MW in non-CBD area; and
4. any non-exporting Rotating generating system of any size in CBD area.

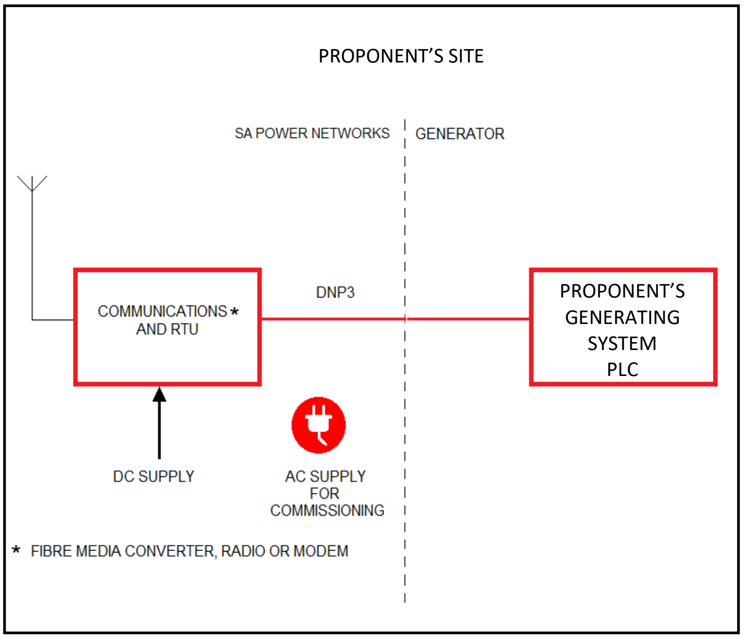


Figure 3
Block Diagram of SCADA/Tel solution for Generating Systems without Inter-Trip

To facilitate connection of the SCADA equipment for this size and type of generating system, the following requirements must be met by the proponent:

Accommodation and Requirements for SA Power Networks' Equipment

Configuration 1: Control Room Provided by the Proponent

1. Allocate space for a SA Power Networks' communications cubicle located inside the proponent's control room and identify any special environmental consideration (eg IP56 rating (wet areas), dust, hazards and temperature/climate control).
2. SA Power Networks is responsible for providing, installing and commissioning its equipment.
3. Allow for 600mm (W) x 600mm (D) x 2.1m (H) floor space for a free-standing equipment cubicle with front and rear access preferred. Front access only will be considered.
4. Within control room, the cubicle clearance shall comply with AS 2067.
5. Refer "Interface" section for distance limitation for RS232 serial communications.

6. Provide 24VDC, 48VDC or 110VDC supply (50W of load) from the proponent's DC battery bank and a supply isolator located adjacent or above SA Power Networks' equipment.
7. Provide an earth bonding point back to the proponent's common earth bar.
8. Provide 230V GPO supply for commissioning purposes.
9. Provide SA Power Networks' telecommunications network access via either radio or optic fibre technology:
   (a) Allowance for entry of fibre or coaxial cable into the proponent's control room and access to the SA Power Networks' cubicle (ie cable ladder).
   (b) Allow for installation of external Yagi radio or private or public mobile carrier Omni antenna.

Configuration 2: Control Room Not Provided by the Proponent

1. SA Power Networks' shall provide a free-standing post mount cubicle notional located adjacent to the point of supply to contain the required communications and SCADA equipment.
2. SA Power Networks is responsible for providing, installing and commissioning its equipment.
3. Allow for space for a free-standing post mount cubicle of dimensions approximately 600mm (W) x 600mm (H) x 400mm (D) notional located adjacent to the point of supply.
4. Outside control room, allow 2.0m clearance around the cubicle.
5. The proponent shall provide a 100mm diameter white telecommunications conduit (refer SA Power Networks' technical standard TS085) from the cubicle location to the proponents generating system controller. Provide a draw-wire in the conduit. Note, pits may be required dependent on the distance between the connection point and generating system's controller.
6. The pathway is to allow for:
   (a) A 'Multi-Mode Optic Fibre' (MMOF) connection contained in sub-duct for telemetry and control data - SA Power Networks to supply.
   (b) A LV power feed from the proponent's LV distribution board sized for the SA Power Networks' cubicle power consumption (50W of load) and voltage drop - proponent to supply.
   (c) A suitable cubicle earth bond point back to proponent's common earth bar - proponent to supply.
7. Allow entry for the conduit into the proponent's control facility.
8. SA Power Networks shall provide and install the MMOF and optical to serial media converters. The latter can be free-issued to the proponent.

Configuration 3: SA Power Networks Provide SCADA-Enabled Load Switch (HV Tee-off Pole)

1. For connections at 11kV and 33kV, SA Power Networks shall provide a SCADA-enabled HV load switch at the connection point. SA Power Networks shall install a pole-mounted communication/SCADA cubicle adjacent to the load switch.
2. The proponent shall provide a 100mm diameter white telecommunications conduit (refer SA Power Networks' technical standard TS085) from the connection point the location of the generating system controller.
3. The pathway is to allow for a 'Multi-Mode Optic Fibre' (MMOF) connection for telemetry and control data. The conduit installed by the proponent shall contain a draw-wire to allow SA Power Networks to install the MMOF cable. Note pits may be required dependent on distance between connection point and generating systems controller.
4. Allow entry for the fibre conduit into the proponent's control facility.
5. SA Power Networks shall provide and install the MMOF and optical to serial media converters. The latter can be free-issued to the proponent.

Generic Requirement for Above Configurations
Interfaces

1. Provide serial RS-232 as interface standard (compliant V24 and V28).
2. Provide serial DNP3 protocol for SCADA interface between proponent's generating system PLC and SA Power Networks' RTU (eg GE Harris iBox).
3. Physical layer delivery can potentially be via a screened copper RS-232 serial communication cable however this standard has a distance limitation of notionally 15m. Note the proponents and SA Power Networks' equipment cubicles shall be solidly bonded under this arrangement. This may be acceptable for configuration 1 however alternate circumstances shall require implementation of an optical interface.
4. For separation distances of notionally greater than 15m the delivery method shall be via a 'Multi-Mode Optic Fibre' (MMOF) in RS-232 serial communication protocol utilising optical to copper serial media converters.

Communication Signal Fail-Safe

The PLC must be capable of receiving a pulse for a healthy communications signal from SA Power Networks' RTU every 60s from which the proponent's generating system PLC will initiate an automatic controlled shutdown of the generating system in the event of a communications failure indicated by the lack of any single pulse.

SCADA Input/Output

1. Proponent to liaise with SA Power Networks to provide a list of SCADA inputs for the generating system.
2. SCADA data shall be via RS-232 serial communication protocol (refer "interfaces"). Hard-wired I/O will not be permitted.
3. Prior to beginning SA Power Networks' SCADA works on site, the proponent's PLC must be brought into SA Power Networks' offices for 'Factory Acceptance Testing' (FAT) and confirmation that the PLC communicates correctly with SA Power Networks' equipment.

Site Access

24 hours site access to SA Power Networks' equipment for faults and maintenance (escorted or non-escorted).

14.1.3 SCADA (Telemetry, Control and Inter-Trip)

The system shown in **Figure 4**, is only applicable for the following generating systems:

1. any export rotating generating system; or
2. any large IES greater than 5MW.

Note that this arrangement includes inter-trip arrangements.

To facilitate connection of this size and type of generating system, the following requirements must be met by the customer:

Accommodation and Requirements for SA Power Networks' Equipment

1. SA Power Networks' communications cubicle shall be located inside the proponent's control room and identify any special environmental consideration (eg IP56 rating (wet areas), dust, hazards and temperature/climate control).
2. Allow for 800mm (W) x 600mm (D) x 2.1m (H) floor space for a free-standing equipment cubicle with front and rear access preferred. Front access only will be considered.
3. SA Power Networks is responsible for providing, installing and commissioning its equipment.
4. Within control room, cubicle clearance shall comply with AS 2067.
5. Provide an earth bonding point back to proponent's common earth bar.

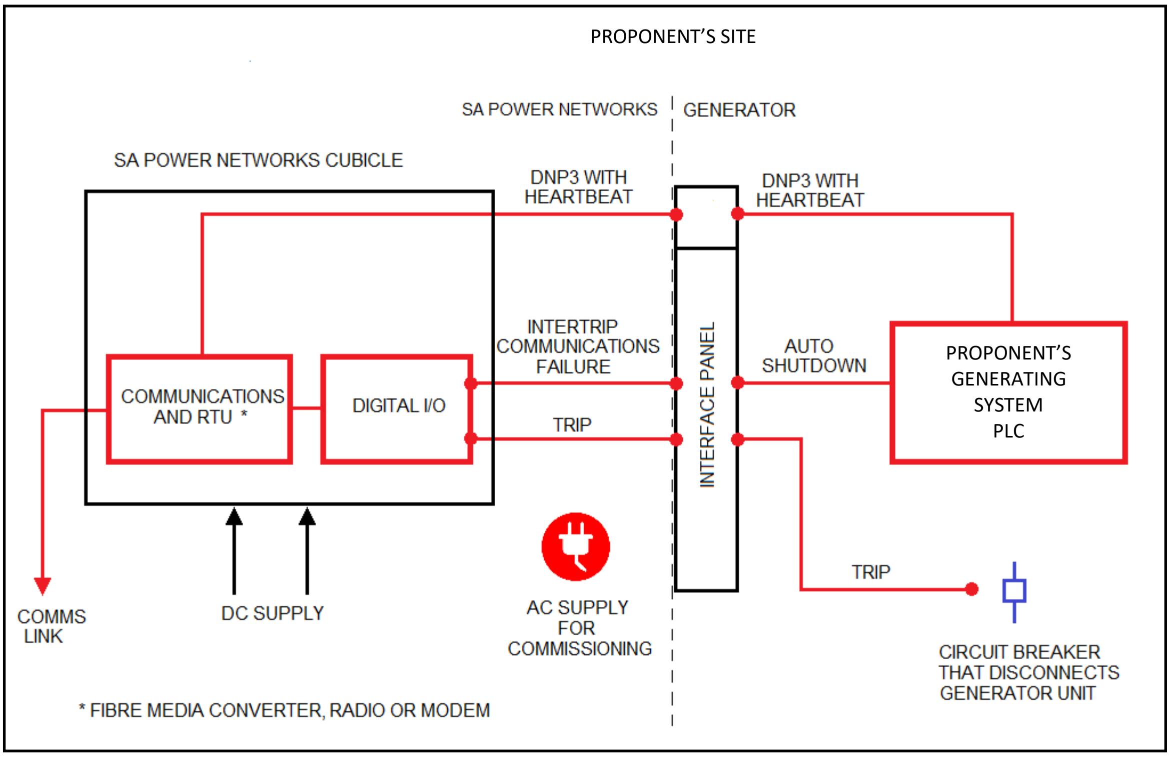


Figure 4
Block diagram of SCADA/Tel solution for Generating Systems with Inter-Trip

Interfaces

1. Provide an interface panel as a demarcation point within the proponent's site adjacent to the SA Power Networks equipment cubicle.
2. Provide Ethernet DNP3 protocol for SCADA interface between proponent's generating system PLC and SA Power Networks' RTU.
3. Provide an Ethernet SCADA interface compliant with IEEE 802.3 standard. The physical layer delivery method shall notionally be via a 'Multi-Mode Optic Fibre' (MMOF) utilising optical to copper Ethernet media converters if required.
4. Fail-safe contact arrangement with SA Power Networks' digital I/O to the demarcation terminal strip.

DC Power System

1. Provide 24VDC, 48VDC or 110VDC from proponent's DC battery bank, connected to SA Power Networks' DC/DC converters.
2. Provide 2 x individual protected feeds from an appropriately rated LV circuit breaker to dual isolators located adjacent or above SA Power Networks' cubicle.
3. Each feed to be able to provide 100W of load.
4. The total survival time for the DC feeds no less than 24 hours.

AC Supply

Provide 230V GPO supply for commissioning purposes.

Circuit Breaker(s) (Disconnecting Generator(s))

The trip circuit to be a normally closed circuit.

Fibre/Radio Connection to Customer Control Room

1. Allowance for external entry of fibres or coaxial cables into the proponent's control room and access to SA Power Networks' cubicle (ie cable ladder). For conduit entry refer to SA Power Networks' technical standard TS085.
2. Allow for installation of external radio mounting structure and antenna should this communications method be utilised.

Communication Signaling Fail-Safe

With SA Power Networks' RTU present in the SA Power Networks' substation (compulsory requirement), a 60s watchdog pulse arrangement will be in place which the proponent's PLC will initiate an automatic controlled shutdown of the generating system in the event of a communications failure (either via proponent's generating system PLC or SA Power Networks' RTU).

SCADA Input/Output

1. Proponent to liaise with SA Power Networks to provide a list of SCADA inputs/outputs for the generating system.
2. DNP3 SCADA data shall be an Ethernet interface compliant with IEEE 802.3 standard notionally delivered via a 'Multi-Mode Optic Fibre' (MMOF) utilising optical to copper Ethernet media converters if required.
3. Prior to beginning SA Power Networks' SCADA works on site, the proponent's generating system PLC must be brought into SA Power Networks' offices for 'Factory Acceptance Testing' (FAT) to confirm that the PLC communicates correctly with SA Power Networks' equipment.

Control Room Temperature

With air-conditioning, temperature range between +20 degrees Celsius and +30 degrees Celsius.

Site Access

24 hours site access to SA Power Networks' equipment for faults and maintenance (escorted or non-escorted).

14.2 Interface Signals

A detailed list of interface signals will be prepared as the proponent's embedded generating system project progresses. However, the following tables are intended to provide an indication of the typical SCADA data interface requirements for multiple generating units connected via a single HV connection point.

The control interface may need to include provision for 'Generation Dispatch Limiter' (GDL) and power factor control that provides for secure dispatch of embedded generating system capacity and SA Power Networks will confirm these requirements on a site-specific basis.
SA Power Networks' SCADA requirements are shown in **Tables 10 to 13**.

Table 10
SCADA Digital Output Requirements

Digital Outputs (From SA Power Networks to Generator)	Signal Condition
Permission to Connect (permissive signalling)	Granted/ Denied
Inter-trip Protection Sent (Exporting Rotating or greater than 5MW IES Generating Systems Only)	Enabled/ Inhibit

Table 11
SCADA Analogue Output Requirements

Analogue Outputs (From SA Power Networks to Generator)	Signal Condition
Generating System Dispatch Limiter Set Point	Analogue Signal
Power Factor Set Point Control	Analogue Signal
Voltage Set Point Control (if required)	Analogue Signal

Table 12
SCADA Analogue Input Requirements

Analogue Inputs (From Generator to SA Power Networks)	Signal Condition
Generating System Real Power Output	Analogue Signal
Generating System Reactive Power Output	Analogue Signal
Generating System Current (Amps)	Analogue Signal
Generating System Voltage (Volts)	Analogue Signal
Number of Generating Units Connected	Analogue Signal
Generating System Dispatch Capacity	Analogue Signal
Power Factor Set Point Control Acknowledged	Analogue Signal
Voltage Set Point Control Acknowledged (if required)	Analogue Signal

Table 13
SCADA Digital Input Requirements

Digital Inputs (From Generator to SA Power Networks)	Signal Condition
All available AC and DC alarms Mains AC Failure DC Supply Battery Charger Failure 110VDC Supply Failure / 48VDC Failure	Normal/ Failed Normal/ Failed Normal/ Failed Normal/ Failed
Permission to Connect Received	Granted/ Denied
Generating System Dispatch Limiter Set Point Acknowledged	Yes/No
Generating System Direct Trip Received	Normal/ Fault
Generating System HV Circuit Breaker Status	Normal/ Fault
Generating System HV Circuit Breaker Status	Open/ Closed
Generating Unit Ready Status (for all Generating Units)	Available/ Unavailable
Generating Unit Status (for all Generating Units)	Running/ stopped
Permission to Connect Denied Time Expired Alarm	Enable/ Inhibit
Inter-trip Protection Received (Inter-Trip 'Heart Beat' Signal)	Enable/ Inhibit

15. Generator Primary Plant

15.1 General Requirements

The use of synchronous generating systems will impose out-of-phase switching duty on the circuit breaker that is opened to disconnect the facility from the distribution system. Potentially, this circuit breaker may see twice the normal phase-to-ground voltage under some system operating conditions.

Other system events may produce higher voltages across the circuit breaker and the proponent should consider these issues and the selection of plant having appropriate ratings. For this reason, embedded generating system circuit breakers should be capable of withstanding 220% of the connecting rated voltage.

SA Power Networks' circuit breakers and reclosers will not be used to separate, switch, serve as breaker failure backup or isolate a proponent's network that the embedded generation is connected to from the remainder of the network.

15.2 Means of Isolation

The Embedded generating system must provide a means of isolation capable of disconnecting the whole of the proponent's electrical system from the distribution network. This means of isolation must be lockable, in the open position only, using SA Power Networks' padlock. The proponent must provide SA Power Networks safe and unhindered access to the means of isolation, at any time.

The means of isolation must comply with SA Power Networks' Service and Installation Rules.

15.3 Insulation Co-ordination

The proponent must ensure that the insulation level of its equipment downstream of the connection point is appropriate for the normal and expected voltage range in accordance with the provisions of AS 1824.1.

All equipment must be capable of withstanding, without damage, power frequency voltage and impulse levels as nominated in **Table 14.** The lightning impulse withstand voltage level is under full-wave dry conditions using the standard 1.2/50ms wave shaped.

Table 14
Insulation Coordination Requirements

Voltage of system (kV)	Application	Minimum power frequency withstand voltage (kV rms)	Minimum lightning impulse withstand voltage (kV peak) [See Note]
3.3	All applications	16	40
6.6	All applications	20	60
7.6	All applications	28	95
11	All applications	28	95
33	All applications	70	170
66	All applications	140	325
	Equipment connected to neutrals	70	170
132	Transformer bushings	230	550
	All other applications	275	650
	Equipment connected to neutrals	38	110

Note: Where equipment meeting these impulse levels is not available, the use of surge arresters should be considered.

The proponent must provide adequate lightning protection on their equipment in accordance with AS/NZS 1768, such that the effect of a lightning strike anywhere within the proponent's electrical installation is not transferred to SA Power Networks' equipment.

Precautions should be taken to prevent transient voltages generated by any connecting loads, reactive plant (eg capacitor banks, reactors) and or the distribution system for causing damage to embedded generating system's components.

15.4 Out of Phase Interrupting Capability

The operation of embedded generating systems may result in out of phase voltages across circuit breakers or reclosers during reclose events or while normally open. The most severe conditions occur when the islanded system and network phases are 180 degrees apart, at which point the steady state voltage will be at least twice the system voltage at the time.

In addition, switching events may produce transient recovery voltages across switchgear during system events (faults). The proponent must consider corresponding out-of-phase switching currents under these conditions and ensure that circuit breakers are adequately rated.

15.5 Protection VT and CT Requirements

If required, the proponent must provide adequate protection CTs cores for protection systems and VT reference signals as required and specified by SA Power Networks.

15.6 Asset Interface Labelling

Where an embedded generating system is connected and synchronised to the network, the asset interface must be clearly labelled and defined for ownership and responsibility at the connection point and all asset interface boundaries.

For more information on labelling please refer to SA Power Networks' Service and Installation Rules.

16. Closed Transition Transfer Switches (CTTS)

For those installations wishing to install back-up generating systems intended to operate only in the event, of a loss of grid supply, CTTS may be used to transfer supply from the network connection to these back-up generators and vice-versa upon restoration of grid supply.

Closed transition transfer switches (CTTS) at LV must be compliant with AS/NZS 3947.6.1 Low-voltage switchgear and control gear - Multiple function equipment - Automatic transfer switching equipment, and AS/NZS 3439.1 Low-voltage switchgear and control-gear assemblies - Type-tested and partially type-tested assemblies.

The transfer switch must be a proprietary device, provided as a packaged unit by an industry recognised manufacturer. The auto changeover must not be assembled from individual components within the switchboard. Unless otherwise agreed in writing with SA Power Networks, the duration of the closed transition of the load between the distribution network and the embedded generating system, and vice versa, must not be longer than 1s.

In addition, the closed transition transfer switches must comply with the Australian Standards listed in this technical standard and SA Power Networks' Service & Installation Rules. Such switches shall be deemed compliant with SA Power Networks' requirements.

This equipment must not cause interference to the quality of supply to our other network users and must comply with the relevant standards AS/NZS 61000.3 (series) Electromagnetic compatibility (EMC) Limits.

An embedded generating system that is connected via a compliant closed transition transfer switch may be installed without the need for SA Power Networks to undertake detailed network investigations or enter into a connection contract for that generating system, however, they may/will be subject to inspection by SA Power Networks to ensure compliance with the requirements of this section and the Service & Installation Rules.

17. Generator (Equipment) Earthing

The proponent is required to ensure that their generating system and or installation facilities have an effective earthing system to limit step and touch earth potential rise to safe values and ensure compliance with the requirements of Australian Standards. In addition, generating system supplied via a HV connection point must ensure they are compliant with Section 9.11 of SA Power Networks' Service and Installation Rules.

Suitable measures will be applied to ensure that remote earths cannot present a hazard to telecommunication facilities and comply with the requirements of AS/NZS 3835 - Earth Potential Rise - Protection of Telecommunications Network Users, Personnel and Plant.

To support co-ordinated neutral earthing outcomes, the following sections define generator neutral earthing requirements:

17.1 High Voltage Generators

Unless otherwise agreed with SA Power Networks, high voltage embedded generating system directly connected to the high voltage distribution network must have their neutral effectively isolated from earth; (ie isolated or earthed via high impedance). This is to limit any contribution to the high voltage distribution network's earth fault levels and inhibit the flow of harmonic currents through the neutral.

17.2 Low Voltage Generators

embedded generating systems connected to the high voltage distribution network via a delta/star transformer, (delta on the network side), may have their neutral directly connected to earth. However, effective isolation of this neutral will normally be required to inhibit the flow of harmonic and zero sequence currents through the neutral.

It is recommended that the proponent should review and investigate suitable methods to limit harmonic currents through neutral connections and apply tests as required during commissioning and testing, to prove no adverse effect of their installation.

18. Distribution Loss Factor (DLF)

Distribution Loss Factors (DLFs) are used to describe the average energy losses for electricity transferred across a distribution network, between a distribution system connected generator and a transmission connection point for a given financial year. In effect, DLFs are a proxy for distribution energy losses and their values are recalculated each year to reflect changes in:

1. customer load;
2. connected generation capacity;
3. generation dispatch patterns; and
4. network configuration.

DLFs are used in the settlement process for proponent and will impact on the revenue received from generation dispatch. It is important that proponent consider the economic impact of DLF assignment and potential for their value to change (either due to themselves or others) on their project economics.

For embedded generating systems with a nameplate capacity greater than or equal to 10MW, SA Power Networks will calculate the applicable site specific DLF as part of the application to connect. For all other generating systems, SA Power Networks will, on request from the proponent and at the proponent's expense, calculate the applicable DLF in line with Clause 3.6.3 of the NER.

Where a proponent requests the calculation of a site specific DLF under Clause 3.6.3 of the NER, SA Power Networks is obliged to apply this DLF irrespective of whether the value calculated is to the benefit or detriment of the proponent.

Each year, SA Power Networks reviews and where necessary re-calculates DLF factors for applicable embedded generating system in line with clause 3.6.3 of the NER and provides this to AEMO for publication on the AEMO internet site (www.aemo.com.au).

19. Modelling Data

19.1 Generating Systems 5MW and Above

For generating systems 5MW and above, and or where dynamic studies are required, proponents will be required to provide SA Power Networks with modelling data in accordance with the NER Clause S5.2, to support system studies and the assessment of power quality and security of supply.

For generating systems exporting 5MW and above, the proponent is to provide to SA Power Networks steady state and dynamic modelling data of the generating system (ie PSS/E and PSCAD simulation models) for feasibility assessment. The proponent may also be required to complete post commissioning tests (R2) to validate their original (R1) generator models in accordance with the AEMO's generating system model guidelines.

The data/models provided to SA Power Networks must be compliant with the software versions specified by SA Power Networks and/or AEMO.

Copies of AEMO's generating system modelling guidelines, data sheets, templates etc are available from AEMO website (www.aemo.com.au) and refer to AEMO publication titled "Data and Model Requirements for generating systems of less than 30 MW", Table 2.

19.2 Generating Systems Less than 5MW

In the case of proponents, who have an installed capacity less than 5MW, SA Power Networks may require reduced information and modelling requirements. SA Power Networks' minimum information requirements for these types of embedded generating system are listed in our application to connect forms, available from our website. SA Power Networks reserves the right however, to request any additional information deemed reasonably necessary to perform the required network assessment.

Depending on the proposed installed capacity, proximity to other generating systems and network connection location, generating systems with a nameplate capacity less than 5MW may require additional generating modelling data. In these circumstances, the model and data requirements will be as per AEMO requirements, summarised in **Table 14**.

Proponents with generating systems less than 5MW may also be required by SA Power Networks to complete post commissioning tests (ie R2 tests) to confirm or calibrate their generator models and establish compliance with any agreed generator performance standards (GPS).

20. Revenue Metering

Revenue or NEM metering is required for the connection of all embedded generating systems (as outlined in NICC270: 'Connection Requirements of Embedded Generation') and is in addition to the SCADA and remote monitoring requirements outlined in **section 14** of this technical standard.

If required, it is the obligation of the proponent to ensure that the generating system's connection point has a metering installation compliant with SA Power Networks' Service and Installation Rules and that the metering installation, where applicable, is registered with AEMO.

The metering installation, including any current and voltage transformers required for metering and or protection of high voltage installations must be fully compliant with the NER, AEMO's Metrology Procedure, ESCOSA's Electricity Metering Code EMTC/08, and SA Power Networks' Service and Installation Rules.

Current and voltage transformers are always required for the purposes of metering services more than 100Amps and 400Volts respectively.

It is a requirement that the metering installation is located on the proponent's side of the connection assets and as close as practicable to the connection point. This arrangement will eliminate the need for external service providers to work on live SA Power Networks' equipment. It shall be located on the proponent's side of the connection point and comply with the NER, ESCOSA's Electricity Metering Code and SA Power Networks' Service and Installation Rules.

Where applicable, copies of NER compliant type test and routine test results must be provided for all instrument transformers to SA Power Networks before the installation can be connected to the distribution network.

The proponent should note that the NER may require installation of check metering facilities depending on the number of MW hours of energy proposed to be generated by the generating system.

It is the proponent's responsibility to ensure that the operational requirements of the generating system and national grid metering arrangements are suitably addressed, with the role of Responsible Person / Metering provider / Meter data agent to be decided by the proponent as part of any registration submission. SA Power Networks has no role with respect to revenue metering or enforcing such arrangements are in place.

21. Project Completion

The proponent connecting to SA Power Networks' distribution network have an obligation to permit and participate in the inspection, testing and commissioning of the generation facilities. These requirements are outlined under NER Clause 5.7 - Inspection and testing and Clause 5.8 - Commissioning and the proponent should make themselves familiar with these requirements.

The information provided in this technical standard complements the information AEMO have published for registered participants, available at the following site: http://www.aemo.com.au/Electricity/Network-Connections/NEM_Generator_Distribution_New-Connection/Stage-6.

The SA Power Networks project completion stage is comprised of three distinct parts:

Part A: Pre-connection off-line testing - Proponent testing to ensure the generating system is ready for connection to the network - (Refer Section 22)

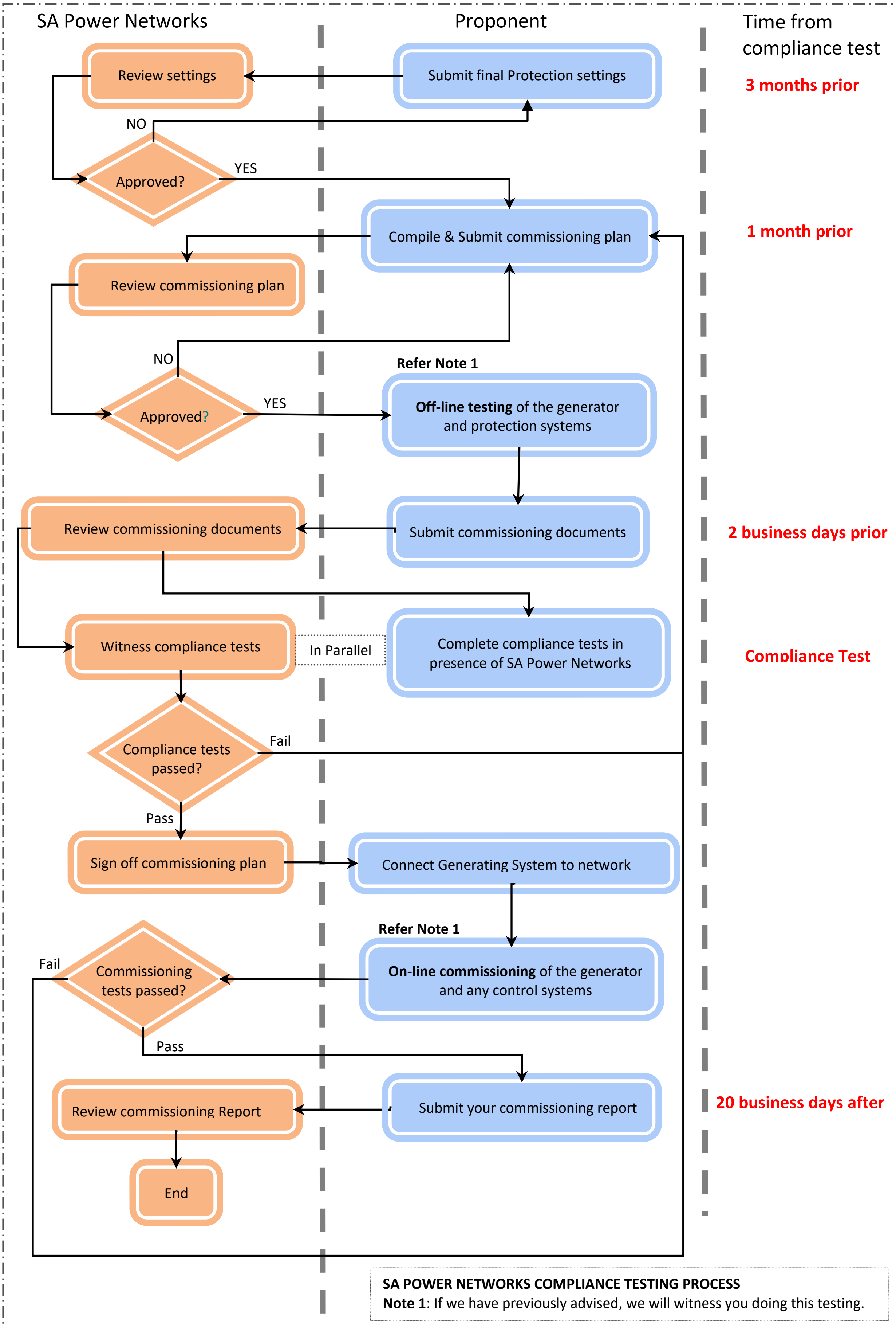
Part B: Compliance testing - Proponent testing to demonstrate that the facility complies with SA Power Networks' technical requirements - (Refer Section 23)

Part C: Post connection or On-line commissioning - Proponent testing to demonstrate the generating system performs as agreed - (Refer Section 24)

It should be noted that for those embedded generating systems equal or greater than 30MW requiring AEMO registration, on line testing will only be permitted following successful registration (based on R1 data and analysis) submission of a dispatch bid and the issuing of a dispatch approval instruction from AEMO.

Proponents required to be registered as market, scheduled generators should discuss registration requirements with AEMO directly and ensure market bidding arrangements are in place prior to the commencement of on-line testing.

The following flow diagram provides an overview of the roles of SA Power Networks and the proponent in the project completion stage.


SA Power Networks
Proponent
Time from compliance test
3 months prior
Review settings
Submit final Protection settings
NO
Approved?
YES
Compile & Submit commissioning plan
1 month prior
Review commissioning plan
NO
Refer Note 1
Approved?
YES
Off-line testing of the generator and protection systems
Review commissioning documents
Submit commissioning documents
2 business days prior
Witness compliance tests
In Parallel
Complete compliance tests in presence of SA Power Networks
Compliance Test
Compliance tests passed?
Fail
Pass
Sign off commissioning plan
Connect Generating System to network
Refer Note 1
Fail
Commissioning tests passed?
On-line commissioning of the generator and any control systems
Pass
Review commissioning Report
Submit your commissioning report
20 business days after
End
SA POWER NETWORKS COMPLIANCE TESTING PROCESS
Note 1: If we have previously advised, we will witness you doing this testing.

21.1 SA Power Networks Site Visit Requirements

As part of the project's connection, SA Power Networks may attend site to witness commissioning and compliance testing. Outlined within this section are the typical arrangements for SA Power Networks to attend site.

A high voltage connection compliance officer will be required to inspect the proponent's installation and once the installation is verified to be compliant with the Service and Installation Rules, a SA Power Networks' representative may attend site to witness commissioning of the generating system to verify operation of the protection and control schemes are compliant with the requirements of this engineering report, applicable standards and regulations.

SA Power Networks' final site visit requirements will be advised in the engineering report or connection offer. SA Power Networks' attendance at site or any subsequent visits will be at the proponent's cost.

SA Power Networks typical site visit requirements for inspection, testing and commissioning are shown in **Table 15**.

Table 15
SA Power Networks Typical Site Visit Requirements for Inspection Testing and Commissioning

Testing and Commissioning Component
Site visit during generator's pre-connection testing (refer Note 1), if advised as required at the time of your Application to Connect.
Compliance witnessing (refer Note 2)
Post connection commissioning (refer Note 2)
Where dynamic studies were involved, site visit will be required to confirm any R2 or model confirmation testing being undertaken (refer Note 1)

Notes:

1. Where dynamic studies were involved, the pre-connection testing may require SA Power Networks to engage a consultant to verify any off-line step response tests that are required.
2. For all large generating systems, the compliance testing and post connection commissioning may be done on the same day. For this to happen, the following must occur:
   (a) this must have been nominated in the commissioning plan submitted; and
   (b) the commissioning officer must be satisfied that the pre-connection testing was passed successfully.

For generating systems requiring AEMO registration, AEMO are also entitled to witness the performance of any testing and will require typically a minimum of one-month advance notice to attend site. Any costs associated with AEMO attending site will be borne by the proponent.

21.2 Commissioning Plan Requirements

Proponents must submit a commissioning plan to SA Power Networks a minimum of 20 business days prior to the commencement of commissioning. This is required to allow for a review of the commissioning plan, advise any errors or omissions and to support the scheduling of resources to attend and witness the commissioning tests.

SA Power Networks will review the nature and relative timing of embedded generating system commissioning tests with respect to the impact on other customers, coordination with other network outages and advise accordingly.

The commissioning plan is to be divided into three (3) parts:

1. part A: Pre-connection off-line testing;
2. part B: Compliance testing; and
3. part C: On-line commissioning.

The proponent's commissioning plan is to be of sufficient detail to allow SA Power Networks to understand the following:

1. what elements of the generating system are proposed to be tested;
2. for each element that is being tested, the specific steps that the proponent proposes to undertake/require testing this element;
3. pass/ fail criteria for each test, including any settings/values that are to be verified; and
4. the proposed timeframe for testing and commissioning.

If the proponent is required to complete post commissioning tests (R2) in accordance with the AEMO generating system Model Guidelines, a copy of the (R2) test plan should be included with the commissioning plan submitted to SA Power Networks one month prior to commencement of commissioning.

Where such testing is required, AEMO may also nominate to be present during the performance of such tests. Any costs incurred by SA Power Networks or AEMO in witnessing these tests will be at the proponent’s expense. Further information relating to AEMO’s commissioning requirements can be found on their website.

22. Pre-Connection Offline Testing and Commissioning

Pre-connection off-line testing and commissioning is required to prove that the equipment that has been installed is operating correctly under test conditions. It also confirms the required functionality of each individual component prior to network connection and on-line testing and operation.

SA Power Networks is entitled to witness proponent testing and commissioning of those parts of the generating system that may have direct impact on the network. This could include injection testing for incoming circuit breakers, earth grid testing or other generator control system testing.

Where dynamic studies were required, the pre-connection testing may require SA Power Networks to engage a consultant to verify any offline step response tests that are required, the cost of which will be borne by the proponent.

22.1 Pre-Connection Commissioning Documentation

Pre-connection commissioning records for all tests undertaken must be kept by the proponent.

SA Power Networks requires some of these commissioning records be submitted for review and acceptance. SA Power Networks will not attend site to complete the next phase of commissioning until the required documentation has been submitted.

The following commissioning documents must be submitted to SA Power Networks two clear business days prior to the date arranged with SA Power Networks to attend site. Documents showing compliance with all relevant Standards, including:

1. a copy of the Electrical Certificate of Compliance;
2. for IES, a copy of the commissioning records in line with AS/NZS 5033;
3. any other applicable off-line testing records, including HV and earthing systems as applicable);
4. protection test certificates (either type test results and injection test results as required);

5. written statement from a competent protection technician certifying that the system is installed as per engineering report and or connection offer and protection settings applied are as agreed by SA Power Networks;
6. for generating systems greater than 5MW, evidence of registration with (or exemption from) AEMO is required; and
7. for high voltage connected installations, confirmation from SA Power Networks' connection compliance officers that the installation has complied with the requirements of the Service and Installation Rules.

23. Compliance Testing

Prior to connection of the generating system to the network, SA Power Networks is entitled to inspect and where necessary, require the proponent to test those parts of the generating system that may have a direct adverse effect on the distribution network should they fail to operate as intended. This is to enable us to satisfy ourselves that the generating system is acceptable for connection and complies in all respects with the requirements of the engineering report and the applicable standards and regulations.

Compliance tests must be undertaken by suitably accredited parties having appropriate skills and competencies. All 'Injection Testing' should be performed by a competent protection technician. SA Power Networks' representatives may witness the compliance tests undertaken by the proponent or their representative in accordance with their approved commissioning plan. SA Power Networks is not responsible for directing, leading or performing any of the required tests.

The extent of compliance testing will vary depending on the generation capacity and connection configuration, and will include a combination of:

1. **Injection Testing:** Simulation of system events by applying test signals to protection and control systems and confirming the correct response of the generator unit control system; and
2. **Controlled Testing**: Controlled testing of the protection and control systems by manipulating relevant settings and confirming the correct response of the generating system circuit breakers or isolation facilities.

Table 16 provides an indication of the compliance tests that may be required for given protection and control elements. Where tests are nominated as required by both injection testing and controlled testing, compliance can be undertaken based on either test method or a combination of both.

Please note that **Table 16** is intended as a guide only. The actual extent of pre-commissioning testing and commissioning will vary depending on the type, size and connection location of the embedded generating system and will be advised in the engineering report or in response to the submitted commissioning plan for your project.

Table 16
Protection and Control Compliance Test Requirements

Compliance Requirement	Inverter (AS/NZS 4777 or Equivalent) Generating System		Other Generating System	
	Injection Test	Controlled Test	Injection Test	Controlled Test
Inhibits / Interlocks	No	Yes	No	Yes
Under/ Over frequency	Yes	Yes	Yes	Yes
Under/ Over voltage	Yes	Yes	Yes	Yes
ROCOF/ Delta V	Yes	No	Yes	No
Voltage unbalance	Yes	Yes	Yes	Yes
Synchronisation	No	No	No	Yes
Pole slip	No	No	Yes	No
Inter-tripping	No	No (See Note 2)	No	Yes
Circuit breaker fail	Yes	No	No	Yes
Minimum import	Yes	Yes	Yes	Yes (See Note 1)
Fault level interlocks	No	No	Yes	No

Notes:

1. Where minimum import testing is proposed through controlled testing this must occur when the site load is at or near the agreed maximum demand.
2. Inter-tripping will be required for export Inverter generating systems above 5MW and will involve a ‘Controlled Testing’.

Any deficiencies detected during the compliance tests must be resolved before making the final network connection and a revised commissioning plan must be submitted. SA Power Networks will not connect an embedded generating system that is unsatisfactory for reliable connection to the distribution network. Any additional site visits by SA Power Networks to witness commissioning tests shall be at the expense of the proponent.

24. Post Connection or Online Commissioning

Post connection or online commissioning is required to confirm that the generating system performs as expected and that operation is consistent with the performance standards included in the connection offer or engineering report. The extent of post connection commissioning testing will vary depending on the type, size and connection location of the proposed generating system.

Post-commissioning tests are also required to confirm that the embedded generating system performs as expected and that operation is consistent with the assigned performance standards in the Connection Offer or engineering report.

For generating systems with a high voltage ‘Point of Common Coupling’ (POCC), if the most practical location for undertaking the commissioning tests is the low voltage main switchboard, the results at the high voltage (HV) POCC at 33kV or lower, may at SA Power Networks’ discretion, be inferred from the low voltage test results. This will preliminarily depend on the distance from the POCC to the connection on point and LV switch board.

Table 17 provides an indication of the post connection online tests that may be required for given generating system.

Please note that **Table 17** is intended as a guide only. The actual extent of post connection online commissioning will vary depending on the type, size and connection location of the embedded generating system and will be advised in the engineering report for your project. For generating systems to be registered with AEMO, reference should be made to AEMO's commissioning requirements.

Table 17
Indicative Post Connection Online Test Requirements

Post-Commissioning	Inverter (AS/NZS 4777 or Equivalent) Generating System	Other Generating System
Synchronisation	No	Yes
Ramp rate	Yes (See Note 1)	Yes
Set point controls	Yes	Yes
Generation dispatch limiter	Yes	Yes
Power factor controller	Yes	Yes
Reactive power capability	Yes	Yes
Quality of supply	Yes	Yes
Permissive Signalling	Yes	Yes
Performance standards tests (See Note 2)	Yes	Yes
R2 or Model confirmation tests (See Note 2)	Yes	Yes

Notes:

1. Ramp rate tests will most likely not be required for IES installations.
2. R2 or model confirmation tests to be undertaken if requested by AEMO or SA Power Networks. This will require extensive testing to demonstrate the dynamic response of the generating system. Further information regarding this is available within AEMO's commissioning requirements and R2 Testing Guideline.

The proponent must compile the commissioning test results in a commissioning report and submit this report to SA Power Networks for review within 20 business days of undertaking the tests. The commissioning report must confirm that all protection and control systems are functional and their settings are consistent with information provided to and approved by SA Power Networks. If required, a report confirming compliance with the assigned Generator Performance Standards and R2 model report must also be provided. Any R2 model report should be submitted to AEMO within 3 months of commissioning of the generating system.

Any deficiencies detected during the post connection tests must be resolved in a timeframe to be agreed between the proponent and SA Power Networks. SA Power Networks will not allow the ongoing connection of embedded generating system that has demonstrated unsatisfactory performance testing in order to maintain the integrity of the distribution network. Such disconnection may be made by SA Power Networks via permissive signalling where available.

For sites registered with AEMO, any non-compliances must be reported to AEMO via SA Power Networks together with a rectification plan as soon as possible, using the non-conformance template available from the AEMO website. The NER requires that any such non-conformances are rectified with 6 months.

24.1 Quality of Supply Considerations

Post connection logging of the quality of electricity generated is required to be undertaken by the proponent, using measurement instruments meeting the specifications listed below.

The minimum period that the logging equipment must be installed is one week, and this should include a period of at least two days where the generating system is not operating. In cases where potential for power quality issues have been identified as part of the network studies, the logging period required may be greater than one week, and the time periods will be advised as part of the engineering report.

The complete power quality logging data is to be provided to SA Power Networks in Microsoft Excel format, as an accompaniment to the commissioning report.

Table 18 details the specifications for the power quality measurement instruments and event recording.

Table 18

Power Quality Measurement Requirements

Attribute	Relevant Standard or Specification
Methods for measurement and interpretation of results	AS/NZS 61000.4.30
Class of measurement	Class S
Voltage, Amps, Freq, Power Factor, kV, kVA, kVAR	AS/NZS 61000.4.30
Sample rate	AS/NZS 61000.4.7
Total harmonic distortion & harmonics	AS/NZS 61000.4.7
Flicker (Pst and Plt)	AS/NZS 61000.4.15 (10min Pst & 2hr Plt)
Voltage and current unbalance	AS/NZS 61000.4.30
High speed event recording	Voltage, current and transient trigger enabled
RMS and waveform snapshots	Enabled

25. Joint Operating Protocols and Procedures

25.1 Joint Operating Protocols

Joint operating protocols are required to ensure co-ordinated management of the operation and dispatch of generation capacity. When required, the joint operating protocols will be developed in conjunction with the proponent.

The requirement for a joint operating protocol will be determined post acceptance of the connection offer for your project, however in general the following types of generating system will require the development of a joint operating protocol:

1. export generating systems, excluding large IES generating system exporting 200kW or less;
2. SCADA controlled generating systems (ie permission granted/denied);
3. GDL and power factor set point controlled generating system; and
4. high voltage connected generating systems.

The principles within the joint operating protocol will include, but not be limited to:

1. the proponent must gain permission from SA Power Networks' NOC prior to the connection and disconnection of any generator to the network;

2. an authorised representative of the embedded generating system must be available always when the generating plant is operating to receive communications and directions from the SA Power Networks' NOC so that emergencies can be addressed and dispatch limits applied if required; and
3. the proponent will ensure that appropriately trained operators are available as required, consistent with the operating protocol.

These protocols will be revised at regular intervals or as required considering any changes in system operating conditions, generation dispatch arrangements or contact detail changes. It is the responsibility of the proponent to advise SA Power Networks should any contact details change and ensure the joint operation protocol is permanently up to date/valid.

25.2 Operating Procedures

Prior to completion of the project, operational procedures must have been developed and adopted for the day to day operation of the installation. These procedures must complement the joint operating protocols to be developed.

The operating procedures will be designed to protect the network and to maximise the proponent's access to and use of the network within the agreed limits. The operating procedures will need to include, amongst other things:

1. details of the operating procedures and nomenclature standards to be adopted in relation to the interface between SA Power Networks' NOC and the proponent's generating system;
2. details of the procedures to be adopted by both parties in relation to the NOC oversight, monitoring, control and operation of the network and generating system access;
3. contact details for both parties' authorised persons available on 24 hours, seven days a week basis;
4. permission to connect / denied procedures; and
5. high voltage and isolation switching procedures.

The agreed operating procedures once developed, will need to consider the existing operating procedures used by SA Power Networks' NOC for the operation of the entire network.

26. Compliance Monitoring and Maintenance

The obligation of ensuring compliance with any generator performance standards resides with the proponent and will require ongoing demonstration of compliance with SA Power Networks' requirements and appropriate standards and regulations under the National Electricity Rules.

The proponent must adequately maintain the protection and control systems of the generating system and any other service provided by the proponent in relation to the generating systems that impacts on the individual generating unit, its safety or operation, or the safety or operation of the distribution network.

The proponent will ensure that the overall electrical installation and generating system is maintained in accordance with good electricity industry practice and will not create a hazard or cause interference with the SA Power Networks' distribution system. The proponent must arrange for periodic testing of the protection system to ensure it continues to function as designed and commissioned.

No later than six months after the generating system is first connected to the network, the proponent must develop and submit to SA Power Networks a compliance monitoring program for review at least 5 business days prior to the date of commissioning and connection of the generating system to the network.

The compliance monitoring program is to include an agreed method by which the generating system's ongoing compliance with applicable standards and regulations and continued operation in accordance with good engineering practice can be demonstrated.

The proponent will make available a copy of the agreed compliance monitoring program to SA Power Networks within three months of initial connection to the network and any resultant test results as and when required by the agreed compliance monitoring program. The cost of such compliance testing and maintenance shall be borne by the proponent.

Failure to provide a compliance monitoring program or adhere to its requirements may result in disconnection of the generating system by SA Power Networks using permissive signalling (where available).

26.1 Frequency of Testing

The compliance program must include the frequency and the testing methods at which the tests will be undertaken to prove ongoing compliance with the applicable performance standards or requirements in the engineering report.

The actual frequency of testing should take into consideration all relevant factors including:

1. the technology of the plant;
2. experience with the particular generation technology;
3. manufacturer's advice with respect to maintenance of the particular generating unit/ model; and
4. the level of maintenance required to provide reasonable assurance of compliance.

For most performance standards or requirement in the engineering report, the tests undertaken shall include, but not limited to:

1. all protection systems (circuit breakers, relays, trip signals, generating system protection and DC supply);
2. reactive power capability;
3. active power control;
4. voltage and reactive power control;
5. quality of electricity generated;
6. response to disturbances (frequency, voltage, contingency events); and
7. power station auxiliary transformers/supplies; and Fault level/current mitigation devices.

The minimum recommended frequency of testing is:

- Every 3 years; After any plant change; and after any disturbance event.

For communications equipment (comm. links including backup), remote monitoring capability (SCADA) and UPS systems, the recommended frequency of testing is:

- Annually; After any equipment change; and after any disturbance event.

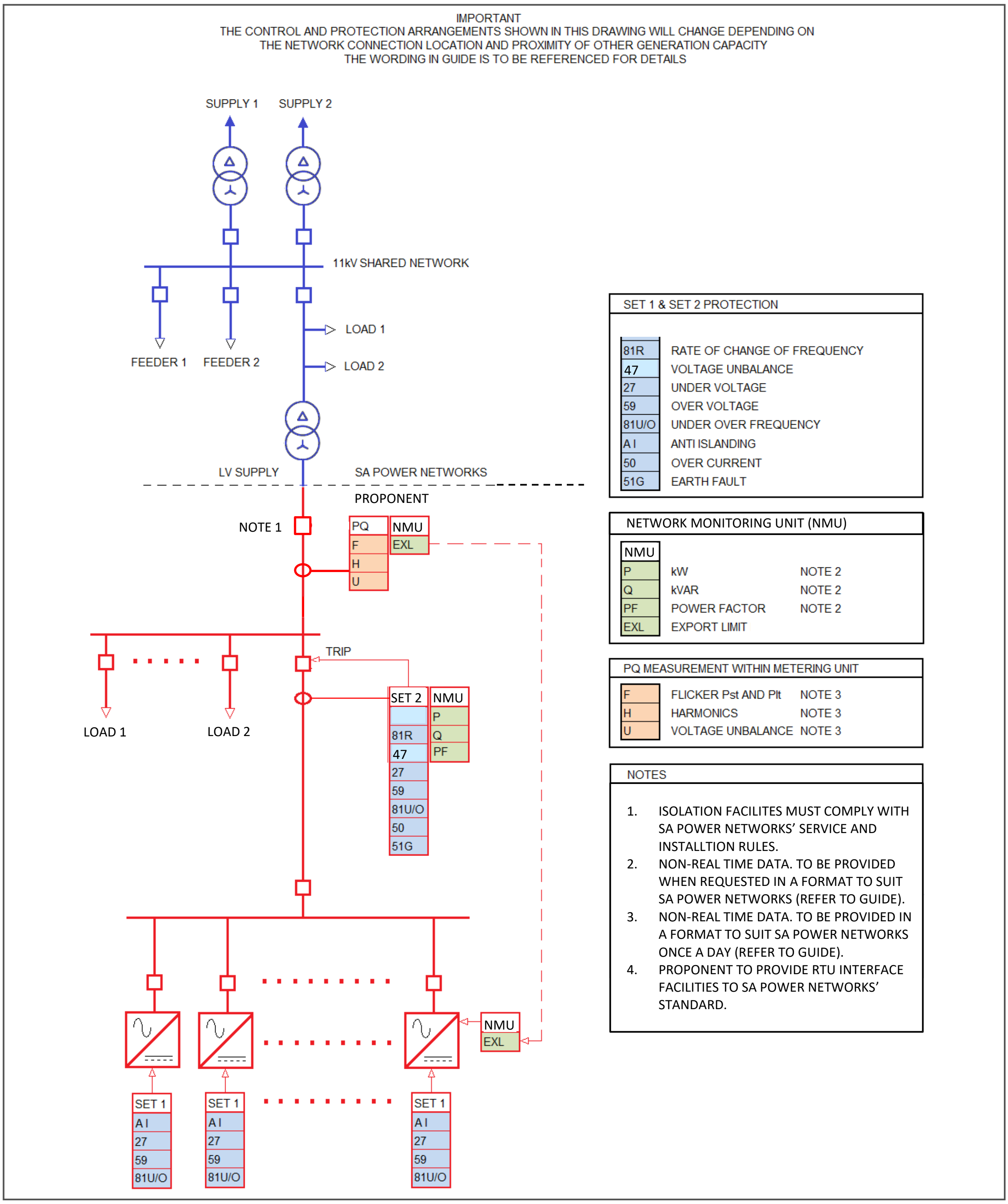
27. Who you should talk to?

For all enquiries with Inverter Energy Systems (IES) above 200kW or rotating generating systems, please contact SA Power Networks via email LargeGeneration@sapowernetworks.com.au.

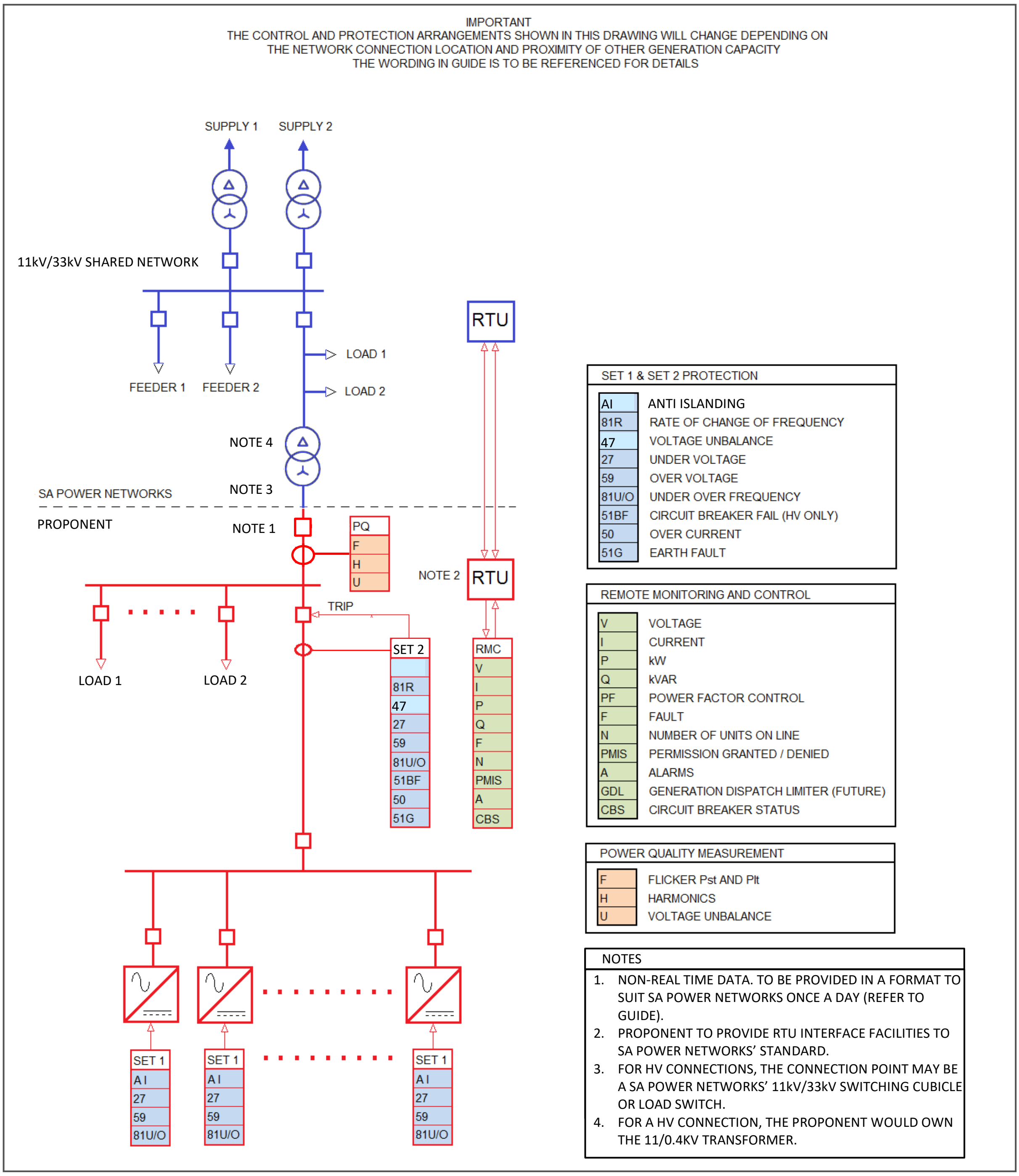
Appendices

A. Preferred Connection Arrangements

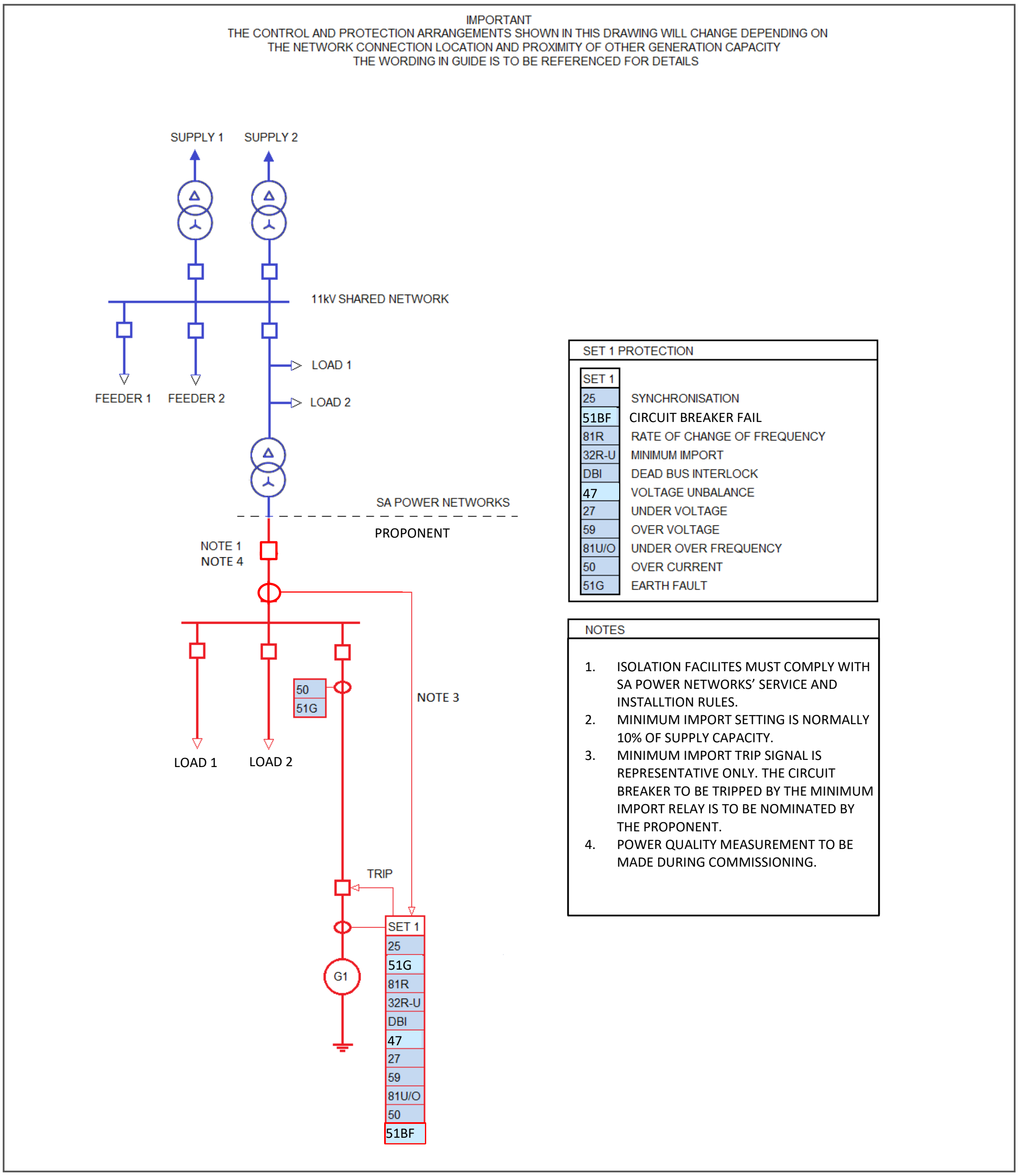
A.1 Above 200kW and ≤ 1MW Connected IES Gen-System, with < 200kW Export



A.2 Above 200kW and < 5MW Connected IES Gen-System, with > 200kW Export



A.3 Under 5MW Connected Non-Export Rotating Generating System



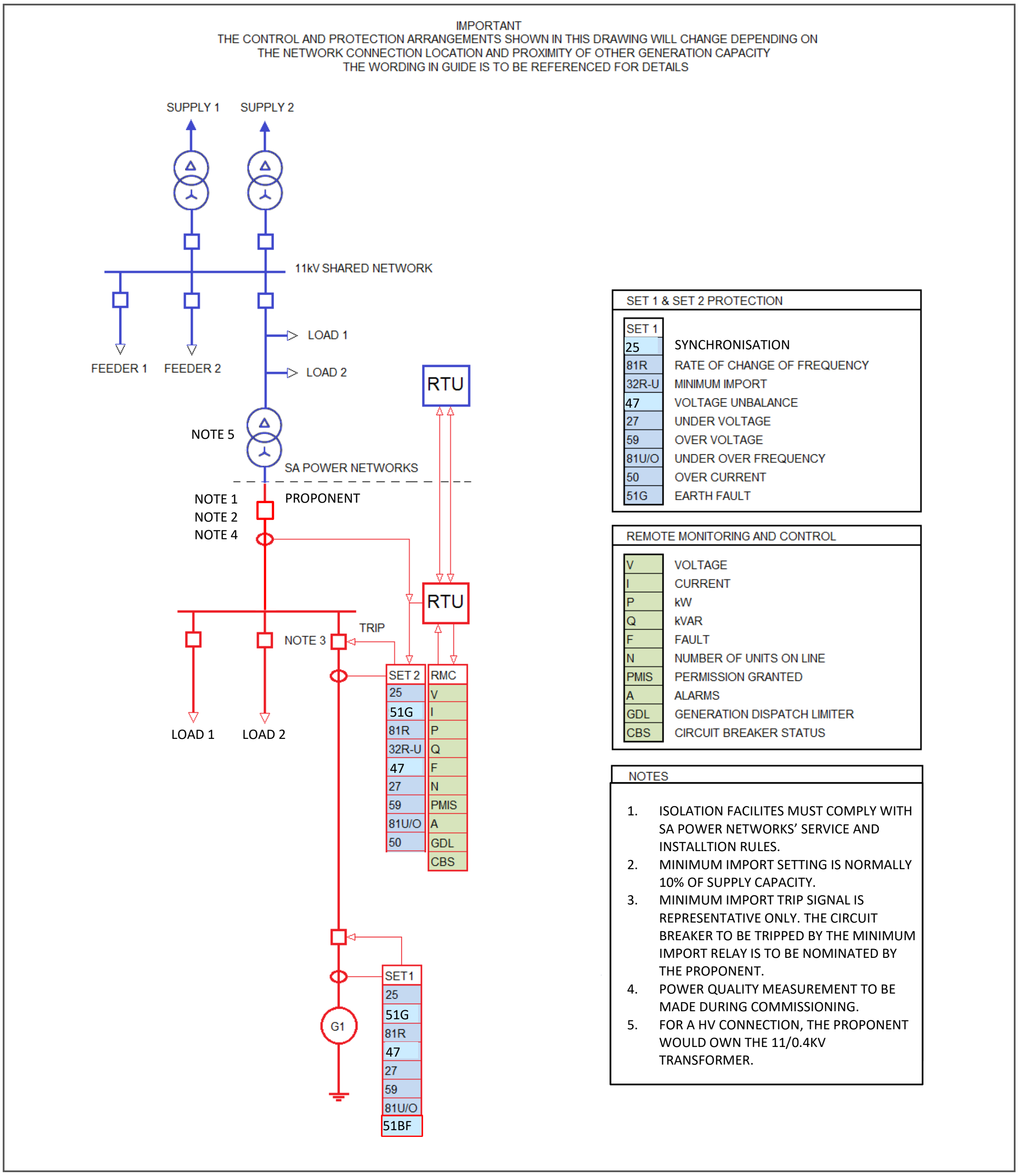
SET 1 PROTECTION

SET 1	
25	SYNCHRONISATION
51BF	CIRCUIT BREAKER FAIL
81R	RATE OF CHANGE OF FREQUENCY
32R-U	MINIMUM IMPORT
DBI	DEAD BUS INTERLOCK
47	VOLTAGE UNBALANCE
27	UNDER VOLTAGE
59	OVER VOLTAGE
81U/O	UNDER OVER FREQUENCY
50	OVER CURRENT
51G	EARTH FAULT

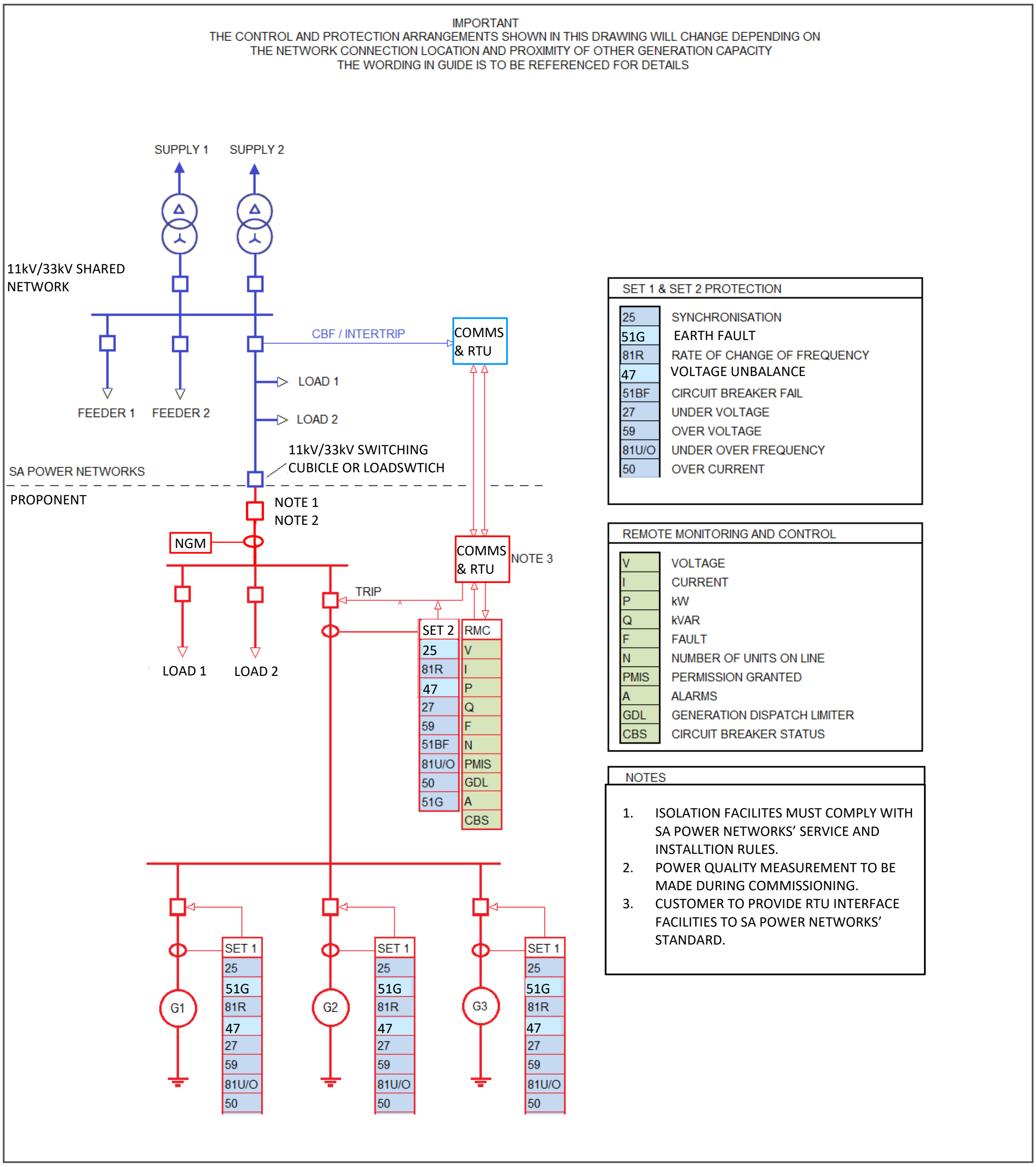
NOTES

1. ISOLATION FACILITES MUST COMPLY WITH SA POWER NETWORKS' SERVICE AND INSTALLTION RULES.
2. MINIMUM IMPORT SETTING IS NORMALLY 10% OF SUPPLY CAPACITY.
3. MINIMUM IMPORT TRIP SIGNAL IS REPRESENTATIVE ONLY. THE CIRCUIT BREAKER TO BE TRIPPED BY THE MINIMUM IMPORT RELAY IS TO BE NOMINATED BY THE PROPONENT.
4. POWER QUALITY MEASUREMENT TO BE MADE DURING COMMISSIONING.

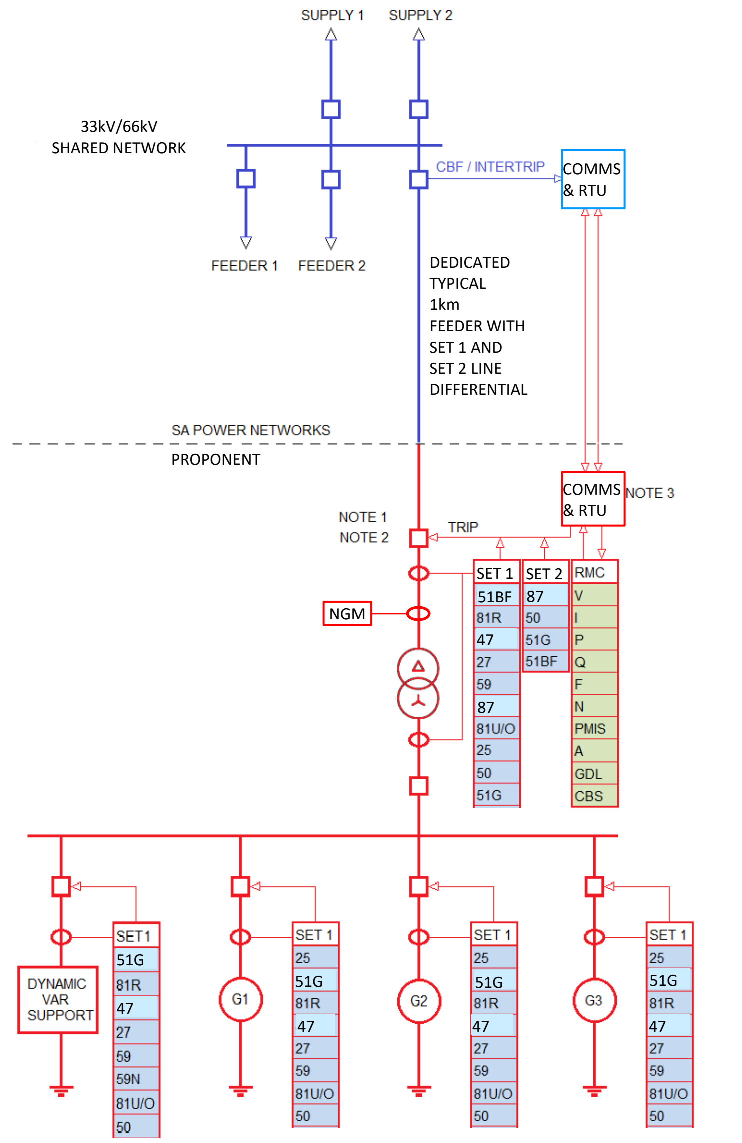
A.4 Above 5MW Connected Non-Export Rotating Generating System



A.5 Under 5MW Connected Export Rotating Generating System



A.6 5MW-10MW HV Connected Export Rotating Generating System



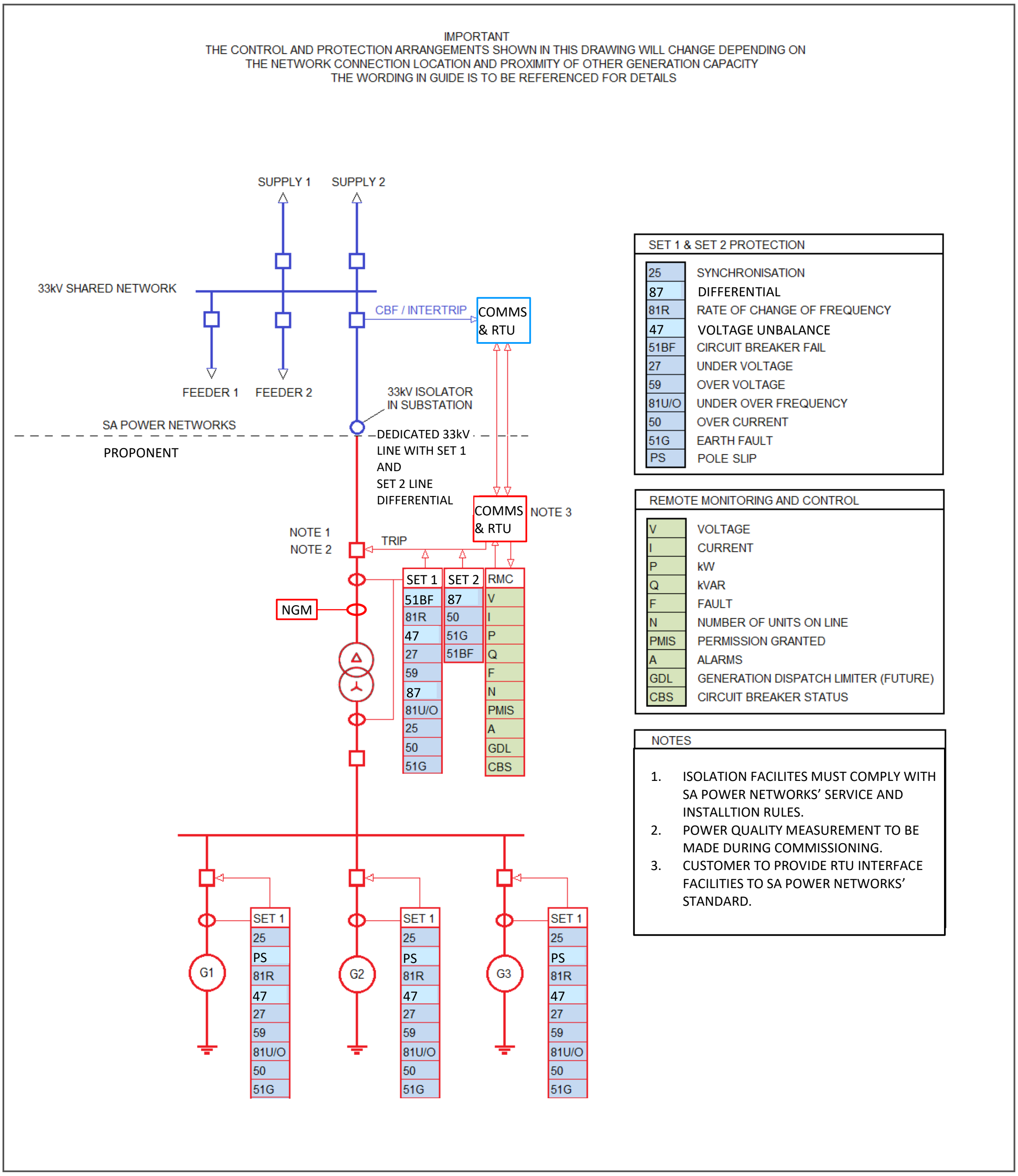
SET 1 & SET 2 PROTECTION	
25	SYNCHRONISATION
87	DIFFERENTIAL
81R	RATE OF CHANGE OF FREQUENCY
47	VOLTAGE UNBALANCE
51BF	CIRCUIT BREAKER FAIL
27	UNDER VOLTAGE
59	OVER VOLTAGE
81U/O	UNDER OVER FREQUENCY
50	OVER CURRENT
51G	EARTH FAULT

REMOTE MONITORING AND CONTROL	
V	VOLTAGE
I	CURRENT
P	kW
Q	kVAR
F	FAULT
N	NUMBER OF UNITS ON LINE
PMIS	PERMISSION GRANTED
A	ALARMS
GDL	GENERATION DISPATCH LIMITER (FUTURE)
CBS	CIRCUIT BREAKER STATUS

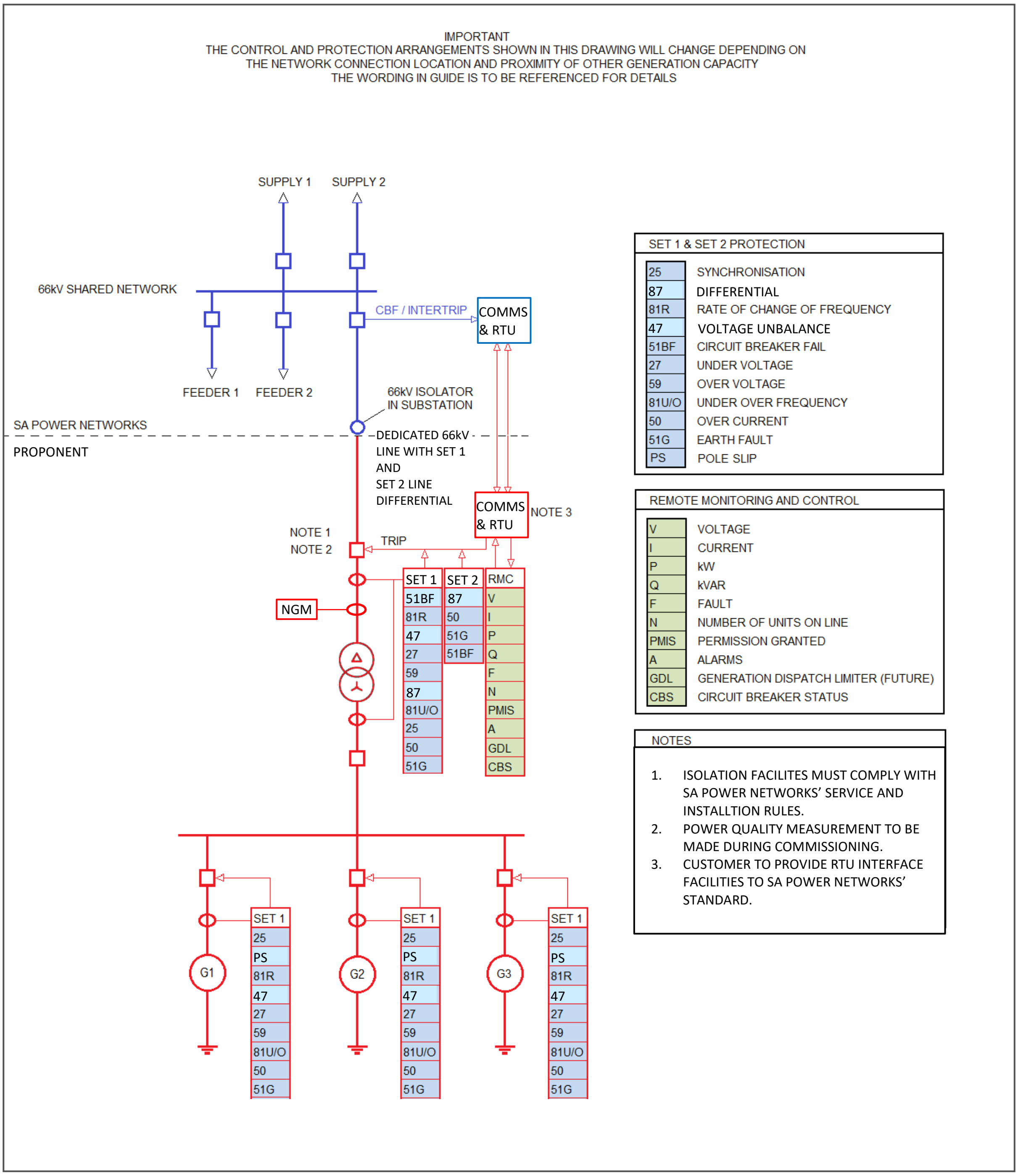
NOTES

1. ISOLATION FACILITES MUST COMPLY WITH SA POWER NETWORKS' SERVICE AND INSTALLTION RULES.
2. POWER QUALITY MEASUREMENT TO BE MADE DURING COMMISSIONING.
3. CUSTOMER TO PROVIDE RTU INTERFACE FACILITIES TO SA POWER NETWORKS' STANDARD.

A.7 Over 5MW Generating System (33kV Connection)



A.8 Over 5MW Generating System (66kV Connection)



B. Definitions

AEMO:	The Australian Energy Market Operator Limited (or its successor).
Applicable Regulations:	All regulations as per Appendix C – References.
AVR	Auto Voltage Regulator
Connection Point:	As per Electricity (General) Regulations 2012: A connection point to a Transmission or distribution network. For this document connection point also has the same meaning as Point of Supply as defined in AS/NZS 3000. The agreed point of supply established between SA Power Networks and the customer and or the proponent.
Contractor:	A contractor and their sub-contractor who is engaged by SA Power Networks to conduct works on or near SA Power Networks infrastructure.
Customer:	A person who engages in the activity of purchasing electricity supplied through the distribution network to a connection point.
Distribution Network:	Has the meaning given to that term in the Electricity Act 1996, namely the whole or a part of a system for the distribution of electricity, but does not include anything declared by regulation not to be a distribution network or part of a distribution network. For the purposes of these rules references to distribution network means the network poles, wires, underground cables, transformers, substations etc, operated by SA Power Networks, which transports electricity from the transmission system to a customer's Connection Point.
Electricity Distribution Code (EDC):	The Electricity Distribution Code made by ESCOSA pursuant to Section 28 of the Essential Services Commission Act 2002.
Embedded Generating Unit:	A generating unit connected within a distribution network and not having direct access to a Transmission Network.
Embedded Generator:	A generator (ie proponent), who owns, operates or controls an embedded generating unit.
ESCOSA:	Essential Services Commission of South Australia.
Generating System:	All embedded Generating Units and the associated control and protection equipment that is located on the proponent's side of the connection point.
Generating Unit:	The actual generator of electricity and all related equipment essential to its function as a single entity.
Generator:	A person/entity who engages in the activity of owning, controlling, or operating a generating system that supplies electricity to, or who otherwise supplies electricity to, a transmission or distribution network.
IES:	Inverter Energy System
Inverter:	The device that forms part of the generating system which uses semiconductor / power electronics devices to transfer power between a DC source and AC source or load.

B: Definitions (Continued)

Large Embedded Generation Installation:	For this guide, a large-embedded generation installation is defined as: • IES installations greater than 5kVA (SWER), or 30kVA (three phase); • large fuel-cell installations; • wind turbine generating units; • synchronous and asynchronous generating units driven by hydro turbines; and • synchronous generating units driven by gas engines, gas turbines or diesel engines. The final mentioned category includes any commercial plant which is operated and connected in parallel with the distribution network by arrangement with SA Power Networks for demand management or for routine on-load testing.
Must/Shall:	Is to be understood as mandatory.
Nameplate Capacity:	The maximum continuous output or consumption in MW of an item of equipment as specified by the manufacturer, or as subsequently modified;
National Electricity Rules (NER):	The rules as defined in the National Electricity Law as set out in the Schedule to the National Electricity (South Australia) Act 1996.
NEM:	National Electricity Market.
NOC:	SA Power Networks' Network Operations Centre.
PLC:	Programable Logic Controller
Point of Common Coupling:	The location at which the impact of the generating system on the network will be assessed.
PSS:	Power System Stabiliser.
Proponent:	Person applying for access to or connection of embedded generation System to SA Power Networks' network.
PV:	Photo Voltaic. The generation of electrical power by converting solar radiation into direct current electricity.
Retailer:	The holder of an electricity retail license granted under the Electricity Act, 1996, who is contracted to sell electricity to the customer at the Supply Address.
ROCOF:	Rate of change of frequency. An islanding detection method for decentralised generation units.
RTU:	Remote Telemetry Unit. (Also known as 'Remote Terminal Unit' or 'Remote Telecontrol Unit')
SCADA:	Supervisory Control and Data Acquisition.
Should:	Is to be understood as non–mandatory, ie advisory or recommended.
Suitable (or Suitably):	To the satisfaction of the relevant SA Power Networks Manager.
Supply:	The delivery of electricity.
Customer's Property Address:	The address at which SA Power Networks supply the generator and / or customer with electricity.
Terms and Conditions:	SA Power Networks Publication Terms and Conditions for External Contractor Construction, as amended from time to time.
TNSP:	Transmission Network Service Provider.

B: Definitions (Continued)

Transmission Network:	ElectraNet's electricity Transmission Network.
UPS:	Uninterruptible Power Supply. UPS is a device that provides battery backup when the electrical power fails or drops to an unacceptable voltage level.
Voltage Unbalance:	In a three-phase system, voltage unbalance takes place when the magnitudes of phase or line voltages are different and the phase angles differ from the balanced conditions, or both

C. References

The following listed documents are for additional information and other documentation may be required on a project specific basis. **Please Note**: It is your responsibility to ensure you have complied with all applicable, SA Legislative Regulations (under Acts), ESCOSA/ENA/AEMC/IEC documentations, relevant AS/NZS standards, the SA Power Networks publications, and you have ensured their current publications, before implementing them.

South Australian Legislations:

- Electricity Act 1996 & Electricity (General) Regulations 2012
- WH&S Act 2012 & Work Health & Safety Regulations 2012

Essential Services Commission of South Australia (ESCOSA) Codes:

- SA Electricity Distribution Code (EDC)
- SA Electricity Metering Code (EMTC)

Energy Networks Association (ENA) Publications:

- ENA NENS 03: National Guidelines for Safe Access to Electrical and Mechanical Apparatus
- ENA NENS 04: National Guidelines for Safe Approach Distances to Electrical and Mech. Apparatus

Australian Energy Market Commission (AEMC) Publications: National Electricity Rules (NER)

Standards Australia Publications:

AS 1319	1994	Safety Signs for the Occupational Environment
AS 1359.0	1998	Rotating Electrical Machines - General Requirements Part 0: Introduction and list of parts
AS 1824.1	1995	Insulation co-ordination – Definitions, principles and rules
AS 1931.1	1996	High voltage - Test techniques - General definition and test requirements
AS 2067	2016	Substations and high voltage installations exceeding 1 kV a.c.
AS 2467	2008	Maintenance of Electrical Switchgear
AS 60038	2012	Standard voltages
AS 60068.1	2003	Environmental testing - General and Guidance
AS 60529	2004	Degrees of Protection Provided by Enclosures (IP Code)
AS/NZS 1768	2007	Lightning protection
AS/NZS 3000	2007	Electrical Installations (known as the wiring rules)
AS/NZS 3010	2017	Electrical Installations - Generating sets
AS/NZS 3017	2007	Electrical installations - Testing User Guides
AS/NZS 3100	2017	Approval and test specification - General requirements for electrical equipment
AS/NZS 3439.1	2002	Low-voltage switchgear and control gear assemblies - Type-tested and partially type-tested assemblies
AS/NZS 3835.1	2006	Earth Potential Rise - Protection of Telecommunications Network Users, Personnel and Plant – Code of practice
AS/NZS 3835.2	2006	Earth Potential Rise - Protection of Telecommunications Network Users, Personnel and Plant – Application guide
AS/NZS 3947.6.1	2001	Low-voltage switchgear and control gear - Multiple Function equipment - Automatic transfer switching equipment
AS/NZS 4777.1 & AS/NZS 4777.2	2016	Grid connection of energy systems via inverters Part 1: Installation requirements & Part 2: Inverter requirements
AS/NZS 5033	2014	Installation and safety requirements for photovoltaic (PV) arrays
AS/NZS 61000.1.1	2016	Electromagnetic compatibility (EMC) - General - Application and interpretation of fundamental definitions and terms

C: References (Continued)

IEC Standards:

IEC 60255.1	2009	Measuring Relays and Protection Equipment Part 1: Common requirements

IEEE Publications:

IEEE C37.90.1	2012	Standard Surge Withstand Capability Tests for Relays and Relay Systems Associated with Electric Power Apparatus

AEMO Documents:

Version 1.0 - 28 June	2013	Data and model requirements for generating systems less than 30MW

SA Power Networks Documents:

Manuals:

Manual 14	Safety, Reliability, Maintenance & Technical Management Plan
Manual 18	Network Tariff & Negotiated Services
Manual 32	Service and Installation Rules

Technical Standards & NICC Brochures:

NICC269	Connection Requirements of Small Embedded Generation
NICC270	Connection Requirements of Embedded Generation
TS129	Small Inverter Energy Systems (IES) – Capacity not exceeding 30kW
TS130	IES above 30kW and up to or equal to 200kW
TS304	Substation Design - Signage