Standard

Protection of HV Busbars and Feeders

Version 3.0

R246419

Tasmanian Networks Pty Ltd (ABN 24 167 357 299)

Authorisations

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Review cycle	30 months	

Responsibilities

This document is the responsibility of the Substations Asset Strategy Team, Tasmanian Networks Pty Ltd, ABN 24 167 357 299 (hereafter referred to as "TasNetworks").

Please contact the Substations Asset Strategy Team Leader with any queries or suggestions.

- Implementation All TasNetworks staff and contractors.
- Compliance All group managers.

Minimum Requirements

The requirements set out in TasNetworks' documents are minimum requirements that must be complied with by all TasNetworks team members, contractors, and other consultants.

The end user is expected to implement any practices which may not be stated but which can be reasonably regarded as good practices relevant to the objective of this document.

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Record of revisions

Section number	Details
1.5	Updated abbreviations
1.6.1	Updated reference standards
2.1	Added section for incomer protection and control
2.4.1	Removed specific sections for HIBP and LIBP
2.5.5	Added the requirement to enable and disable the SEF and added core balance CT requirements. Also changed the setting for 11 kV and 22 kV
2.5.6	Changed section to Fast protection rather than Live Line and changed the definite time setting to instantaneous and removed the SEF from Fast Protection settings
3.5.4	Removed section on thermal overload protection as not normally enabled
3.5.5	Removed section on negative phase sequence protection as not normally enabled
3.5.6	Removed section on over and under voltage protection as not normally enabled
Appendix 1	Removed the appendix that specified device models

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General

1.1 Purpose

The purpose of this document is to define the requirements and describe the application philosophy for the protection of High Voltage (HV) busbars and the protection and control of feeders connected to the HV network under the responsibility of Tasmanian Networks Pty Ltd (hereafter referred to as 'TasNetworks').

1.2 Scope

This document applies to the equipment installed within TasNetworks transmission substations for protection and control of incomers, busbars and feeders operating at voltages between 6.6 kV and 44 kV. This standard contains requirements for design of protection and control equipment and is to be applied to new installations as well as redevelopment of part or all existing installations.

This does not include the installation of fuses and pole mounted reclosers.

1.3 Objective

TasNetworks requires design as covered in this standard to ensure:

(a) personnel and public safety;

(b) safety of TasNetworks' assets;

(c) reliability and continuity of power supply to the power transmission network;

(d) that relevant Australian legal requirements are met;

(e) ease in operation and maintenance;

(f) minimum disruption to the HV supply system following a fault;

(g) that the requirements of TasNetworks' corporate plan are met;

(h) that the exposure of TasNetworks' business to risk is minimised; and

(i) that TasNetworks' responsibilities under connection agreements are met.

1.4 Precedence

Any apparent conflict between the requirements of this standard and the law, mandatory requirements, industry standards, project specifications, non-statutory standards or guidelines, and any other associated documents should be brought to the immediate attention of TasNetworks for resolution and no action must be taken that might result in a breach of law or mandatory standard.

Where there may be a conflict between the requirements of this standard and any:

(a) law, mandatory requirement or industry standard, then that law or statutory requirements will prevail over this standard;

(b) non-mandatory standard, or guideline, then this standard will prevail over that standard or guideline; or

(c) project specification, then a deviation must be specifically requested and approved in writing by TasNetworks' Substations Asset Strategy Team Leader.

Approval for a deviation to this standard may only be accorded if it does not reduce the quality of workmanship, pose a safety risk to personnel or equipment and does not deviate from the intent of this standard.

1.5 Abbreviations

CB	Circuit Breaker
CBF	Circuit Breaker Failure
CT	Current Transformer
DC	Direct Current
DNP3.0	Distributed Network Protocol version 3.0
HMI	Human Machine Interface
HV	High Voltage
IEC	International Electrotechnical Commission
MCB	Miniature Circuit Breaker
MI	Major Industrial
NOCS	Network Operational Control System
RTU	Remote Terminal Unit
SCADA	Supervisory Control and Data Acquisition
SCB	Shunt Capacitor Bank
SOE	Sequence of Events
TCS	Trip Circuit Supervision
VT	Voltage Transformer

1.6 References

As a component of the complete specification for a system, this standard is to be read in conjunction with other standards and documents as applicable. In particular, this includes the project specifications and the literature mentioned below.

1.6.1 TasNetworks standards

Distribution Standard - Protection and Control	R750976
Protection of HV Capacitor Banks Standard	R245703
Protection and Control of Supply Transformers Standard	R245707
SCADA Systems Standard	R246439
Testing, Commissioning and Training Standard	R246497
Secondary Equipment Testing Standard	R244782
Secondary Cable and Wiring Standard	R1744962
Secondary Systems - General Requirements Standard	R246444
UFLS Scheme Standard	R246508

DC Distribution System Standard	R522693
High Voltage System Standard	R565983

2 Protection and control design

2.1 Incomer protection and control

A single protection relay similar to the relays installed on the bus coupler and outgoing feeders shall be installed on each incoming circuit.

The incomer protection and control relay shall be designed to provide:

(a) operational control of the incomer CB;

(b) operational metering of the incomer circuit;

(c) interlocking logic for the incomer CB;

(d) trip circuit supervision for the incomer CB;

(e) CB tripping via hard wiring direct to the CB ‘A’ and ‘B’ trip coils respectively;

(f) back-up overcurrent and earth fault protection for the busbar and connected feeders with a minimum grading margin of 200ms to the next downstream protection;

(g) detection of faults on any connected feeder, overlapping the next downstream protection scheme such as a pole mounted recloser or distribution transformer;

(h) overcurrent check for arc detection or sudden pressure busbar protection, when applied; and

(i) busbar overcurrent and earth fault blocking where a dedicated high speed busbar protection scheme is not provided.

The incomer relay is not required to provide backup to the feeder SEF protection.

2.2 Bus coupler protection and control

Where sufficient CT are available, each bus coupler CB shall be fitted with a relay of identical type as those used on the feeder and incomer CBs.

The bus coupler protection and control relay shall be designed to provide:

(a) operational control of the bus coupler CB;

(b) operational metering of the bus coupler circuit;

(c) interlocking logic for the bus coupler CB;

(d) trip circuit supervision for the bus coupler CB;

(e) back-up overcurrent and earth fault protection for the busbars and connected feeders with a minimum grading margin of 200ms to the next downstream protection;

(f) busbar overcurrent and earth fault blocking where a dedicated high speed busbar protection scheme is not provided;

(g) CB tripping via hard wiring direct to the CB ‘A’ and ‘B’ trip coils respectively;

(h) detection of faults on any connected feeder, overlapping the next downstream protection scheme such as a pole mounted recloser or distribution transformer. For such back-up operations, the bus coupler overcurrent and earth fault protection must coordinate with the back-up functions of the incomer protection to ensure the opening of the bus coupler before the supply transformer on the adjacent bus trips; and

(i) bus coupler automatic closure on loss of either transformer.

The bus coupler relay is not required to provide back-up to the feeder SEF protection.

2.2.1 Bus coupler auto close function

Automatic closure of bus coupler CBs shall be implemented as follows:

(a) For a particular substation arrangement, the bus coupler CB may be designed to be open under normal conditions to limit the fault level on the feeders. In the event that one transformer is tripped, the bus coupler CB must be closed automatically to maintain continuity of supply.

(b) Operation of any busbar main or back-up protection scheme shall block the auto close scheme from operating. This includes operation of the incomer or bus coupler protection itself.

(c) The auto closing scheme on the bus coupler CB shall be capable of being enabled or disabled locally or remotely by an operator command.

(d) The logic for the bus coupler CB auto close will be implemented within the bus coupler relay. However, where a dedicated bus coupler relay cannot be accommodated, the project specification will describe the preferred location for the auto close logic, as it is acceptable to utilise the main substation remote terminal unit (RTU) to perform this function.

2.3 CB failure protection

CB failure protection shall be applied as follows:

(a) CB failure (CBF) protection shall not be installed on the feeder CB. However, CBF shall be applied to the incomer and bus coupler CBs.

(b) Overcurrent elements within the incomer and bus coupler relays shall be utilised to detect continued fault current and these same relays will provide trips to upstream CBs.

(c) For this protection, the tripping time delay setting shall be 250 ms after initiation by main protection.

2.4 Busbar protection

The protection of HV busbars shall be designed to ensure that:

(a) faults on any part of an HV busbar installation are detected by a high speed independent protection scheme and a back-up protection scheme capable of initiating fault clearance. Back-up protection is provided by overcurrent and earth fault elements in the incomer and bus coupler relays;

(b) at substations with more than one busbar or busbar section, the busbar protection shall be capable of discrimination between the busbars to ensure that the minimum number of CBs are tripped to clear the fault;

(c) the protection scheme is arranged to ensure that no ‘dead zone’ exists and no part of the primary busbar system is unprotected;

(d) the busbar protection shall remain stable for all through fault conditions;

(e) the busbar protection shall have auxiliary tripping relays to trip all circuits on the busbars. Such auxiliary relays shall have adequately rated contacts, be latching requiring local resetting and shall have sufficient spare contacts to cater for the final proposed development of the substation; and

(f) the busbar protection scheme shall consist of any of the following types, dependent on the new or existing busbar CT arrangement:

(i) High impedance busbar differential protection for each bus section.

(ii) Low impedance busbar differential protection for each bus section or all bus sections if the relay is capable.

(iii) Arc flash detection where metal enclosed switchgear and busbars are supplied.

(iv) Frame earth leakage protection, only where existing.

(v) Sudden pressure detection where such devices are capable of application to the metal enclosed switchgear and busbars.

(vi) Overcurrent and earth fault blocking.

2.4.1 Busbar differential protection

The following design principles shall be implemented in the busbar differential protection scheme:

(a) Capability to detect and operate for all types of shunt faults on the HV busbar.

(b) Phase segregated measurement and phase identification for the faulted phase.

(c) Insensitive to harmonic and dc components in the fault current.

(d) Stabilisation for faults external to the busbars and CT saturation.

(e) Provision of supervision of current inputs to detect open circuited CTs.

(f) The dc supply shall be derived from the ‘A’ dc supply system.

(g) One CT core per connection is required and a check zone is not required for HV applications.

(h) All CTs associated with a high impedance protection shall have the same ratio and performance designation.

(i) The protection shall employ overlapping CTs for bus section applications where there is usually a protection zone boundary.

(j) The alarm from the CT supervision relay shall be connected to the SCADA.

(k) All CTs associated with a low impedance protection do not require to have the same ratio and performance designation.

Setting of the busbar differential protection must be undertaken as per the manufacturers recommendations. The following is a list of settings to be provided to TasNetworks for the busbar differential protection:

(l) The effective primary operating current. The protection shall be set to not operate for an inadvertent CT open circuit on the heaviest loaded feeder.

(m) Operating voltage for the high impedance busbar protection scheme.

(n) Value of stabilising resistor used in the high impedance protection.

(o) The slope setting characteristic for the low impedance protection.

(p) The CT supervision shall be set to operate for current less than 10 per cent of load current on the lightest loaded feeder, generating an alarm after 3 seconds.

2.4.2 Arc detection and sudden pressure busbar protection

Arc detection and sudden pressure busbar protection schemes shall provide the following functionality:

(a) Capability to detect all faults on the busbar.

(b) Trip only the faulted section of the busbar and remain stable for faults in other busbar zones.

(c) Capable of identifying the faulted chamber i.e. cable, bus, CB chambers, etc.

(d) Indication of the faulted busbar zone.

(e) Arc flash or sudden pressure detection systems shall be checked by an overcurrent element in the incomer protection relays.

(f) For arc flash and sudden pressure detection systems, operation must trigger the waveform capture in all feeder, incomer and bus coupler relays to allow for an accurate determination of the correct operation of the equipment.

(g) Where possible, arc flash and pressure detection systems should be designed to allow testing of each sensor without removing the busbars from service or opening service hatches which will expose live equipment.

2.4.3 Frame earth leakage protection

TasNetworks does not prefer the application of frame earth leakage for HV busbar protection on new HV switchboard installations; however, for existing switchboards where the installation of high impedance, low impedance, arc flash or sudden pressure protection methods are not feasible to replace an existing frame earth leakage protection scheme, the frame earth leakage detection method shall be retained. In this case, the frame earth leakage scheme shall be arranged in the following way:

(a) The frame earth leakage protection scheme shall be accompanied by an overcurrent and earth fault blocking protection scheme.

(b) The earth leakage relays shall be checked by the earth fault element connected to the HV neutral of the supply transformer(s). In the case of two supply transformers with a bus coupler CB, both transformer check relays will check all of the bus section earth leakage relays.

(c) Each bus section shall have a dedicated earth leakage relay.

(d) A time delay of 60ms shall be applied for the trip operation of the faulted bus section. All CBs connecting to the faulted bus section shall be tripped by the frame earth leakage scheme.

(e) A further 300ms time delay shall be applied to back-trip adjacent bus sections. On operation, all CBs connecting to the adjacent bus sections shall be tripped by the frame earth leakage scheme.

2.4.4 Overcurrent and earth fault blocking protection

TasNetworks does not prefer the application of a blocking scheme for HV busbar protection on new HV switchboard installations; however, a refurbishment of a substation may demand that the existing overcurrent blocking method is retained. The blocking scheme shall be designed as follows:

(a) The blocking scheme shall utilise the instantaneous or starting elements of the overcurrent and earth fault protection covering each in-feed to the relevant busbar section in conjunction with the phase and earth fault instantaneous elements on the feeder protection relays.

(b) A time delay of 100ms shall be applied to the operation of the bus coupler protection, where applied, in order to avoid a contact race that may result in an inadvertent outage due to bus coupler overcurrent or earth fault elements operating before the feeder overcurrent or earth fault elements.

(c) A time delay of 200ms shall be applied to the operation of the incomer protection in order to grade with the operation of the bus coupler un-blocked overcurrent or earth fault element. Where a dedicated bus coupler protection relay is not available, a time delay of 100ms shall be applied to the incomer protection relays.

(d) Where a source is connected to the feeder due to a parallel connection with a feeder from another substation or a generator on a particular feeder, the blocking scheme shall be supplemented by the application of directional elements applied in conjunction with the feeder instantaneous elements such that the particular feeder instantaneous protection does not operate for current inflow to the faulted busbar. The Contractor or relay design engineer must ensure that adequate zero sequence voltage is available for high resistance earth faults to correctly polarise the directional earth fault element. Directional earth fault should be blocked if the direction cannot be determined due to insufficient polarising voltage.

2.5 Feeder protection and control

For most installations, a single relay is used to provide protection, control, metering and monitoring for each feeder. On some Major Industrial (MI) or sub-transmission and critical infrastructure feeders, line differential protection and direct inter-tripping is required which shall be requested within the project specification.

The design for the sub-transmission line differential protection and inter-tripping will not be described in this standard as it will form part of the zone transformer protection scheme and will be described in the Distribution Standard - Protection and Control as will the line differential protection applied to critical infrastructure feeders.

The design for the line differential protection on MI feeders is the responsibility of the MI customer, however, the overarching requirements for installing a relay within the TasNetworks substation will be defined in this standard and must be adhered to.

The feeder protection and control relay shall be designed to provide:

(a) operational control of the feeder CB;

(b) operational metering of the feeder circuit;

(c) interlocking logic for the feeder CB;

(d) trip circuit supervision for the feeder CB;

(e) overcurrent, earth fault, sensitive earth fault, and frequency protection; and

(f) fault location facilities back to the NOCS.

The feeder protection and control scheme shall be designed to ensure that:

(g) where embedded generation is connected to the feeder:

    (i) a voltage transformer shall be installed on the feeder in order to detect feeder voltage and apply the appropriate auto re-closing regime. Where this requirement exists it shall be included in the project specification. Design aspects for the feeder VT shall be in accordance with the High Voltage System Standard;

    (ii) where an overcurrent and earth fault blocking scheme is utilised, the relay should be directional and send a blocking signal for forward looking faults only;

    (iii) the protection on the feeder with the embedded generation should be directional to maintain coordination with adjacent feeders; and

    (iv) provision should be made for an inter-trip from the embedded generator to the TasNetworks feeder CB;

(h) the arrangement of the feeder protection shall:

    (i) initiate CB tripping via hard wiring direct to the CB ‘A’ and ‘B’ trip coils respectively;

    (ii) provide local and remote control of the feeder CB;

    (iii) be fed from the protection cores of the feeder current transformers (CT); and

    (iv) use an appropriate voltage transformer (VT) secondary circuit for its voltage input. Any voltage input to the protection relay shall be routed via an MCB.

2.5.1 Customer owned line differential protection

In some instances, feeders will also have a line differential protection relay provided by the customer and owner of the feeder circuit. TasNetworks shall still provide a feeder relay with enabled protection functions as backup to the line differential protection. Additional to tripping the local CB, the TasNetworks relay shall provide a contact for inter-tripping of the remote end CB via the line differential protection relay.

TasNetworks shall provide the following facilities for the customer’s line differential protection relay:

(a) CT secondary current supply from the appropriate protection CT.

(b) DC auxiliary voltage via a dedicated circuit originating from the ‘B’ battery. TasNetworks protection supply is derived for the ‘A’ battery.

(c) Tripping supplies from the appropriate TasNetworks circuitry.

The following signals shall be directed from the customer’s relay to the TasNetworks relay:

(d) Protection trip and inter-trip signal for alarm logging in TasNetworks’ relay.

(e) Auto reclose blocking signal.

(f) Blocking of CB closing.

Note: All tripping and inter-tripping signals from the customer’s relay shall be hardwired to the TasNetworks CB trip coils.

2.5.2 Overcurrent and earth fault protection

Overcurrent and earth fault protection shall be provided to detect phase and earth faults on the feeder.

The protection shall have an instantaneous characteristic immune against operation for inrush current conditions associated with the energisation of distribution transformers connected to a feeder and capable of being blocked by the operation of the auto re-close function.

2.5.3 Time delayed overcurrent and earth fault protection

Under normal system operation, the requirement for overcurrent and earth fault protection settings is as follows:

(a) The overcurrent pick-up setting should be above maximum cold load pick-up and above maximum present and future feeder load.

(b) The inverse time characteristic applied shall be graded with the time delay characteristics of any downstream protection including fuses. However, compatibility may not be able to be achieved if the difference between the minimum fault level at the substation HV busbar and the maximum load current is insufficient to allow the application of an inverse time characteristic thus requiring the application of a definite time characteristic.

(c) The feeder protection setting should grade with upstream over current protection settings for all fault levels and types with a safety margin of at least 200ms.

(d) The operation of the overcurrent or earth fault protection shall initiate auto re-closure of the feeder CB.

2.5.4 Instantaneous overcurrent and earth fault protection

The overcurrent and earth fault instantaneous protection elements should only be applied where appropriate grading with downstream protection can be achieved. Where required the settings shall be applied as follows:

(a) Under conditions of maximum source impedance, the instantaneous function of the overcurrent and earth fault protection shall be set to detect phase to phase and phase to earth faults respectively, located close to the substation. The DC asymmetrical factor should be considered in calculation of phase to phase and phase to earth faults.

(b) Where a Shunt Capacitor Bank (SCB) installation is directly connected to the feeder, the instantaneous element of the feeder protection shall be set such that faults located between the reactor and the capacitor terminals are not detected by this function. When discrimination between close-in feeder faults and faults between the reactor terminals and the SCB cannot be achieved by settings, a signal from the SCB instantaneous protection shall block the feeder protection initiated CB auto re-close function.

(c) Where there is a considerable length of cable between feeder CB and SCB CB, the instantaneous protection of the feeder CB shall be set and cover the whole length of the cable even if grading coordination with instantaneous element of SCB CB cannot be achieved.

(d) The instantaneous overcurrent element shall be set such that the protection shall remain stable for the inrush currents of distribution transformers along the feeder during manual energisation of the feeder either via NOCS or by site personnel.

(e) The overcurrent and earth fault instantaneous protection functions shall initiate auto re-closure of the circuit CB in all cases.

(f) In the event that a second instantaneous element is required for application in a blocking scheme for busbar protection, the current setting shall be 0.3 times the minimum fault current for faults located on the busbar, lower than the current settings on the instantaneous elements on the transformer incomer protection and 1.5 times the maximum load current of the feeder. Where possible, the starting element of overcurrent and earth fault protection of the feeder relay should be used to send the blocking signal to upstream protection rather than an instantaneous element.

2.5.5 Sensitive earth fault protection

The sensitive earth fault protection shall be capable of:

(a) detecting high impedance earth fault currents on the feeder having a minimum primary value of 5 Amps;

(b) operating on a definite time delay characteristic;

(c) being applied within multiple setting groups;

(d) being remotely and locally switched in and out; and

(e) responding only to the fundamental component of current.

The parameters below shall be followed when applying and setting the sensitive earth fault protection:

(f) The SEF input to the relay shall be derived from a core-balance CT connected to the outgoing feeder circuit where the core-balance CT exists; however, where the core-balance CT is not already fitted, the SEF input shall be derived from the residual current of the protection CT connected to the relay.

(g) The current setting for the sensitive earth fault protection shall be 5 Amps for 11 kV connected feeders and 10 Amps for 22 kV and above.

(h) In the event that a power supply source is located on the feeder or at the remote line end, a directional characteristic may need to be applied. For this application a negative phase sequence polarising quantity shall be applied if the zero sequence polarising quantity proves to be inadequate.

(i) The time delay setting for the feeder sensitive earth fault protection shall be 5 seconds.

(j) The operation of the sensitive earth fault relay shall not initiate auto re-closing of the feeder CB.

(k) The feeder SEF protection is not required to be checked by an earth fault element fed from the transformer neutral. New operating procedures will require the feeder SEF protection to be remotely switched off prior to any field switching operations being undertaken.

2.5.6 Fast protection setting group

The fast protection setting group is intended for selection when work is being undertaken in the vicinity of live apparatus connected to the associated feeder. Fast protection shall be configured in each outgoing feeder relay with the following parameters:

(a) Auto re-close is automatically disabled.

(b) Overcurrent and earth fault elements are set to instantaneous.

(c) Overcurrent and earth fault operating values shall be as in the default setting group. The default setting group is that setting group applied to the protection during normal service.

(d) The following controls and indications are to be configured on each outgoing feeder relay, on the local SCADA HMI and the remote SCADA (NOCS):

  (i) Fast protection settings enabled/disabled.

  (ii) Auto re-close enabled/disabled.

  (iii) SEF enabled/disabled

(e) The auto re-close shall remain disabled when the fast protection setting group is de-selected.

(f) The SEF shall remain enabled or disabled when selecting or de-selecting the fast protection setting group. If the SEF element is required to be remotely disabled to facilitate switching operations, it shall be controlled independently from the fast protection setting group selection.

2.5.7 Live-line voltage check

Where embedded generation is connected to an HV feeder, the feeder protection relay must be configured to apply a live-line voltage check before allowing the CB to be closed. The CB must be interlocked to not permit a CB closure when a voltage of 10 per cent of nominal rating is detected by the feeder relay. Where live-line conditions are detected and the interlock is enforced, a signal must be sent to the local and remote SCADA to alert the operator to this failure to close.

2.5.8 Under frequency protection

Under frequency protection shall be available in order for the feeder to be included in the Tasmanian Under Frequency Load Shedding (UFLS) scheme if required. The relay must be able to provide multiple independent frequency stages with dedicated time delays and rate of change of frequency functionality combined with a set frequency level. If required, the settings of the frequency elements will be supplied in the project specification as per the settings of the Tasmanian Under Frequency Load Shedding (UFLS) scheme.

2.5.9 Feeder CB automatic reclose

(a) CB automatic re-close functionality shall be implemented within the feeder relay as follows:

  (i) The dead time setting shall be 20 seconds and the reclaim time setting shall be 30 seconds.

  (ii) Where there is a source located along the feeder, a feeder auto re-close operation shall only be permitted in the event of a live-bus and dead-line condition being fulfilled.

  (iii) The auto re-close function shall be a repetitive single shot.

(iv) The auto re-close function shall be capable of being switched out of service both manually and via SCADA. When switched out of service during live line work, any protection normally blocked by the re-close function shall be unblocked.

2.5.10 Distance to fault location

The feeder relay shall be capable of calculating distance or impedance to fault and send this information to the NOCS via the SCADA system.

3 Protection of feeders with capacitor banks connected

In order to ensure that the feeder CB does not trip for faults on the capacitor bank installation, the following protection arrangements shall be implemented:

(a) The time delayed protection associated with the capacitor bank shall grade with the time delayed elements of the feeder protection.

(b) The instantaneous overcurrent and earth fault elements on the capacitor bank shall be set lower than those on the feeder to cover faults located between the terminals of the reactor and the terminals of the capacitor.

(c) The instantaneous overcurrent on the feeder and capacitor bank protection shall be set above maximum capacitor inrush current as calculated according to Appendix D of IEEE standard C37.99-2000 and consideration of detuning reactor.

(d) The time delayed overcurrent protection of feeder and capacitor bank CB shall not operate for capacitor inrush current.

(e) If the feeder is a dedicated feeder for capacitor bank, the auto re-close functionality of feeder relay shall be disabled.

(f) The feeder protection must inter-trip the capacitor bank CB.

4 Common design requirements

The following requirements shall be applied for all HV substation protection and control relays:

(a) Overcurrent and earth fault protection elements shall have:

- (i) four independent selectable elements;
- (ii) inrush current detection and blocking ;
- (iii) selectable delayed operation characteristics of definite time and inverse time selectable from the IEEE and the IEC standard inverse time characteristics;
- (iv) respose only to the fundamental component of current; and
- (v) capability of both directional and non-directional operation.

(b) Oscillographic fault recording and Sequence of Events (SOE) recording shall include:

- (i) time synchronising for this feature as defined in the SCADA System Standard;
- (ii) the oscillographic fault recorder shall be set to record 500ms of pre-fault data and 1.5 second of post fault data;
- (iii) the oscillographic channels shall record all phase voltages and all phase currents including the residual current;

(iv) the digital signals shall be arranged to record all protection tripping operations and CBF protection operation; and

(v) under voltage and residual overcurrent elements shall be programmed to trigger the fault recorder.

(c) The following software controls and cyber monitoring must be implemented:

(i) The device default password must be changed.

(ii) Disable or remove unused interfaces.

(iii) Disable built-in or default user accounts.

(iv) When any changes are made to the relays, if possible, record:

a what activity was performed (e.g. setting changes);

b who performed the activity (e.g. engineer or operator); and

c when the activity was performed (e.g. time and date).

(d) The monitoring and control functions that shall be included in the relays are:

(i) CB and disconnector status monitoring.

(ii) CB control.

(iii) Disconnector interlocking.

(iv) CB condition monitoring.

(v) CB racked in/out position status.

(vi) CB earth position.

(vii) Each trip circuit shall be monitored and alarmed back to NOCS on failure.

(viii) Relay self-supervision.

(ix) All monitoring status' shall be sent back to the NOCS. The communication protocol between the relays and the substation RTU must be via DNP3.0 or IEC 61850 protocol if requested in the project specification.

(x) For operational metering purposes, the relay shall be supplied by the selected voltage of the closest energised voltage transformer.

(xi) The circuit CB control functions for remote and manual operations shall be derived from the 'A' battery.

(e) The naming of protection and control devices will be in accordance with the Secondary System – General Requirements Standard.

(f) All relays must be capable of either 1 Amp or 5 Amp CT inputs and be capable of continuously withstanding at least two times the nominal rating.

(g) All testing, commissioning and training requirements must be undertaken in accordance with the Testing, Commissioning and Training Standard and Secondary Equipment Testing Standard.