Eskom	Standard	Technology

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1. Introduction

This document describes the common requirements for protection scheme and module solutions for use within Eskom Distribution. This standard supersedes corresponding requirements previously stipulated in TST 41-1062, DST 34-462 and DST 34-465.

This document shall be referenced in the product/application-specific protection scheme standards, the latter documents providing specific details of the required functionality for each scheme.

2. Supporting clauses

2.1 Scope

This standard defines the generic design- and functional requirements for Distribution protection schemes. The standard covers both electrical and mechanical aspects of scheme designs. Application/product-specific scheme requirements, for example: transformer protection, HV feeder distance protection etc., shall be provided in separate, lower level documents that shall refer to the present standard. The detailed protection product specifications shall be based on this document structure and requirements.

2.1.1 Purpose

This standard details the generic requirements for protection schemes and modules. The requirements presented in this standard shall be supplemented by scheme/module-specific requirements in the detailed standards prepared per scheme type.

2.1.2 Applicability

This standard shall apply to protection scheme designs for the Distribution Division of Eskom Holdings SOC Limited.

2.2 Normative/informative references

Parties using this document shall apply the most recent edition of the documents listed in the following paragraphs.

2.2.1 Normative

[1] IEC 60255-5: Electrical relays – Part 5: Electrical relays – Insulation coordination for measuring relays and protection equipment – Requirements and tests

[2] IEC 60255-149: Measuring relays and protection equipment – Part 149: Functional requirements for thermal electrical relays

[3] IEC 60255-151: Measuring relays and protection equipment – Part 151: Functional requirements for over/under current protection

[4] 240-42066934: IEC 61850 protocol implementation document for the purposes of substation automation

[5] 240-60725641: Specification for standard (19”) equipment cabinets

[6] 240-62629353: Specification for panel labelling standard

[7] 240-62773019: Specification for low voltage electrical auxiliary components

[8] 240-64100247: Specification for earthing of secondary plant equipment in substations

[9] 240-64636794: Standard for wiring and cable marking in substations

[10] 240-64685228: Generic Specification for protective Intelligent Electronic Devices (IEDs)

[11] 240-68111223: Goods information for: Standard networking devices for the substation environment standard

[12] 240-70413291: Specification for electrical terminal blocks

[13] 240-70975231: Specification for current and voltage transformer test blocks

[14] 240-75655504: Corrosion Protection Standard for New Indoor and Outdoor Eskom Equipment, Components, Materials and Structures Manufactured from Steel Standard

[15] 240-81321219: Substation automation – Network architecture standard for Distribution substations

[16] TSP 41-1043: Specification for Control, Selector, Isolation and Test Switches

2.2.2 Informative

[17] Cigré Working Group B5.27: Implications and Benefits of Standardised Protection and Control Schemes

[18] TST 41-1062: Standard for electronic protection and fault monitoring equipment for power systems

[19] DST 34-462: Standard design for Distribution protection schemes

[20] DST 34-465: Generic requirements with regard to Distribution protection equipment enquiries and contracts

2.3 Definitions

2.3.1 General

Definition	Description
Circuit-breaker not healthy alarm	Any condition indicating that the circuit-breaker will not be able to perform its intended function.
Intelligent electronic device	A microprocessor-based device that encompasses all or some of the following functionalities: protection, control and automation, metering, telecontrol, substation DC and auxiliary supply systems, quality of supply monitoring, and disturbance and event recording.
Process Interface Unit (PIU)	Also referred to as a 'digital merging unit' or 'binary input/output device'; an Intelligent Electronic Device (IED) that collects binary data from process devices, typically electrical primary plant equipment, by way of status contacts, and processes and publishes this data to other IEDs in a digital format (e.g. IEC 61580-based communication). The device similarly converts digital commands from other IEDs into electrical control signals to the primary equipment. PIUs are typically installed on or near the primary equipment with which they exchange data.
Protection not healthy	An alarm condition indicating that the protection system is not able to perform part or all of its intended protective function.
Scheme	A set of components that work together in order to execute a specific behaviour under predefined power system conditions sensed through the scheme interface (Cigré Working Group B5.27). 'Scheme' is most commonly applied in the context of power system protection equipment where it historically applied to the secondary plant components associated with the protection and control of a specific primary bay. In the latest design philosophy each main or back-up protection module associated with a specific primary bay are designated as separate, independent schemes.

Definition	Description
Switch	A mechanical device which, by manual operation (through rotation, pressing, pulling or axial movement), will either close or open contacts forming part of an electrical circuit.

2.3.2 Disclosure classification

Controlled disclosure: controlled disclosure to external parties (either enforced by law, or discretionary).

2.4 Abbreviations

Abbreviation	Description
A	Ampere(s)
AC	Alternating Current
ARC	Auto Reclose
AVR	Automatic Voltage Regulation/Regulator
AVRS	Automatic Voltage Regulating Switch
BFI	Circuit-breaker Fail Isolated
BZI	Buszone Isolated
CT	Current transformer
CTTB	Current transformer test block
DC	Direct current
DCI	Direct current isolation
ETHSW	Ethernet switch
F	Frequency
GOOSE	Generic Object Oriented Substation Event
HMI	Human machine interface
HV	High voltage
IEC	International Electrotechnical Committee
JB	Junction box
LOR	Local Off Remote
MCB	Miniature Circuit-Breaker
MMS	Manufacturing Message Specification
MV	Medium voltage
P	Active power
PF	Power factor
PIU	Process interface unit
PNH	Panel Not Healthy
PVC	Polyvinyl chloride

Abbreviation	Description
Q	Reactive power
QA	Quality assurance
SANS	South African National Standard
SCADA	Supervisory Control And Data Acquisition
SEF	Sensitive Earth Fault
SF6	Sulphur Hexafluoride
SIS	Supervisory Isolate Switch
SYNC	Synchronism check
TNS	Test Normal Selection
TPIS	Teleprotection isolating switch
TTPB	Trip Test Push-Button
V	Voltage
VT	Voltage transformer
VTTB	Voltage transformer test block

2.5 Roles and responsibilities

Protection design shall utilise this document as basis for the detailed distribution protection solutions standards.

2.6 Process for monitoring

The SCOT Protection & Automation study committee shall evaluate and monitor the compliance to this standard.

2.7 Related/supporting documents

This standard supersedes the following standards:

- 34-462 Standard design for Distribution protection schemes; and,
- 34-465 Generic requirements with regard to protection equipment enquiries and contracts.

3. Requirements

3.1 Introduction

This standard describes the generic design requirements for Distribution protection scheme and module solutions. In doing so, it serves to promote uniformity in the look and feel of Distribution protection schemes despite their differing specific functions. The document describes both electrical and mechanical design aspects pertaining to protection schemes. The document shall be referenced in the product/application-specific scheme specifications, the latter documents providing specific details of the required functionality for each scheme.

3.2 Design philosophy

3.2.1 Overview

The protection design philosophy is based on a modular system whereby each primary bay may be protected by Dual Main, Single Main plus Back-up or Single Main protection via the selection of the appropriate modules.

Applications using Dual Main and Single Main plus Back-up design philosophies shall include the flexibility to replace or refurbish either module without removing the bay/primary equipment from service, and minimising the possibility of erroneously operating the “live” protection scheme in the process.

To this end, each bay panel shall consist of a “shell” which shall house the required DC supply interface, AC supply interface and Instrument Transformer interfaces to the associated protection modules. The protection modules will be mounted onto the panel and interfaced with the scheme shell. Protection modules should not have any hardwired connections between them except via the scheme shell terminal strip.

The concept of a “Scheme shell” will be applicable to Single Main protection schemes as well, whereby the “shell” will provide the interface to up to three protection modules for three different primary bays (typically MV feeders).

3.2.2 Scheme shell

The scheme shell shall provide for the interfacing and onward distribution of input quantities for the protection modules housed in the panel. It shall provide for:

- DC distribution: Circuit-breaker spring rewind circuits, protection module DC supplies and panel Ethernet switch DC supply.
- AC distribution: AC supply for local Protection Not Healthy alarms and junction/mechanism heater supplies
- Current Transformer inputs: for interfacing with the protection modules
- Voltage Transformer inputs: for busbar VT selection (where ordered) and interfacing with the protection modules.

The shell shall include protection and safety isolation functionality for the various circuits.

The panel Ethernet switch shall be installed on the scheme shell.

The scheme shell shall be an independent design with an own set of scheme diagrams. The main and back-up protection modules shall also be independent designs with own sets of module diagrams.

3.2.3 Main protection modules

This section will be used in detailed scheme specifications to describe the features of the main protection modules required by Eskom.

The main protection module shall be an independent design with an own set of scheme diagrams.

The main protection module shall include:

- Main Protection Device with all the required protection functions integrated within a single hardware device;
- Breaker tripping, breaker closing and breaker status via the process interface unit (IEC61850 – GOOSE Data); and,
- Primary plant controls, statuses and alarms via the process interface unit (IEC61850 – GOOSE Data).

3.2.4 Back-up protection modules

This section will be used in detailed scheme specifications to describe the back-up features of the protection modules required by Eskom.

The back-up protection module shall be an independent design with an own set of scheme diagrams.

The back-up protection module shall include:

- Back-up Protection Device with all the required protection functions integrated within a single hardware device; and,
- The back-up protection module shall effect tripping and closing of the circuit-breaker via hard wire interface.

3.2.5 Process interface units

The process interface unit shall provide the IEC 61850 interface between the primary plant and the main protection & control module IED. The process interface units will be located in close proximity to the primary plant equipment. The process interface unit inputs and outputs will be specified within the detailed specifications. The process interface units IEC61850 data shall be as per the logical node requirements. The process interface units shall meet the requirements as per the “Generic Specification for Protective Intelligent Electronic Devices (IEDS) Standard (240-64685228).

3.2.6 Communications topology

The Ethernet switch, per bay, shall interface with the substation automation network topology as per the Substation Automation – Network Architecture Standard for Distribution Substations, Unique Identifier 240-81321219. Unless specified to the contrary, the “Fault Tolerant” network architecture of the aforementioned standard shall be applied.

Each protection and control scheme shall include an Ethernet switch with 100 Megabit Multi-mode fibre ports for the bay IEDs (main protection, back-up protection and process interface units) connections and at least. Two Gigabit ports shall be provided on Ethernet switches for connection to the station backbone Gigabit Ethernet switches.

All the IEDs (including the PIUs) within a specific bay shall connect to the Ethernet switch in a star topology.

The connections between the Ethernet switch, IEDs and PIUs shall be via multi-mode fibre.

The IEDs and PIUs fibre optic port requirements shall comply with the Generic Standard for Intelligent Electronic Devices (IEDs) Standard, Unique Identifier 240-64685228.

The fibre cabling within the substation shall comply with the standard Substation Automation – Network Architecture Standard for Distribution Substations, Unique Identifier 240-81321219.

The Ethernet switch design and requirements shall comply with the Goods information for: Standard Networking Devices for the Substation Environment Standard, Unique Identifier 240-68111223.

3.3 Scheme variants & model numbers

Each scheme/module type and variant shall be assigned a unique model number. The number shall be allocated as per Eskom’s numbering system and shall be approved by an Eskom protection representative. The scheme/module type number shall be utilised to identify the solution, use for codification, applied to the scheme diagrams and all relevant documentation.

3.3.1 Scheme hardware identification

The protection schemes are to be identified by an 11- or 12-digit code as follows:-

5	FZ	-	#	1	00	-	1	0	0		0
Generation of scheme (Phase)	Scheme group code (Type)		Manufacturer code (Vendor ID)	Series number (Scheme Type)	Major revision number (Scheme design revision)		Voltage level (110 VDC=1 and 220 VDC =2)	Option 1 selected (0= not selected, 1 = selected)	Option 2 selected (0= not selected, 1 = selected)		Option n selected (0= not selected, 1 = selected)

3.3.2 Generation of scheme

The next generation of protection equipment will be identified by using phase number 5. The phase number will increment by 1 for any subsequent group of core commodity contracts (typically after an 8 year contract period).

3.3.3 Scheme group code

The function of a scheme will be identifiable via the scheme group code of this table.

Code	Description	Code	Description
AC	A.C. board	FP	Pilot wire feeder
AD	A.C./D.C. Modules / Board	FZ	Distance protection feeder
BC	Bus coupler/section	FZD	Distance/Diff protection feeder
BP	Busbar protection	LM	Under Frequency Load shedding
BZ	Bus zone	LS	Load shedding
CB	Shunt Capacitor bank	RF	Rural feeder
CF	Cable Feeder	SC	Series Capacitor bank
CO	Chop-over/Change-over	SR	Series or Shunt reactor
DC	D.C. board	TA	Auto-transformer
DIP	Diameter Interface	TC	Tap-changer

Code	Description	Code	Description
DR	Disturbance Recorder	TM	Power transformer
FC	Phase comparison/Differential feeders	TSS	Transient Stability System
FD	Differential feeder	TT	Traction transformer

3.3.4 Manufacturer code

The scheme manufacturer will be identifiable by a number following the scheme group code. Additional numbers will be assigned on contract award:

Code	Manufacturer
0	[Vacant]
1	ACTOM
2	Siemens
3	ABB
4	[Vacant]
5	Powertech System Integrators
6	VAMP Solutions
7	Consolidated Power Projects (CONCO)

3.3.5 Series number (Scheme Type)

The series number shall be allocated to differentiate between scheme permutations where the same main protection IED is used (e.g. 1, for scheme with transfer and 2, for the same scheme but without transfer).

3.3.6 Major revision number (Scheme design revision)

The starting number for the first approved production schemes shall be 00. This number shall be incremented for any major scheme design change or IED hardware change.

3.3.7 Voltage level

Eskom utilise the following standard station DC voltage supplies:

- 110 VDC (Code = 1); and,
- 220 VDC (Code = 2).

3.3.8 Option 1 selection

First selectable option within the standard scheme design (e.g. with or without teleprotection device) (0= not selected, 1 = selected).

3.3.9 Option 2 selection (0= not selected, 1 = selected)

Second selectable option within the standard scheme design (e.g. with or without busbar voltage selection) (0= not selected, 1 = selected).

3.3.10 Option "n" selection (0= not selected, 1 = selected)

Selectable option "n" within the standard scheme design (0= not selected, 1 = selected).

3.3.11 Serial, hardware and firmware version numbers

Each functional unit of each scheme (e.g. rack, sub-rack and auxiliary relay) shall contain a unique, indelible and easily identifiable serial number and where applicable, the hardware and firmware version number. A list of all items (with associated serial numbers, hardware version numbers and firmware version numbers) shall be provided with each production scheme. The successful tenderer shall maintain a comprehensive record of all transactions involving serialised items.

3.4 Scheme interfaces

3.4.1 DC supplies

Each scheme shall be provided with a 110 or 220V DC supply for the main protection system, back-up protection system, Ethernet switch, process interface unit and breaker spring rewind circuits.

The products shall operate normally with a voltage supply variation of ± 20% of nominal.

3.4.2 240V AC supply

The 240V AC supply shall be used to illuminate the amber alarm 'Protection Not Healthy' lamps on each protection module. The 240V AC shall also supply the mechanism box heaters via dedicated 5A miniature circuit-breakers.

The products shall operate normally with a voltage supply variation of ± 10% of nominal.

3.4.3 Current Transformers

The standard current transformer secondary outputs are 1 Amp, with a continuous rating of 2 Amp. The standard practice is to earth the neutral (4th wire), at one place only, where the CT cable is connected to the terminals within the panel/module.

A sliding link terminal shall be provided on the earth connection for isolation purposes in order to facilitate insulation resistance testing.

The protection modules, main and back-up IEDs, shall use separate protection-class CT cores. The same CT inputs shall be used for protection and measurements purposes.

3.4.4 Voltage Transformers

The standard voltage transformer secondary outputs are 63.5 volt per phase (110 volt, phase-phase). For multi-phase supplies, the standard practice is to earth the neutral (4th wire) in the VT JB.

Dedicated 4mm^2 cables are used for the VT secondary connections between the VT JB and the protection scheme/module.

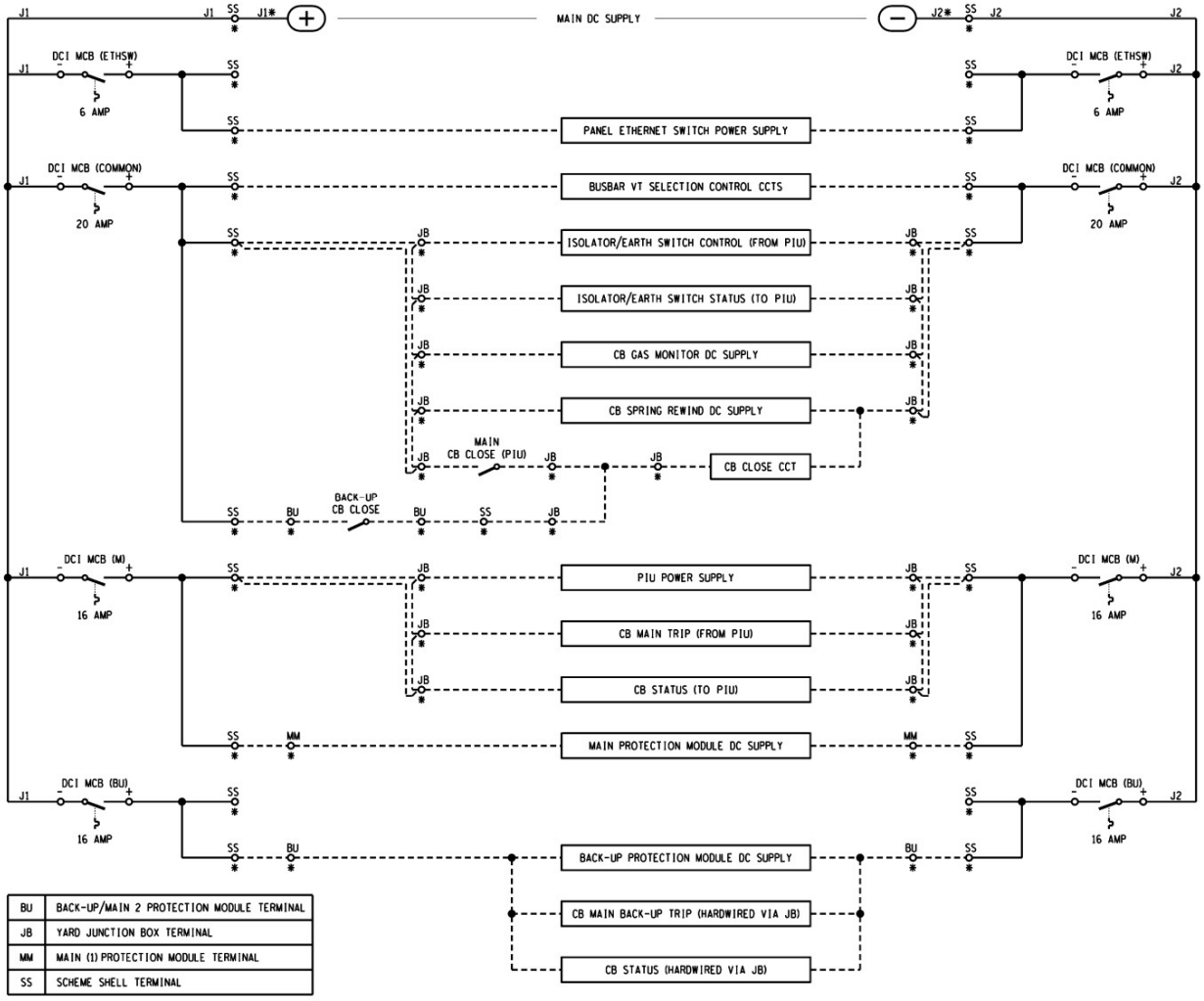
Where specified, an option shall be provided to allow voltage from the connected busbar VTs to be automatically selected depending which busbar the feeder/transformer is connected to. This selection shall be done via latching relays on the scheme shell, and the switched VT supplies made available to the protection modules. Busbar VT supplies shall be protected by MCBs in each protection module.

Line VT supplies (where applicable) shall be routed directly from the VT JB into the applicable protection module, with no MCBs being provided in the module. Where a Line VT supply is to be shared by more than one module (e.g. HV feeder main and back-up protection modules), the Line VT supply shall be routed via an MCB mounted on the scheme shell. VT MCBs shall include auxiliary status contacts.

3.5 Detailed module descriptions – Scheme shell

The scheme shell will be fitted into a swing frame cabinet as per specification 240-60725641 (Specification for standard 19" equipment panels). The shell will provide AC and DC supply distribution to the protection modules and the yard junction box(es), as well as the interface for instrument transformers. The shell makes provision for the fitting of the panel Ethernet switch (ordered separately), and the power supplies thereto. The scheme shell also houses the fibre optic cable patch panel (ordered separately).

The design of the scheme shell shall be such as to physically separate circuits for different protection modules as much as possible. For example, the MCBs and terminal blocks associated with the Main (1) protection module shall be grouped together on the left hand side, and those for the Main 2 / Back-up module shall be grouped together on the right. Interface wiring from the shell to the protection modules, shall similarly follow different paths (left and right)



3.5.1 DC supply distribution

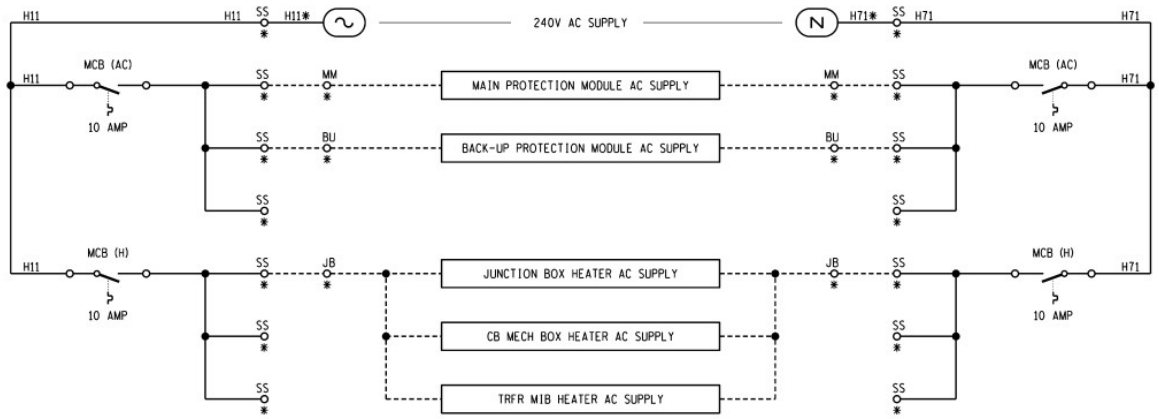
Typical DC supply distribution by a scheme shell is illustrated below.

The scheme shell includes the following DC MCBs:

- Ethernet Switch DC Isolating MCB - DCI (ETHSW) (6 Amp);
- Common DC Isolating MCB - DCI (C) (20 Amp);
- Main DC Isolating MCB - DCI (M) (16 Amp);
- Back-up DC Isolating MCB - DCI (BU) (16 Amp);

3.5.2 AC supply distribution

Typical AC supply distribution by a scheme shell is illustrated below.



The scheme shell includes the following AC MCBs:

- Module AC supply MCB - MCB(AC);(10 Amp)
- Heater supply MCB - MCB(H) (10 Amp)

3.5.3 Current transformer circuit interface

Current transformer circuits from the primary equipment shall be wired to the main or back-up protection modules via the scheme shell terminal strip. The CT terminal blocks on the scheme shell shall include test barrels for shorting using banana plug test leads.

Where Current Transformer circuits need to be shared by main and back-up protection, this will be done via the scheme shell terminal strip with the Main (1) protection being first in the series connection from the yard.

3.5.4 Voltage transformer circuit interface

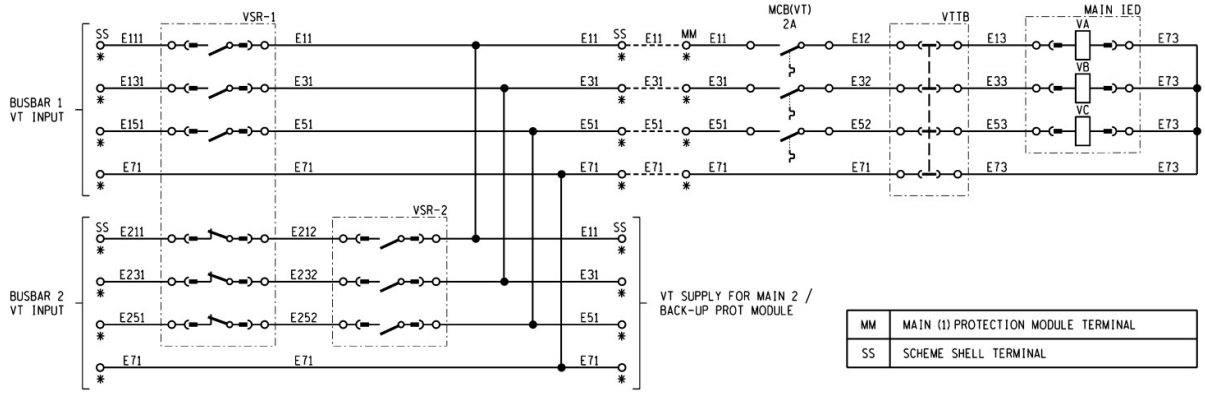
Voltage transformer circuits from the primary equipment shall be wired to the main or back-up protection modules via the scheme shell terminal strip.

The scheme shell will not include VT supply MCBs except for the Line VT MCB in HV Feeder applications. These shall be provided on the respective protection modules. VT Test blocks (where applicable) will be installed on the protection modules.

Busbar VT selection is to be achieved via latching relays and controlling disconnector status contacts installed as part of the scheme shell, and the selected VT outputs made available to the protection modules. VT selection shall be an ordering option on the scheme shell.

The design of the VT selection circuitry shall prevent paralleling of the two busbar VT supplies. The Tenderer shall ensure that all protection functions making use of this switched supply are secure from maloperation due to the short interruption of VT supplies introduced during change-over of supplies. Protection shall remain operative during VT supply selection such as to be able to detect busbar disconnector closure onto a fault or disconnector flashover whilst under operation.

A VT selection circuit design is illustrated below.



3.6 Detailed module descriptions – Main protection

The main protection modules shall comprise all the required main protection functions, bay control functionality (SCADA, auto-reclosing, measurements, etc.), test blocks, switches, pushbuttons and indications for the specific application.

The main protection IED, switches, indications, test blocks and pushbuttons shall be located in a module fitted to the door of the swing frame cabinet.

The interface to the module shall be via a terminal plate which is mounted at the back of the swing frame cabinet.

Both the module and the terminal plate shall be mounted in a flush mount 19 inch rack system.

The main protection system and back-up protection system shall be independent and galvanically isolated.

The main protection device shall constitute a single node through which all protection tripping (all internal protection functions; plus all trip commands from the external devices, routed to binary inputs of the main protection device) and control functions (primary plant controls, auto-reclosing, synchronism check and tap change control) shall be routed. All the protection and control functions of the main protection module shall reside within the main protection device.

3.6.1 Main protection IED composition

The main protection module shall have one IED with all the required protection, measurement and bay control functions integrated within the IED. The IED shall comply with the Generic Standard for Intelligent Electronic Devices (IEDs) Standard, Unique Identifier 240-64685228.

3.6.2 Current Transformer

The main protection module shall be connected to the first protection CT core. The protection CT connections shall be routed via standard terminals and through a four-way current transformer test block, CTTB(M), to the main protection IED.

The main protection IED will be utilised to report the measurements quantities (local and remote). Measurements shall be derived from the protection CT core input.

3.6.3 Voltage Transformer

Incoming VT supplies from the scheme shell shall be routed via a three phase MCB (curve C) with a 2 Amp rating to a PK2 4-way test block VTTB(M), and thereafter to the main protection IED. The test block shall be in accordance with 240-62773019.

The VT MCBs shall include auxiliary status contacts for status indication to the main IED, as required in a functional scheme specification.

3.6.4 Binary Inputs

The required binary inputs will be defined within the functional scheme specifications.

3.6.5 Binary Outputs

The required binary outputs will be defined within the functional scheme specifications.

3.6.6 GOOSE Messaging

The GOOSE data is utilised to communicate plant information and protection information between IEDs (and test equipment). The detailed functional standards will include the list of GOOSE data points (Logical nodes and data attributes) for horizontal communication. The vendors shall use IEC 61850 as “purely” as possible (e.g. defined logical node names and data attributes). The vendor shall comply with the IEC61850 standards and Eskom’s requirements as per document 240-42066934.

3.6.6.1 GOOSE data from the Main Protection IED to the Circuit-breaker PIU

Refer to each detailed functional standard for the detailed GOOSE data requirements.

3.6.6.2 GOOSE data from the Main Protection IED to the Transformer PIU

Refer to the transformer detailed functional standard for the detailed GOOSE data requirements.

3.6.7 Local control interface

The primary local operator interface shall be via the substation HMI. Local controls will, however be required on the module and the main protection IED. The preferred method of providing local controls is via integrated programmable push buttons on IEDs. As an alternative, the required local controls can be provided for (push buttons with indications) on the main protection module. Any local control shall be available immediately, without the need for any navigation into the IED menu.

3.6.8 Local indications

The primary local operator interface shall be via the substation HMI with the required primary plant status information and alarm data. Local indications are required on the module and the main protection IED. Where the local controls is via integrated programmable push buttons on IEDs the status information shall also be on the IED HMI. In the event that the local controls are provided for (push buttons with indications) on the main protection module, the local indications shall also be at the same physical level. The IED HMI indications or as an alternative the panel mimic control visual indications shall indicate the true status being selected either from local or remote.

Any local indication shall be available immediately, without the need for any navigation into the IED menu.

Indication lamp colours shall be as follows:

- Red: Trip conditions, Switch Closed;
- Amber: Alarm conditions, Not healthy condition;
- White (or Amber): Earth applied, Automatic Voltage Control on Manual; and,
- Green: Healthy, Switch Open

Local indications are required on the main protection IED. The IED HMI shall indicate the IED health, protection start and trip information. Any local indication shall be available immediately, without the need for any navigation into the IED menu. The local IED indications will be within the detailed specifications.

3.6.9 Testing Facilities

Testing functionality is required as an integral part of the product offerings in support of the objective of minimizing requirements for and durations of primary equipment outages for secondary equipment commissioning and testing. The following testing aids are required:

a) When the Test-Normal Switch (TNS) on the bay level protection scheme is set to the “Test”, PIUs shall automatically be placed in a test mode whereby output contact operation is blocked, yet information regarding attempted contact operation is made available via (preferably) IEC 61850 Edition 2 test mode (see SANS/IEC 61850-7-1 Section 7.8.4) and/or an engineering PC connected to the Ethernet network in the substation control room.

b) It shall be possible to simulate SCADA alarm binary points on an IED for communication to the Gateway and HMI via IEC 61850 MMS, without the need for secondary injection of the protection system. It shall similarly be possible to simulate binary points in the PIU for communication to the substation IEDs via IEC 61850 GOOSE, without physically applying a wetting voltage to the PIU’s binary inputs.

c) It shall be possible to disconnect the protection scheme, including the relay panel-installed IEDs and the yard-installed PIUs from the station Ethernet network, testing all bay-level functionality in isolation of station-level functionality.

d) It shall be possible to physically unplug input/output wiring from the PIUs for testing purposes.

3.6.9.1 GOOSE data for testing

The GOOSE data is utilised to communicate plant information and protection information between IEDs (and test equipment). The detailed functional standards will include the list of GOOSE data points (Logical nodes and data attributes) for horizontal communication. The vendors shall use IEC 61850 as “purely” as possible (e.g. defined logical node names and data attributes). The vendor shall comply with the IEC61850 standards and Eskom’s requirements as per document 240-42066934.

The main protection IED shall be configured with GOOSE data to verify each setting within the IED. The test equipment will utilise the GOOSE data points to monitor each function under test. The test equipment will also simulate test points for verification and fault playback purposes. The simulated GOOSE signals shall be enabled (TNS Test Selected) and disabled (TNS Normal selected) within the IED to prevent any simulated GOOSE signal to remain high and hence adversely affect the in-service performance of the IED. All functions to be tested shall be enabled with the TNS selected to the Test position.

The GOOSE data requirement details will be within the functional standards.

3.6.9.2 Test points

Banana plug test points shall be provided in conjunction with a TNS. The function of the test points is to facilitate testing, under live conditions, of the various protection functions’ output contacts. The test points shall be wired to either the "Test 1" and/or "Test 2" positions on the TNS, depending on the function from which access is being provided. The test points shall be accessible from the front of the panel.

3.6.9.3 Current transformer test block

Every three phase current transformer circuit entering the protection module shall be provided with a four-way test block located between the panel input terminals and the protection IED. The test block for a current transformer shall provide for:

- Automatic short circuiting of the incoming current transformer circuit;
- Measurement of the current in the incoming current transformer circuit of all three phases and the neutral individually, with a test plug and meter;

- Injection of test currents into the panel circuits on all three phases and the neutral individually, with a test plug and source; and,
    - The test facilities incorporated within individual IEDs will not be considered as substitutes for the test blocks called for in this standard.

3.6.9.4 Voltage transformer test block

Every three phase voltage transformer circuit entering the protection module shall be provided with a four-way test block located between the panel input terminals and the protection IED. The test block for a voltage circuit shall provide for:

- Open circuiting of the incoming voltage transformer circuit;
- Measurement of the phase to phase and phase to neutral voltage of the incoming voltage transformer circuit with a test plug and meter;
- Injection of test voltage into the panel circuits with a test plug and source; and,
    - The test facilities incorporated within individual IEDs will not be considered as substitutes for the test blocks called for in this standard.

3.6.9.5 Test Block Types

Only the following type of test blocks shall be for use in Eskom's protection panels.

- PK2 four-way and six-way test blocks.

Other types of test blocks may be considered for special applications, and shall be approved by Eskom.

3.6.10 Main protection programmable logic & tripping matrix

The minimum amount of circuit-breakers shall be tripped to isolate a fault condition and on lines to auto-reclose for supply restoration. The main protection device shall trip (on a per phase basis where applicable) the main trip coil of the circuit-breaker (or transfer circuit-breaker where applicable) via the circuit-breaker PIU through the trip-duty rated output contacts when the TNS(M) is in the 'Normal' or 'Test 1' positions. The back-up protection device shall trip the back-up trip coil of the circuit-breaker through the trip-duty rated output contacts of the back-up protection when the TNS(B/U) is in the 'Normal' or 'Test 1' positions.

All the protection functions shall initiate the circuit-breaker fail function. The busstrip command from the circuit-breaker fail function shall issue a busstrip command to trip the adjacent circuit-breakers:

- Buszone protection scheme with the TNS selected to the 'Normal' position;

The detailed tripping matrix will be within the individual detailed standards.

3.7 Detailed module descriptions – Back-up protection

The back-up protection modules shall comprise all the required back-up protection functions, test blocks, switches, pushbuttons and indications for the specific application.

The back-up protection IED, switches, indications, test blocks and pushbuttons shall be located in a module fitted to the door of the swing frame cabinet.

The interface to the module shall be via a terminal plate which is mounted at the back of the swing frame cabinet.

Both the module and the terminal plate shall be mounted in a flush mount 19 inch rack system.

The main protection system and back-up protection system shall be independent and galvanically isolated.

The back-up protection device shall constitute a single node through which all protection tripping (all internal protection functions; plus all trip commands from the external devices, routed to binary inputs of the back-up protection device). All the protection and control functions of the back-up protection module shall reside within the back-up protection device.

3.7.1 Back-up protection IED composition

The back-up protection module shall have one IED with all the required protection integrated within the IED. The IED shall comply with the Generic Standard for Intelligent Electronic Devices (IEDs) Standard, Unique Identifier 240-64685228.

3.7.2 Current Transformer

The back-up protection module shall be connected to the second protection CT core. The protection CT connections shall be routed via standard terminals and through a four-way current transformer test block, CTTB(BU), to the back-up protection IED.

3.7.3 Voltage Transformer

The VT supply for the back-up protection circuits shall be taken via the optional voltage selection (VSR) relay (where applicable) to the back-up protection IED via standard terminals and then routed through a MCB (curve C) with a 4 Amp rating to a PK2 4-way test block CTTB(BU). The test block shall be in accordance with 240-62773019.

For the directional earth fault function, where a residual ($3V_0$) voltage input is required for the back-up IED, the auxiliary transformers required to develop this voltage (i.e. an open delta connection) shall be supplied with the scheme. The auxiliary transformers shall not be supplied in the preferred arrangement where the IED develops the residual voltage internally.

3.7.4 Binary Inputs

The back-up protection device shall constitute a single node through which all protection tripping shall be routed (all internal protection functions, plus all trip commands from the external devices). The required binary inputs will be within the functional standards.

3.7.5 Binary Outputs

The back-up protection device shall constitute a single node through which all protection tripping shall be routed (all internal protection functions, plus all trip commands from the external devices). The required binary inputs will be within the functional standards.

3.7.6 GOOSE Messaging

The GOOSE data is utilised to communicate plant information and protection information between IEDs (and test equipment). The detailed functional standards will include the list of GOOSE data points (Logical nodes and data attributes) for horizontal communication. The vendors shall use IEC 61850 as “purely” as possible (e.g. defined logical node names and data attributes). The vendor shall comply with the IEC61850 standards and Eskom’s requirements as per document 240-42066934.

3.7.7 Local control interface

The primary local operator interface shall be via the substation HMI. Local controls will, however be required on the module and on the main protection IED. The back-up protection module does not require any control capability.

3.7.8 Local indications

The primary local operator interface shall be via the substation HMI with the required primary plant status information and alarm data. Local indications are required on the module and the back-up protection IED. The IED HMI shall indicate the IED health, protection start and trip information.

Any local indication shall be available immediately, without the need for any navigation into the IED menu.

3.7.9 Testing Facilities

Testing functionality is required as an integral part of the product offerings in support of the objective of minimizing requirements for and durations of primary equipment outages for secondary equipment commissioning and testing. The following testing aids are required:

a) It shall be possible to simulate SCADA alarm binary points on an IED for communication to the Gateway and HMI via IEC 61850 MMS, without the need for secondary injection of the protection system.

b) It shall be possible to disconnect the protection scheme, including the relay panel-installed IEDs from the station Ethernet network, testing all bay-level functionality in isolation of station-level functionality.

3.7.9.1 GOOSE data for testing

The GOOSE data is utilised to communicate plant information and protection information between IEDs (and test equipment). The detailed functional standards will include the list of GOOSE data points (Logical nodes and data attributes) for horizontal communication. The vendors shall use IEC 61850 as “purely” as possible (e.g. defined logical node names and data attributes). The vendor shall comply with the IEC61850 standards and Eskom’s requirements as per document 240-42066934.

The back-up protection IED shall be configured with GOOSE data to verify each setting within the IED. The test equipment will utilise the GOOSE data points to monitor each function under test. The test equipment will also simulate test points for verification and fault playback purposes. The simulated GOOSE signals shall be enabled (TNS Test Selected) and disabled (TNS Normal selected) within the IED to prevent any simulated GOOSE signal to remain high and hence adversely affect the in-service performance of the IED. All functions to be tested shall be enabled with the TNS selected to Test.

The GOOSE data requirement details will be within the functional standards.

3.7.9.2 Test points

Banana plug test points shall be provided in conjunction with a TNS. The function of the test points is to facilitate testing, under live conditions, of the various protection functions’ output contacts. The test points shall be wired to either the "Back-up" position on the TNS, depending on the function from which access is being provided. The test points shall be accessible from the front of the panel.

3.7.9.3 Current transformer test block

The current transformer circuit entering the protection module shall be provided with a four-way test block located between the panel input terminals and the protection IED. The test block for a current transformer shall provide for:

- Automatic short circuiting of the incoming current transformer circuit;
- Measurement of the current in the incoming current transformer circuit of all three phases and the neutral individually, with a test plug and meter;
- Injection of test currents into the panel circuits on all three phases and the neutral individually, with a test plug and source; and,
    - The test facilities incorporated within individual IEDs will not be considered as substitutes for the test blocks called for in this standard.

3.7.9.4 Voltage transformer test block

The voltage transformer circuit entering the protection module shall be provided with a four-way test block located between the panel input terminals and the protection IED. The test block for a voltage circuit shall provide for:

- Open circuiting of the incoming voltage transformer circuit;
- Measurement of the phase to phase and phase to neutral voltage of the incoming voltage transformer circuit with a test plug and meter;
- Injection of test voltage into the panel circuits with a test plug and source; and,
    - The test facilities incorporated within individual IEDs will not be considered as substitutes for the test blocks called for in this standard.

3.7.9.5 Test Block Types

Only the following type of test blocks shall be for use in Eskom's protection panels.

- PK2 four way and six way test blocks.

Other types of test blocks may be considered for special applications, and shall be approved by Eskom.

3.7.10 Back-up protection programmable logic & tripping matrix

The minimum amount of circuit-breakers shall be tripped to isolate a fault condition and on lines to auto-reclose for supply restoration. The back-up protection device shall trip (on a per phase basis where applicable) the back-up trip coil of the circuit-breaker (or transfer circuit-breaker where applicable) via trip-duty rated output contacts (back-up protection IED) when the TNS(BU) is in the 'Normal' or 'Test 1' position.

All the protection functions shall initiate the circuit-breaker fail function within the back-up protection device. The busstrip command from the circuit-breaker fail function shall issue a busstrip command to trip the adjacent circuit-breakers:

- Buszone protection scheme with the TNS selected to the 'Normal' position.

The detailed tripping matrix will be within the individual detailed standards.

3.8 Detailed module description - Process Interface Unit Modules

The process interface unit module shall be 19" rack mount and will be fitted within the circuit-breaker or transformer JB in close proximity to the associated primary equipment.

The main 1 PIU shall be the interface (IEC61850) between the primary plant and the main 1 protection and control scheme/module IED(s). The main 2 PIU shall be the interface (IEC61850) between the bay primary plant and the main 2 protection and control scheme/module IED(s) (where applied). The PIU inputs and outputs shall be as per the detailed specifications. PIUs shall meet the requirements as per the "Generic Specification for Protective Intelligent Electronic Devices (IEDs) Standard (240-64685228).

PIU devices shall be capable of surviving the harsh temperature and humidity conditions prevalent in yard cubicles in the South African climate. It is preferred that PIUs should be hardware devices purpose-designed for this function.

The PIUs shall mainly be used to digitise binary signals including tap changer position encoded in Binary Coded Decimal (BCD) (decoded by the PIU).

Transformer PIUs shall support a minimum of three analogue transducer inputs for digitisation of winding and oil temperature measurements and data from other sensors[1]. Transducer inputs shall be specified in accordance with Section 3.9 of the "Generic Specification for Protective Intelligent Electronic Devices (IEDs) Standard (240-64685228. Transformer PIUs and corresponding IEDs shall support publishing and subscription to analogue GOOSE messages (or an alternative method subject to Eskom approval) for interfacing of the measured values from the process network.

PIUs shall support IEC 61850 logical nodes related to the primary equipment with which they interface (e.g. XCBR, SIML, YPTR). The use of GGIO logical nodes shall be limited and subject to Eskom approval.

3.9 Performance requirements

3.9.1 Sensitivity

The sensitivity of the protection functions is the measure of the ability of the relay to detect faults, either with low primary quantities, or with small deviations from the healthy state.

The protection system is required to respond correctly, including correct phase selection, without and with pre-fault load flow.

Within the measurement capability of the IED, e.g. minimum current, minimum deviation from healthy state, voltage limit for accurate reach point measurement, the phase selection / directional determination shall be assured, and the variation in IED performance (tripping time) must be in accordance with the required tripping times.

3.9.2 Reliability: Security & Dependability

3.9.2.1 Security

Security is defined as the probability of not having an unwanted operation under given conditions for a given time interval. The protection system shall have as high security as possible.

3.9.2.2 Dependability

Dependability is defined as the probability of not having a failure to operate under given conditions for a given time interval. The protection system shall have as high dependability as possible.

3.9.2.3 Directionality

Directionality is the ability of a protection functions to distinguish between forward and reverse fault conditions, and in-zone and out of zone faults. The protection functions shall be capable of correctly determining the fault position, without any added delay to the overall tripping time, for any fault occurring and for any network condition.

3.9.3 Speed

Clearance of network faults in the shortest time is a fundamental requirement, but this must be seen in conjunction with performance requirements for the specific application. The Protection Systems applied shall comply with the operating times specified within the product specific documentation. Speed shall not compromise dependability and security.

As a general rule, the tripping time for faults at 5 times rated current shall be ≤20 msec. The tripping time requirements is for the setup where the protection device GOOSE the trip signals to the PIU and the PIU binary outputs are connected to the breaker trip coils. The tripping time is measured from fault inception (current injection into the protection device) to the closure of the PIU binary output (GOOSE inclusive).

3.9.4 Longevity

The protection scheme/module shall be designed for a minimum operational life of 20 years.

3.10 Physical design

The required protection scheme shall comprise of three main components: swing frame panel with scheme shell, main protection system module and back-up system protection module.

3.10.1 Main and Back-up protection module design

The main and back-up protection module shall have a maximum depth of 350 mm and a maximum height dictated by the detail design requirements (fitting into the 48U aperture of the swing frame panel). The main protection module shall be located at the top and the back-up protection module at the bottom within the swing frame panel. Module wiring tails shall be made long enough to allow free movement when mounted within the swing frame (door). Easy access shall be provided to the back of all IEDs. No plug-in system (except for the connector terminal rails provided on IEDs and auxiliary components) will be allowed.

Where the module is constructed in a box-form, the rear of the module shall be open to ease access to the internal components and to improve heat dissipation.

Where the scheme fills a complete panel (more than half) then the full panel is considered a module, whereas if the scheme fills less than half of a panel it shall be considered for modular design. A module should be easily transportable and shall be designed to be easily removed.

Rack mountable IEDs shall be firmly attached to the chassis of the front panel module, independently of the 19' rack securing bolts. The IED shall be positioned at an acceptable working height, but not lower than 500mm off ground level. The IED with HMI used for local control execution and local measurements display shall be at an acceptable height for ease of access and readability.

The design of a scheme shall be such that, when fitted in a swing frame panel to 240-60725641, with all doors closed and covers in place and with all internal equipment correctly mounted and fully operational, the temperature rise at any free air point shall not exceed 10 °C. Forced cooling shall not be used.

The front of the panels shall be compatible with a flush mount 19 inch rack system in accordance with IEC 60297-1. Nineteen inch (19") rack mounting hole arrangements shall be as per the IEC 60297-1. Only closed holes shall be permitted.

The classification of enclosures shall be in accordance with SANS 60529. The minimum degree of protection provided shall be IP 41 for the front panel, and IP 1X for the rear of the module and back plate.

3.10.2 Trip and close circuit design

All IED output contacts which operate circuit-breaker tripping and closing circuits shall be rated to break 10A DC at the nominal DC supply voltage, L/R = 20ms. This may be achieved through the use of "high-break" output contacts, or through the application of snubber circuits. Snubber circuits shall have been type tested by a reputable testing agency, their documentation confirming fulfilment of Eskom's current breaking capacity requirements.

Auxiliary relays with output contacts (or the series combination of these) meeting the above breaking capacity requirements may be used in circuit-breaker closing circuits to avoid exposure of the IED contacts to high current breaking scenarios.

Where snubber circuits are provided for PIU output contact protection, these shall be mountable on the PIU such as to form part of the PIU device.

The closing command to a circuit-breaker shall be interlocked with any trip command (closing blocked if any electrical trip is active, including trips via the other protection module). The closing command shall have a settable pulse length and shall be immediately reset upon occurrence of any electrical trip command to the circuit-breaker. In this way, protection module designs are not required to include an anti-pump timer.

3.10.3 Panel finishing

After fabrication is complete the metal surfaces shall be finished in accordance with Eskom Standard 240-75655504 Corrosion Protection Specification. The paint colour of the interior and exterior of the housing shall be to SANS 1091 colour code G29: Medium Grey. The base channels, base backplate and checker plate support angle shall be gloss black. The interior side plates and terminal back plate shall be smooth powder coated to SANS 1091 colour white.

3.10.4 LV components and component mounting and fixing

MCBs and auxiliary components shall comply with the Specification for low voltage auxiliary electrical components standard, Unique Identifier 240-62773019.

Unless specified to the contrary in the individual product specifications, the following shall apply to all AC (including VT supplies) and DC MCBs:

- Rated ultimate short-circuit breaking capacity (Icu) ≥ 5 kA
- Rated service short-circuit breaking capacity (Ics) = Icu

Lock washers shall be used with all screwed fittings except where the use of self-locking nuts or fasteners, make their use unnecessary. Permanent fixings such as rivets shall only be used for fixed mechanical parts, and not for electrical or electronic components. Self-tapping screws shall not have sharp points and shall not be used for fixing items such as cover plates which may have to be removed and replaced.

Components shall be located, secured and disposed with respect to each other and the structural members so that they, together with all connecting wires, can be inspected, removed and replaced without damage to, or undue disturbance of, other parts of the equipment or wiring.

Components shall be mounted inside the scheme or module. Components shall not be mounted on the back plate or on the side of the panel which shall be reserved for terminal blocks only.

Test blocks shall be located in the lower region of the 19” rack module and shall be easily accessible from the front of the panel with the door open. Cables hanging from test plugs inserted in the blocks shall not obscure or in any way interfere with any test or operational feature of any equipment mounted in the 19” rack. The minimum height of such test blocks above floor level shall be 150 mm. The input circuits from the outside plant shall always be connected to the lower terminals of the test blocks and the panel circuits shall always be connected to the upper terminals of the test blocks. When observed from the front of the panel the phase order of the connections to both the upper and lower terminals shall be (from left to right) Red, White, Blue, Neutral.

3.10.5 Terminals

Terminals for connection to external circuits shall be to Eskom approval. Not more than two conductors shall be connected to any side of a terminal. Terminals shall be suitable for use with crimped or compression type terminations. Refer to document 240-70413291 (Terminal block specification).

Terminals shall be permanently and indelibly marked in an approved manner. Each terminal shall be clearly and unambiguously identifiable by suitable marking which is on or adjacent to it.

3.10.6 Terminal strips

The terminal strips shall be legibly numbered: X1, X2, etc. To improve visibility, the label shall be placed on the right side of each terminal strip for the swing frame. The terminal strips shall be positioned horizontally top to bottom on the back plate of the swing frame panels: X1, X2, etc.

The design shall cater for the termination for all used cores within a common cable on one terminal strip only. Terminal strip functionality shall be divided according to the following table:

Terminal Strip number	Functionality (in recommended order)

Terminal Strip number	Functionality (in recommended order)
X1	Power terminals: • DC supplies; and, • AC supplies.
X2	CT terminals
X3	VT terminals
X4	Trip interface terminals: • Trip signals to circuit-breaker; • Circuit-breaker fail signals to the buszone scheme; • Reactor interfacing; • Series capacitor bank interfacing; • External trip interfacing; and,
X5	Inter scheme/module interfacing; • Trip signals between object protection schemes.
X6	JB interface terminals (signals between the scheme/module and the JB).
X7	Teleprotection interface
X8	Protection equipment interface (internal to the scheme/module)
X9	External disturbance recorder interface
X10	Interface with third party equipment

3.10.7 Wiring trunking

Wiring trunking shall be provided for all wires on the back plate. Each trunking shall be fitted with a cover of insulating material. These covers shall be designed so that they can be fixed in position, and removed without the use of tools. Trunking shall be adequately dimensioned to accommodate the maximum number of cables especially where the cables enter the trough.

For the swing frame panels, a horizontal plastic trunking strip shall be provided above and below each terminal strip to accommodate wiring. Where space permits, the wiring for the top and bottom or left and right of each terminal strip shall be accommodated in separate trunking strips of minimum dimensions 60mm (h) x 25mm (w). This means that double rows of trunking will be provided between all terminal strips.

Where there is insufficient space on the terminal back plate or terminal rear side to accommodate double rows of trunking, a single trunking strip of minimum dimensions of 60mm (h) x 40mm (w) may be provided between terminal strips.

Trunking shall be of the ‘fine’ tooth type (tooth width 6.1 mm as opposed to 12.0 mm).

In order to facilitate easy access to all terminals and wires, a minimum gap of 30mm shall be provided between trunking and the top and bottom of the terminal blocks. To further improve accessibility, the terminal attachment rail may be mounted on posts or an angle iron such that the rail is raised from the back plate by up to 70mm. The number of terminal strips required will depend on the terminal requirements per individual scheme.

Proprietary brands of PVC or equivalent material trunking shall be used, but regardless of the type of construction, the design and sizing of the trunking with cover shall be subject to Eskom approval before manufacture commences.

3.10.8 Wiring supports

Vertical lacing supports of non-magnetic material shall be provided for securing cable tails. Joints or splices in any wiring are not acceptable. Any support for wiring must be of a non-conductive material. Vertical lacing supports of non-magnetic material shall be provided for securing cable tails. Wiring and cabling shall be adequately supported and clamped. Where wiring is routed from the inside of a panel to a panel door, its' wiring shall be routed through a protective wiring sock. Grommets or bushes shall be used where wires or cables pass through metalwork. Wiring and cabling shall be routed such that its insulation is not subject to injurious temperatures or stresses.

3.10.9 Wiring terminations

The selection of specific terminal block types for application in a scheme shall take cognisance of the typical wire size to be applied at the scheme interface. Link type terminals shall be used in the following applications:

- CT and VT Circuits that are not routed via test blocks
- Tripping and Closing Circuits that are not fed via local remote switches – LOR switches.

The terminals of all relays and other panel components shall be readily accessible when the panel is fully wired. Any difficulties experienced, either with layouts or terminal accessibility shall be referred to Eskom prior to the commencement of the wiring.

Not more than two conductors shall be connected to any side of a terminal and where two conductors are connected to a terminal, care shall be taken to ensure that lugs and ferrules are fitted to the conductors so as to allow the wires to approach the terminal as near parallel as possible.

The stripping of insulation shall be carried out so that no damage to conductors occurs. Any nicked wiring will be rejected. The stripping tools used shall be of the type which permits the length of strip to be pre-set.

All wires and cables less than 6 mm² in the panel shall be terminated with pre-insulated crimped connectors of approved types. Other types of lug which are to Eskom's approval may be considered.

Schemes shall include at least two spares of each terminal block type used.

The scheme back plate shall include horizontal terminal strips for the swing frame panels and vertical terminal strips for the fixed front-rear entry panels.

For the swing frame panels with horizontal terminal strips, internal scheme wiring to terminal strips on the terminal back plate shall be connected to the lower side of the terminals and the cables shall be connected to the upper side. The input circuits from the outside plant shall always be connected to the lower terminals of test blocks and the panel circuits shall always be connected to the upper terminal. When observed from the front of the panel the phase order of the connections shall be (from left to right) red, white, blue, neutral.

For the fixed front-rear entry panels with vertical terminal strips, internal scheme wiring to terminal strips on the inside of the panel, for the left terminal strip shall be connected to the right side of the terminals and the cables shall be connected to the left side. For the right terminal strip, internal scheme wiring to terminal strips on the inside of the panel shall be connected to the left side of the terminals and the cables shall be connected to the right side.

Wiring terminations shall be of such a length and executed in such a manner that the conductors are not subject to injurious tensile stresses or flexing which might cause fatigue failure, whether as a result of vibration or otherwise.

All terminations shall be made with the tool recommended by the manufacturer of the lugs. Crimping tools shall be of the type which will not release the termination during normal operation until the crimp has been correctly formed. A double die crimping tool shall be used in order to affect both the lug and insulation support crimp simultaneously.

All wires and cables larger than 6 mm² shall be terminated with an approved lug. The lug shall be crimped with a hydraulically actuated hexagonal die tool as recommended by the manufacturer of the lug.

There shall be no bare wire exposed between a lug and the insulation of the wire to which it is crimped.

All tools used shall be regularly inspected and tested with approved gauges, and maintained or repaired as necessary. Tools shall be inspected and tested initially at weekly intervals, but this period may be extended in the light of experience. A log of inspections shall be maintained for Eskom's inspection.

The lugs selected shall be the correct barrel size for the size of wire or cable with which they are to be used, and the dimensions of the tongue shall match the stud, screw or aperture of the terminal to which they will be connected.

A sample of each type of lug, wire, tool and finished connection if not previously approved shall be submitted to Eskom for approval before wiring is commenced.

The size, current and voltage rating shall match the wire and cable used.

3.10.10 Wiring identification

Wiring leads connected to the boundary terminals shall be permanently marked with an approved type of marking device, with black letters impressed on a white background or black letters on a yellow background provided that the colour selected is consistent throughout the panel and/or suite of panels and is to Eskom's approval.

Interlocking slip-on types of ferrules or one piece ferrules may be used and shall match the size of wire onto which they will be fitted.

For heavy conductors and very light telephone type wiring where the preferred type of marking ferrule is not available, other methods will be subject to Eskom's prior approval.

All wiring shall be identified using numbers, at each end, following the alphanumeric wire identification conventions stated in the generic equipment standard for wiring, wire marking and cable numbering, Unique Identifier 240-64636794.

3.10.11 Wiring sizing and practices

The wiring sizing and practices shall be as per the wiring standard 240-64636794.

The overload rating of the scheme/module wiring shall be higher than the protected MCB rating.

3.10.12 Earthing

All earthing shall be done in accordance with the Standard for Earthing of Protection Equipment, Unique Identifier 240-64100247.

3.10.13 Labeling

All labelling shall be done in accordance with the Standard for Panel Labelling, Unique Identifier 240-62629353.

3.10.14 Packaging for transport

Packaging and transporting shall be done in accordance with the Specification for Standard (19") Equipment Cabinets (240-60725641).

3.10.15 Safety and regulatory requirements

No approval given or implied by Eskom shall relieve the supplier of any statutory obligations regarding safety.

4. Functional Element Description

This section defines the scheme functional elements, grouped as far as possible per the Logical Node groupings of IEC 61850-7-4. Functions are described wherever possible without reference to the IEDs that will perform them, that is, this section describes “what” rather than “how”.

The description of each functional element will include a description of input conditions, the desired scheme response to an output (e.g. tripping) and the functional requirements (what is required from the element and the performance requirements).

The detailed logical node standard descriptions regarding functional requirements, settings, performance, inputs, outputs and data attributes will be compiled, at a later stage, as standalone documents. Due to the unavailability of the detailed logical node documents, the detail requirements will be included within each detailed functional spec.

4.1 System Logical Nodes

The following Logical Node and Data Attributes shall be available to the Eskom System Configurator for modelling Interfacing and Archiving functions relative to the functions and/or remote process I/O provided by the IED concerned.

4.1.1 Logical Physical Device Information - LPHD

This Logical Node models the common issues for physical devices (protection IED). The following Logical Nodes and Data Attributes shall be available to the Eskom System Configurator for modelling issues such as physical description, physical health, communications, and power supply. The detailed requirements are within document 240-42066934 section 6.2.

4.1.2 Common Logical Node Information

The compatible logical nodes classes are specialisations of this common logical node class.

4.1.3 Logical Node Zero - LLN0

This LN contains the data related to the IED of the Physical Device (PD) independent from all included logical nodes (device identification/name plate, messages from device self-supervision, etc.). This LN may also be used for actions common to all included logical nodes (mode setting, settings, etc.), if applicable. This LN does not restrict the dedicated access to any single LN by definition. Possible restrictions are a matter of implementation and engineering.

4.2 Protection Functions (Group P)

This section refers to modelling of protection and protection related Logical Nodes.

- If there are several stages to one function (i.e. for multi-zone relay), each stage shall be a separate instance of the LN. Examples are PDIS (n zones) or PTOV (2 stages);
- Multiple instances shall be used if LNs of the same LN class are operating with different setting groups in parallel;
- If different measuring principles such as phase or ground are required, each shall be represented by an instance of the same basic function. An example is PTOC (used for phase or ground in dedicated instances); and,
- Other logical nodes have been added to model complex protection devices and schemes. As an example, line protection uses LN PSCH to combine the outputs from multiple protection LNs.

4.2.1 Instantaneous Overcurrent – PIOC

The instantaneous overcurrent or rate-of-rise relay is an instantaneous function that operates on an excessive value of current or on an excessive rate of current rise.

4.2.1.1 Switch-onto-fault protection

A switch-on-to-fault (line check) function is required for all single and three-pole closures of the circuit-breaker (manual closures as well as automatic reclosures). All switch-on-to-fault tripping shall be three-pole. Switch-on-to-fault tripping shall only occur for faults occurring on a switched (from open to closed) phase. For three-pole closures (manual or automatic) a fault on any phase(s) shall result in switch-on-to-fault tripping as all phases will have been switched. However, for single-pole reclosures, switch-on-to-fault tripping shall only occur if the fault includes the switched phase.

Switch-on-to-fault tripping shall not occur when energising transformers. Furthermore, switch-on-to-fault tripping logic shall not be spuriously armed, but shall only be armed for actual circuit-breaker open/line (phase) discharged conditions. This condition shall be determined by measurement, and not by the status of the circuit-breaker auxiliary contact(s). Activation of the switch-on-to-fault function shall be done after successful fault clearance and resetting of the protection elements and current detection that did operate during the fault. Tripping by way of the switch-on-to-fault logic shall only occur within the switch-on-to-fault window. The switch-on-to-fault window shall commence timing on detection, by measurement, that the pole(s) of the circuit-breaker are no longer open, or that the line (phase) is no longer discharged. The switch-on-to-fault window shall be a settable fixed value, and shall not be reset on detection of healthy line voltage.

The switch-on-to-fault function shall cover the full line length. Switch-on-to-fault tripping of close-in faults shall be effected by way of a high-set overcurrent element, and of remote faults by way of the release (timing bypassed) of the second zone (first overreaching zone, forward direction only). The requirement for the release of this zone, and not a farther reaching or starting/fault detector zone, which may also be non-directional, is due to the switch-on-to-fault window being a fixed value.

Switch-on-to-fault protection function shall following a three pole closure (manual or auto-reclose):

- Trip the circuit-breaker three pole for single line to ground faults and multi-phase faults (PTRC1 - with trip seal-in in accordance with the trip seal-in logic) and block auto-reclosing. The outputs from PTRC1 shall trip the circuit-breaker and initiate the circuit-breaker's breaker fail function;
- Three phase switch-on-to-fault trip signal shall be connected to the IED internal disturbance recorder function (RBDR); and,
- Three phase switch-on-to-fault tripping shall be reported to the gateway and station HMI.

Switch-on-to-fault protection function shall following a single pole closure (single pole auto-reclose):

- Trip the circuit-breaker three pole for single line to ground faults and multi-phase faults (PTRC1) and initiate three pole auto-reclosing (or block auto-reclosing, user selectable). The outputs from PTRC1 shall trip the circuit-breaker and initiate the circuit-breaker's breaker fail function;
- Initiate teleprotection permissive transmit, user selectable;
- Single phase switch-on-to-fault trip signal shall be connected to the IED internal disturbance recorder function (RBDR); and,
- Single phase switch-on-to-fault tripping shall be reported to the gateway and station HMI.

4.2.2 Time Overcurrent – PTOC

AC time overcurrent relay is a function when the AC input current exceeds a predetermined value, and in which the input current and operating time are inversely related through a substantial portion of the performance range.

PTOC elements shall be in accordance with IEC 60255-151. Specifically, the following dependent time curves shall be provided as a minimum: Type A (Normal Inverse), Type B (Very Inverse) and Type C (Extremely Inverse).

As per IEC 60255-151, dependent time curves shall have an effective operating range of at least 2 to 20 multiples of pick-up setting. That is, curves shall obey the standard characteristic equations and accuracy limits within this range of operating currents.

Unless stated otherwise in a product functional specification, PTOC elements shall use the RMS value of the fundamental component of the input signal(s) as their operating quantity.

PTOC elements except for Broken Conductor elements shall include a settable definite time reset feature. Should the operating current fall below the drop-off threshold of a started element, the element shall retain its state value for a settable reset time. It shall continue timing from this state value in the event of a further pick-up occurring prior to the expiry of the reset timer. The reset timer shall not apply to the resetting of an element following operation/tripping of the element.

4.2.2.1 Phase overcurrent

Each phase PTOC logical node shall consist of three measuring elements: one element per phase. If so requested in the product functional specification, a cold load pick-up (CLP) feature shall be provided that allows user selectable modification of phase PTOC characteristics under conditions of system energisation. The CLP function may be provided in one of the following ways:

- [Preferred] The pick-up current setting of the element may be modified by a settable scaling factor for a settable CLP duration. The rapid over current element shall be blocked for this time;
- The rapid and/or low-set PTOC element may be blocked for the CLP time duration; and,
- An automatic intelligent method of CLP may be applied whereby previous load and outage time is taken into account when modifying the over current elements dynamically.

The CLP function shall include an output that may be used to block other fast PTOC and PIOC elements.

4.2.2.2 Earth fault protection

The acceptable measurement method for earth fault PTOC logical nodes shall be indicated in a detailed product specification. Use of a dedicated measuring element (e.g. a neutral current measurement) is preferred, however, operating quantities derived from a logical summation of phase current measurements may be acceptable.

The operating quantity of earth fault PTOC elements using derived measurements shall be zero sequence current ($3I_0$).

4.2.2.3 Sensitive earth fault protection

Sensitive earth fault is a low-set definite time protection function that is used on Eskom's medium voltage overhead lines. Where required, at least two SEF-PTOC elements shall be provided, one for use as a tripping element, and one for research/recording purposes at specific sites.

The MV sensitive earth fault function shall have both DTL and IDMTL curves, setting ranges and accuracy classes indicated in the A/B schedules. In the case of the DTL function the timer setting shall have a setting range from 0 – 15 seconds adjustable in 1 second or smaller increments. The MV sensitive earth fault function shall operate the MV circuit-breaker main and back-up trip coils. The MV sensitive earth fault trip output shall also be able to be altered from a DTL element to an IDMTL element via settings or marshalling. It shall be possible to use both DTL and IDMTL curves simultaneously.

The MV sensitive earth fault element shall be able to pick-up for 2 amps primary with a CT ratio of 400/1. This equates to an element with a minimum pick up of 5 milliamps.

4.2.2.4 Broken conductor detection

If so requested in the product functional specification, a broken conductor detection function shall be provided. This shall be a definite time overcurrent function that uses the ratio of negative- to positive phase sequence current as its operating quantity. Alternative algorithms shall be subject to Eskom approval.

4.2.3 Overvoltage – PTOV

4.2.3.1 Local overvoltage protection for lines

The purpose of the local overvoltage function is to disconnect the protected line for a local overvoltage condition. The overvoltage function is therefore required to make a local 'measurement' and then to trip the local circuit-breakers. The measurement voltage shall be positive sequence (V_1). The local overvoltage function shall have a threshold setting and a definite time delay setting.

The local overvoltage function shall:

- Trip the circuit-breaker three pole (PTRC - with trip seal-in in accordance with the trip seal-in logic) and block auto-reclosing. The outputs from PTRC shall trip the circuit-breaker and initiate the circuit-breaker's breaker fail function;
- Local overvoltage trip signal shall trigger the direct transfer trip send function;
- Local overvoltage start signal shall be connected to the IED internal disturbance recorder function (RBDR);
- Local overvoltage trip signal shall be connected to the IED internal disturbance recorder function (RBDR); and,
- Local overvoltage tripping shall be reported to the gateway and station HMI.

4.2.4 Protection Trip Conditioning – PTRC

This logical node shall be used to connect the "operate" outputs of one or more protection functions to a common "trip" to be transmitted to XCBR. In addition or alternatively, any combination of "operate" outputs of the protection functions may be combined to a new "operate" of PTRC.

4.2.5 Thermal Overload – PTTR

The thermal overload function protects load carrying objects from thermal damage by measuring AC current flow through the equipment and using a thermal model with a memory function.

4.2.5.1 Thermal overload protection

Thermal overload protection shall comply with the requirements of IEC 60255-149. It shall be able to detect overloading on any phase of a three phase system.

The heating expression shall take into consideration the effect of load current prior to the over load condition, that is the "hot curve" expression of IEC 60255-149 shall be supported

$$t(s) = \tau \times \ln \frac{I^2 - I_p^2}{I^2 - (k \times In)^2}$$

where:

t = thermal element tripping time

τ = heating time constant (cooling)

I = measured phase current (maximum r.m.s. value of three phase currents)

Ip = preload current (corresponds to the heating level reached)

k = overload factor

k x In = steady-state current, which corresponds to the pick-up of the thermal element

In = rated current

The heating time constant (τ) and the load current factor (k) corresponding to the maximum thermal load shall be user-adjustable. The factor k defines the load current value which, when exceeded, results in a thermal trip.

The cooling time constant of the thermal overload protection shall be the same as the heating time constant. The thermal overload stage shall also be provided with a separately adjustable alarm function.

- The trip output shall be reported as an urgent alarm;
- The start and alarm outputs shall be reported as non-urgent alarm;
- The function shall be reported locally via LED; and,
- Shall be reported remotely via SCADA (IEC 61850).

4.2.6 Undervoltage – PTUV

An undervoltage function operates when its input voltage is less than a predetermined value.

4.2.6.1 Local undervoltage protection

Undervoltage protection is required at the interconnection points of Independent Power Producers. The undervoltage function makes a local measurement and then to trips the local circuit-breakers. The measurement voltage shall be positive sequence (V_1). The local undervoltage function shall have a threshold setting and a definite time delay setting.

The local undervoltage function shall:

- Trip the circuit-breaker three pole (PTRC - with trip seal-in in accordance with the trip seal-in logic) and block auto-reclosing. The outputs from PTRC shall trip the circuit-breaker and initiate the circuit-breaker's breaker fail function;
- Local undervoltage trip signal shall trigger the direct transfer trip send function;
- Local undervoltage start signal shall be connected to the IED internal disturbance recorder function (RBDR);
- Local undervoltage trip signal shall be connected to the IED internal disturbance recorder function (RBDR); and,
- Local undervoltage tripping shall be reported to the gateway and station HMI.

4.2.6.2 Voltage control undervoltage supervision

It is required that an under-voltage blocking function shall be provided for the voltage regulating function. This function shall inhibit the operation of the voltage regulating function when the supplied voltage falls below certain set limits.

4.3 Protection Related Functions (Group R)

4.3.1 Disturbance Recorder Function – RDRE

The disturbance recorder function, at bay level, described as a requirement in IEC 61850-5 is decomposed into one logical node class for analogue channels (RADR) and another logical node class for binary channels (RBDR). The output refers to the "IEEE Standard Format for Transient Data Exchange (COMTRADE) for Power Systems" (IEC 60255-24). Disturbance recorders are logical devices built up with one instance of logical node RADR or LN RBDR per channel.

Triggering by an analogue channel shall be independently selectable per channel. The triggering levels for (High/Low) for analogue quantities shall be independently selectable, and also selectable to OFF (not permitted to trigger). All analogue channels shall be recorded independent on the trigger mode. Only the allocated (used) analogue channel shall be recorded.

Triggering by a binary channel shall be independently selectable per channel. Triggering shall be selectable between a change from a logical 0 to a logical 1, logical 1 to a logical 0 and OFF (not permitted to trigger). All binary channels shall be recorded independently of the trigger mode. Only the allocated (used) binary channel shall be recorded.

The pre-fault, fault and post-fault durations shall be independently selectable and the set duration shall be sufficient to record an auto-reclose cycle.

Any protection device failure or abnormality shall also be stored and accessible. The presentation of the sequence of events, device failure or device abnormality information shall be such that an inexperienced person can access and evaluate it easily. The analogue traces and sequence of events shall be displayed within a single window when the data is uploaded to the device's operating and analysis software for post fault analysis purposes.

4.3.2 Disturbance Recorder Channel Analogue – RADR

In addition to the channel number, all attributes needed for the COMTRADE file are provided by data from the measured values. The "circuit component" and "phase identification" is provided by the instance identification of the logical node RADR. Channels "1" to "n" are created by "1" to "n" instances.

4.3.2.1 Protection device analogue channels

The protection device internal disturbance recorder shall have the capability to record the listed analogue signals. The analogue traces and binary event information shall be displayed within a single window when the data is uploaded to the device's operating and analysis software for post fault analysis purposes.

4.3.3 Disturbance Recorder Channel Binary – RBDR

In addition to the channel number, all attributes needed for the COMTRADE file are provided by attributes of the binary input (subscribed from another logical node). The "circuit component" and "phase identification" is provided by the instance identification of the logical node RBDR. Channels "1" to "*n*" are created by "1" to "*n*" instances.

4.3.3.1 Protection device binary channels

The line protection device internal disturbance recorder shall have the capability to record the listed binary signals. The analogue traces and binary event information shall be displayed within a single window when the data is uploaded to the device's operating and analysis software for post fault analysis purposes.

4.3.4 Sequence of event recording

Each IED shall include a sequence of event recorder that can log any settings change; settings group change; protection pickup or trip operation; or change in circuit-breaker and/or input and output status. Local and remote control actions (both manual and automatic) shall be logable.

The sequence of event recorder for MV feeder protection shall be capable of recording the maximum phase and neutral currents associated with over current, earth fault and sensitive earth fault protection "pick-up and trip" and "pick-up and drop-off" events.

The signals whose state changes are to be captured in the sequence of event recorder shall be programmable.

Events shall be date and time stamped to 1 msec resolution. The year shall be recorded as a four digit number.

The IED shall store at least 1 000 events. Events shall be stored using the First In – First Out principle.

It shall be possible to save the sequence of events download from an IED in xml (e.g. COMFEDE) and/or text formats. Sequence of events lists which can only be viewed using vendor-proprietary software are not acceptable.

4.3.5 Circuit-breaker Failure – RBRF

The circuit-breaker failure function is required to trip the neighbouring circuit-breakers in the case that the fault is not cleared. Main and back-up protection devices shall include a circuit-breaker failure protection function. The tripping functions within each protection system shall initiate only the circuit-breaker failure function within the same protection device. The circuit-breaker current transformer inputs shall be utilised for the circuit-breaker fail function.

Initiation of the circuit-breaker failure function shall occur, for both single- and three-pole tripping, for all protection tripping of the circuit-breaker, with the exception of circuit-breaker pole discrepancy tripping function. The initiation shall be phase segregated (tripped phase) for single-pole tripping, and all phases (or a single three-phase initiation) for three-pole tripping. A settable circuit-breaker fail timer shall commence timing on initiation of the circuit-breaker failure function for both single-pole and three-pole tripping. Successful opening of the circuit-breaker (fault cleared) shall immediately stop the timer. Failure of the circuit-breaker to open by expiry of the timer shall result in closure of the circuit-breaker fail binary output contact(s).

Successful opening of the circuit-breaker shall be determined by the drop-off of current (by way of a high speed resetting capability), or on detection of change of status (closed to open) of the circuit-breaker auxiliary contacts, and shall not rely solely on the resetting of the initiating signal. This is required to allow the setting on the circuit-breaker timer to be set no longer than is necessary (maximum circuit-breaker opening time, plus a small margin). For single- and three-pole tripping, verification of successful opening of the circuit-breaker shall be by way of:

- current drop-off (current through the circuit-breaker) shall occur whenever current (above a settable threshold) is present on initiation of the circuit-breaker failure function (this verification of circuit-breaker opening by way of current measurement shall co-ordinate with the trip-circuit seal-in by way of current measurement); and,
- circuit-breaker auxiliary contacts shall occur for no (low) current conditions (current through the circuit-breaker below the settable threshold) on initiation (this verification of circuit-breaker opening by way of the circuit-breaker auxiliary contacts shall co-ordinate with the trip-circuit seal-in by way of a fixed duration timer). The no (low) current verification by way of the circuit-breaker auxiliary contacts shall be a selectable option.

If the circuit-breaker failure protection detects current on initiation, verification of successful opening of the circuit-breaker by way of current shall be maintained for the full duration of the fault event, i.e. when the current drops-off following successful opening of the circuit-breaker, the circuit-breaker failure function shall not now convert to the monitoring of the circuit-breaker auxiliary contact status for the no current condition.

For single-pole tripping, the circuit-breaker failure logic shall monitor the current or circuit-breaker status of only the pole to which the trip command was issued. The timing of the circuit-breaker fail timer shall, respectively, be stopped when the tripped phase current is detected to be below the threshold level, or the circuit-breaker auxiliary contacts of the tripped phase indicate that the pole have opened.

For three-pole tripping:

- with the current above the threshold level in all phases, irrespective of which are the actual faulted phase(s), the circuit-breaker failure logic shall monitor the current status of all poles, and shall stop the timing of the circuit-breaker fail timer when all phase currents are detected to be below the threshold level;
- with the current above the threshold level in only the faulted phase(s), the circuit-breaker failure logic shall monitor the current status of all poles, and shall stop the timing of the circuit-breaker fail timer when all phase currents are detected to be below the threshold level (circuit-breaker pole discrepancy detection shall result if the unfaulted pole(s) fails to open); and,
- with the current below the threshold level in the faulted phase(s), irrespective of the current level in the unfaulted phase(s), the circuit-breaker failure logic shall monitor the circuit-breaker auxiliary contact status of all poles, and shall stop the timing of the circuit-breaker fail timer when the circuit-circuit-breaker auxiliary contacts indicate that all poles have opened.

It must be ensured that the circuit-breaker failure protection cannot issue an unnecessary and unwanted circuit-breaker fail command for evolving faults, i.e. for single-pole trips evolving to three-pole trips as the result of single-phase faults evolving to multi-phase faults.

The circuit-breaker fail function shall:

- Issue a circuit-breaker fail command to the buszone protection scheme with the TNS selected to the 'Normal' position;
- Issue a circuit-breaker fail command to the remote end circuit-breaker(s) via the direct transfer trip function;
- Block the circuit-breaker auto-reclosing function;
- Circuit-breaker fail start signal shall be connected to the IED internal disturbance recorder function (RBDR);
- Circuit-breaker fail trip signal shall be connected to the IED internal disturbance recorder function (RBDR); and,
- Circuit-breaker fail shall be reported to the gateway and station HMI.

Manual opening (local and remote) and trip testing of the circuit-breaker shall not initiate the circuit-breaker failure protection function.

The circuit-breaker failure protection output contact shall have link terminal blocks for isolation and testing purposes.

4.3.5.1 Circuit-breaker trip circuit seal-in

Circuit-breaker trip-circuit seal-in is required for all trip outputs, irrespective of the magnitude of the interrupted current. The trip-circuit seal-in logic shall not only seal-in the trip output(s), but also the relevant initiation signals to other scheme functions, (e.g. initiate signals to the circuit-breaker failure function and the auto-reclose functions), and the alarm output signals.

Two methods of seal-in are required, one based on the measurement of AC current, catering for those circumstances for which the interrupted current is above a set threshold, and one based on a fixed time duration, catering for those circumstances for which the interrupted current is small (below the current set threshold).

- For current seal-in, the seal-in shall be maintained until the circuit-breaker opens, at which time the seal-in shall reset (as the current drops below the threshold level). On detecting the current to be below the threshold level, the seal-in shall not now revert from the current seal-in to the fixed time duration seal-in.
- For the fixed time duration seal-in, the seal-in shall be maintained for the set time duration. This time duration shall be independently settable for single- and three-pole tripping.

Seal-in by way of current or by way of the fixed duration timer shall occur irrespective of whether the trip command originates from within the main protection IED itself (from any of the internal protection functions), or from an external device with its trip output routed through the protection IED for tripping.

4.3.6 Directional element: RDIR

The directional element (RDIR) is a dedicated logical node and shall present all the directional protection activation information to the required logical node(s).

The directional element shall have the ability to distinguish between forward and reverse fault conditions. The directional element shall be capable of correctly determining the fault direction, without any added delay to the overall tripping time, for any fault occurring and for any network condition.

4.3.6.1 Directional control for PIOC and PTOC elements

Where specified, the PIOC and PTOC elements for overcurrent, earth fault and SEF protection shall be subject to directional control. In this case, each element shall be independently settable for Non-Directional, Directional Forward or Directional Reverse operation. Directional Forward shall correspond to the direction of the protected object.

The IED shall support at least one of two directionalisation methods for phase over current elements:

- Quadrature connection (i.e. red phase element polarised by the white-to-blue phase voltage); or
- Positive Sequence: using the positive phase sequence current (I_1) and the positive phase sequence voltage (V_1) as the operate and polarising quantities.

The IED shall support at least two directionalisation methods of earth fault and SEF elements, the selection of which shall be user settable:

- Zero Sequence: using the residual current ($3I_0$) and the negative of the residual voltage ($-3V_0$) as the operate and polarising quantities
- Negative Sequence: using the negative phase sequence current (I_2 or $3I_2$) and the negative phase sequence voltage (V_2 or $3V_2$) as the operate and polarising quantities.

Alternative directional polarisation methods/algorithms shall be considered, providing the performance is equivalent to, or better than the requirements of this specification.

The voltage supply for directional polarisation shall be taken from a 3 or 5 limb three phase VT or 3 single-phase VTs with a phase-to-neutral voltage on the secondary of 63.5 V a.c. The IED shall derive all sequence voltages (notably $3V_0$) internally.

Over current directional polarisation shall include a memory function so as to be able to operate correctly for a forward/reverse bolted three phase fault at the circuit-breaker location (which collapses the local phase voltages to zero).

The required response of directional elements in the event of a VT fuse/supply failure shall be individually pre-selectable by the user: Blocked or Non-Directional.

4.3.7 Fault locator – RFLO

The fault locator shall calculate from the protection information (for example the fault impedance of the LN distance function) the location of the fault in km and in percentage of total line length from the local terminal. The distance to fault in Km shall and percentage be displayed on the IED HMI and shall be easily accessible to the operating staff.

4.3.8 Autoreclosing – RREC

Auto reclosing shall generally be of the three-pole type, with single-pole being required on designated varaints of the HV feeder main protection scheme.

Reclose initiation shall take the form of separate signals for single- and three-pole reclose initiates. A reclose block shall be initiated for all functions (protection device tripping functions) and commands (busstrip command and all external trip commands) which are not selected to initiate reclosing.

The close mode selections shall select the required reclose sequence. The main protection device shall, depending on the chosen program, control the tripping mode of the main protection device. The line protection device shall be forced to trip three pole, irrespective of the type of fault, when the 'Three Pole Trip Select' is active. The activation of this signal shall be dependent on the reclose program selected.

The main protection system shall initiate the 1 auto-reclose function within the main protection device, dependent on the TNS(M) switch selection. All automatic reclosing cycles shall commence immediately on (and not before) detecting that the circuit-breaker has opened, and shall not wait for the initiate signal to reset first.

An automatic reclosing cycle (single- or three-pole) shall only commence if the initiate signal is received before expiry of a pre-set time window following opening of the circuit-breaker. If received after expiry of the pre-set time window, no reclosing cycle shall commence.

The auto-reclose function within the main protection device shall revert to the lockout state whenever all three poles of the circuit-breaker are detected to be open with no reclosing permitted. On detecting that all three poles are open:

- lockout shall occur after the pre-set time window if no reclose initiate signal has been received and/or no reclosing cycle has commenced; and
- immediate lockout shall occur, even if a reclose initiate signal is, or has already been, received, if:
  - the ‘block reclosing’ signal is high;
  - the ‘permit three-pole reclosing’ signal is low, i.e. three-pole reclosing is not permitted;
  - the ‘permit no closing’ signal is high; or,
  - no further reclosing shots are permitted.

Once in the lockout state, receipt of a reclose initiate signal shall not result in commencement of an automatic reclosing cycle. The lockout state shall only occur if all three poles of the circuit-breaker are open, and not if only one-pole of the circuit-breaker is open.

Whenever a circuit-breaker three -pole reclosing cycle commences, an overall timer shall be started. If the closing command cannot be issued for whatever reason before this time has elapsed, the cycle in progress shall be stopped and the closing device shall revert immediately to the lockout state. For single-pole reclosing cycles, the overall timer shall also be started. However, in this case, if the closing command cannot be issued, other action, i.e. tripping of the other two poles by the pole discrepancy protection, is expected to occur well before the overall time elapses. When this occurs, on opening of the other two poles, the single-pole cycle in progress shall be stopped, and now, with all three poles open and no cycle in progress, the closing device shall revert immediately to the lockout state. To cater for the possibility that the other two poles may not be successfully opened, and if conditions remain such that the closing command cannot be issued, the cycle in progress shall be stopped when the overall time elapses. The closing device shall, however, not revert to the lockout state as all three poles of the circuit-breaker will not be open.

The timing of the overall timer shall reset with the issue of a close output. If another shot is permitted, and occurs, within the reclosing sequence, the timing of the overall timer shall start again with the commencement of the next cycle. If lockout occurs before the overall time elapses, its timing shall reset when the lockout occurs. The lockout state shall be reset by the receipt of a circuit-breaker manual close initiate signal.

One-pole automatic reclosing shall be permitted only when the ‘permit 1-pole reclosing’ signal is high; similarly, three-pole automatic reclosing shall be permitted only when the ‘permit three-pole reclosing’ signal is high. Manual closing shall always be permitted. When the ‘permit no closing’ signal is high, no automatic reclosing shall be permitted, manual closing shall be permitted. If any of the ‘permit reclosing’ signals are high at the same time as the ‘permit no closing’ signal, the ‘permit no closing’ signal shall take priority, preventing any reclosing and activating the three-pole only trip signal to the circuit-breaker.

Fast three-pole reclosing shall be selected when the ‘select fast three-pole reclosing’ signal is high. If low, slow three-pole reclosing shall be selected.

The inhibit reclosing signal shall be established whenever the ‘circuit-breaker charged’ signal is low, i.e. the circuit-breaker is not charged.

4.3.8.1 Single pole auto-reclosing

Single-pole reclosing shall be permitted if only one pole of the circuit-breaker has opened. Therefore, the single-pole automatic reclosing cycle shall commence (single-pole dead time started/cycle in progress started) following receipt of a single-pole reclose initiate signal, on detection that only one pole of the circuit-circuit-breaker has opened. The cycle in progress shall reset when the close output is issued. The main protection device shall issue the close output following expiry of the dead time without further delay provided that no inhibit signal is present to prevent closing.

Following a single-pole trip, it is expected that the single-pole reclose initiate signal will be received, i.e. if single-pole reclosing is not permitted, no single-pole tripping should have occurred. Therefore, it is not expected that the timing window following opening of the circuit-breaker pole will expire without receipt of the initiate signal. However, if for some unexpected circumstance this input signal is not received, no reclosing cycle shall commence. The circuit-breaker pole discrepancy protection will then eventually trip the other circuit-breaker poles. At this time the closing device will detect all three circuit-breaker poles to be open, and with no cycle in progress, shall revert immediately to the lockout state.

If an inhibit reclosing signal is already present on receipt of the reclose initiate signal, or occurs with a cycle already in progress, the reclosing cycle may commence or continue, but the close output shall not be issued until the inhibit signal has been removed, even if the dead time has elapsed. If the inhibit signal is removed before the dead time elapses, closing shall occur without further delay on expiry of the dead time. However, if by the time the dead time elapses, the inhibit signal has not yet been removed, the close output shall then be issued without further delay on removal of the inhibit signal. If the inhibit signal is not removed by expiry of the circuit-breaker pole discrepancy time, the other two poles will once again be tripped by the pole discrepancy protection. On detecting all three circuit-breaker poles to be open, the 1-pole cycle in progress shall be stopped. Now, with no cycle in progress, and all three poles open, the closing device shall immediately revert to the lockout state.

If a block reclosing signal is received once the cycle in progress has commenced following single-pole tripping, the reclosing cycle (cycle in progress) shall immediately be stopped. Following the tripping of the other two poles by the circuit-breaker pole discrepancy protection, the closing device shall once again revert immediately to the lockout state.

If single-pole reclosing is not permitted, but, for some reason, a single-pole reclose initiate signal is received, and only one-pole of the circuit-breaker is detected to have opened, no single-pole reclosing cycle shall commence. The other poles will be tripped by the circuit-breaker pole discrepancy protection, whereupon the closing device shall revert to the lockout state.

4.3.8.2 Three pole auto-reclosing

Three-pole reclosing shall only be permitted if all three poles of the circuit-breaker have opened. Therefore, the thee-pole automatic reclosing cycle, fast or slow, shall commence (relevant three-pole dead time started/cycle in progress started) following receipt of a three-pole reclose initiate signal, on detection that all three poles of the circuit-breaker have opened, provided that no condition exists which disallows three-pole reclosing, i.e. a condition which causes the closing device to revert immediately to the lockout state. The cycle in progress shall reset when the close output is issued.

If a block reclosing signal is received once the cycle in progress (fast or slow) has commenced, the reclosing cycle (cycle on progress) shall immediately be stopped, and the closing device shall revert immediately to the lockout state.

For slow three-pole reclosing, the close output shall be issued following expiry of the dead time in accordance with the permitted closing conditions set.

If an inhibit reclosing signal is already present on receipt of the reclose initiate signal, or occurs with a cycle already in progress, the reclosing cycle may commence or continue, but the close output shall not be issued until the inhibit signal has been removed, even if the dead time has elapsed. If no inhibit signal is present, or is removed before the dead time elapses, the close output shall be issued once the dead time has elapsed in accordance with the conditions set. However, if closing is prevented upon expiry of the dead time, it shall then be effected as soon as the inhibit signal has been removed, but once again in accordance with the conditions set. If the inhibit signal is not removed by the time the overall time expires, the cycle in progress shall be stopped, and the closing device shall immediately revert to the lockout state.

If the set condition for reclosing and a synchronism check to be performed, the close output may not be issued until verification that the voltages are in synchronism has been concluded. If this verification is not concluded by the time the overall time expires, the cycle in progress shall be stopped, and the closing device shall immediately revert to the lockout state.

If a single-pole cycle is initiated, but all three circuit-breaker poles are detected to be open, the single-pole cycle shall be blocked, or stopped, and a three-pole reclosing cycle initiated, if three-pole reclosing is permitted. If three-pole reclosing is not permitted, the closing device shall immediately revert to the lockout state. Furthermore, a single-pole reclosing cycle, already in progress, shall automatically convert from the single-pole to a three-pole cycle (single-pole cycle stopped, three-pole cycle initiated), if three-pole reclosing is permitted, for a subsequent three-pole trip due to, e.g. an evolving fault, or a fault occurring during the single-pole open period. Once again, if three-pole reclosing is not permitted, the closing device shall immediately revert to the lockout state. For both circumstances, if a single and three pole sequence has been selected, the sequence shall convert to the three-cycle sequence.

On issuing the close output (for manual closing, or automatic reclosing (single- or three-pole)), the closing device shall start the reclaim time. If, following single-pole reclosing, with the five-cycle sequence (single and three pole selected), and three-pole reclosing permitted, a recurring fault, and subsequent reclose initiation, occurs within the reclaim time, this shall constitute the next step in the five-cycle sequence. As before, the reclosing cycle shall commence if all conditions governing commencement of a reclosing cycle are favourable. Commencement of the reclosing cycle shall reset the reclaim time, which shall be started again when, following the expiry of the dead time, and for all closing conditions favourable, the close output is issued.

New faults, with subsequent reclose initiation, occurring after the reclaim time has expired, shall constitute the first step in a new five-cycle sequence.

If the closing function detects, within the reclaim time, that all three poles of the circuit-breaker have re-opened following manual closure, or three-pole automatic reclosure, the bay closing device shall revert immediately to the lockout state, irrespective of the presence of any reclose initiate signal, ensuring no further reclosing attempts are made. However, if the closing function detects, within the reclaim time, that all three poles of the circuit-breaker to have re-opened following a single-pole automatic reclosure, lockout shall only be established, irrespective of the presence of any reclose initiate signal if no further reclosing shot is permitted, i.e. the three-cycle reclosing sequence is selected. If the single and three pole reclosing sequence is selected, lockout must not be established, allowing the three-pole reclosing cycle to commence.

Establishing the lockout state shall reset the timing of the reclaim time.

Following receipt of a manual close initiate signal, the manual close cycle shall commence (manual close cycle in progress) provided that all three poles of the circuit-breaker are open, and the lockout state has been successfully reset. Receipt of the manual close initiate signal shall reset the lockout state provided that closing is permitted (the ‘permit no closing’ binary input is not high), and manual closing is not blocked (the ‘block manual close’ binary input is not high). If either of these binary inputs is high, the lockout state shall not be reset, and no manual close cycle shall commence. Once commenced, a manual close cycle in progress shall reset when the close output is issued.

The overall timer shall also be started whenever a manual close cycle commences. If closing cannot be effected for whatever reason before this time elapses, i.e.:

- the circuit-breaker is not charged (‘circuit-breaker charged’ binary input);
- the set conditions for closing have not been met;

- synchronism could not be concluded; or,
- the cycle in progress shall be stopped, and the closing device shall immediately revert to the lockout state.

If a block manual closing signal is received with a manual closing cycle already in progress, i.e. the manual closing cycle has commenced, but the close output has not yet been issued, the manual closing cycle shall immediately be stopped, and the closing device shall immediately revert to the lockout state.

A manual closing cycle, initiated by the receipt of a manual close input signal, shall be permitted to commence in parallel with a three-pole reclosing cycle already in progress (dead time elapsed), for which the required closing conditions have not yet been met, and for which the overall time has not yet elapsed. If the conditions for manual closing are met, which may be different to those for three-pole reclosing, a close output shall be issued. Issuing of the close output shall reset both cycles in progress. Commencement of the manual closing cycle shall not reset the three-pole cycle in progress, or restart the timing of the overall timer. If the overall time elapses without the close output being issued, both cycles in progress shall be reset, and the closing device shall immediately revert to the lockout state.

The close output, for manual closing, or single- or three-pole automatic reclosing, shall have a fixed (settable, but fixed once set) duration. Once issued, the fixed duration of this output shall not be compromised for any reason, e.g. the subsequent receipt of inhibit/block input signals.

The closing device shall be able to dynamically select the main protection systems for three-pole tripping only by means of a signal from the main protection system. The required signal shall be sustained as logic 1 and a logic 0 state whenever single-pole tripping is allowed. Whenever single-pole tripping is disallowed, i.e. only three-pole tripping is allowed, this signal shall be set to the logic 1 state. Three-pole only tripping shall be selected:

- from reset of the single-pole initiate signal until reset of the reclaim time;
- from start of the three-pole reclosing cycle (cycle in progress) until reset of the reclaim time;
- from establishment of the lockout state until reset of the reclaim time following manual closing;
- whenever the ‘inhibit reclosing’ binary input is high;
- whenever the ‘block reclosing’ signal is high (if the block reclosing input is received during a single-pole cycle in progress before reset of the single-pole initiate signal, three-pole tripping may follow if the three-pole only feedback to the protection is timeously received; otherwise, if after the reset of the single-pole initiate signal, the pole disagreement protection will provide the three pole tripping – no reclosing will occur for either of these circumstances);
- whenever single-pole tripping is not permitted, i.e. the ‘permit single-pole tripping’ signal is low (not selected), or the ‘permit no closing’ signal is high (selected); or,
- whenever the main protection device is out-of-service.

Circuit-breaker Trip Testing (red phase, white phase and blue phase):

- Trip testing is only permitted when the circuit-breaker is 3-pole closed and healthy; and,
- Auto-reclose is ready for a 1-pole auto-reclose cycle.

4.3.9 Auto reclose bay initiation

The protection device shall provide for the suitable initiation of the circuit-breaker auto-reclose functionality within the protection device. Reclose initiation shall take the form of signals for single- and three-pole reclose initiates for a three mechanism circuit-breaker and three-pole reclose initiate for a single mechanism circuit-breaker. The breaker auto-reclose block shall be initiated for all functions (protection device tripping functions) and commands (circuit-breaker fail command and all external trip commands) which are not permitted to initiate a reclosing cycle. The circuit-breaker reclose initiation and reclose block signals to the auto-reclose functions shall be dependent on the TNS selection (permitted when selected to ‘Normal’). The circuit-breaker single- and three-pole auto- reclose initiate signals shall not be slower than the trip signals to the circuit-breakers as to ensure the successful start of an auto-reclose cycle.

4.3.10 Auto reclose mode selections

Main protection modules interfacing with a three mechanism circuit-breaker (single pole tripping capability) shall provide the following auto-reclose mode selections:

Mode selections	Description
ARC(ON)	Auto Reclose ON Selection with Indication
ARC(OFF)	Auto Reclose OFF Selection with Indication
ARC(1P)	1 Pole Auto Reclose Selection with Indication
ARC(3P)	3 Pole Auto Reclose Selection with Indication
ARC(1&3P)	1&3 Pole Auto Reclose Selection with Indication

Auto Reclose ON selection:

Auto-reclose permitted.

Auto Reclose OFF selection:

Auto-reclose not permitted. All tripping from the main protection and back-up protection shall three-pole and shall initiate auto-reclose lock-out.

Auto Reclose selection scenario 1:

ARC(ON), ARC(1P)

Single-line-to-ground faults:

- Circuit-breaker single pole trip (faulted phase) – single pole auto-reclose (single-pole dead time) – three pole trip and lock-out.

Multi-phase faults

- Circuit-breaker – three pole trip and lock-out.

Auto Reclose selection scenario 2:

ARC(ON), ARC(3P)

Single-line-to-ground faults:

- Circuit-breaker three pole trip – three pole auto-reclose (three-pole dead time) – three pole trip and lock-out.

Multi-phase faults

- Circuit-breaker three pole trip – three pole auto-reclose (three-pole dead time) – three pole trip and lock-out.

Auto Reclose selection scenario 3:

ARC(ON), ARC(1&3P), 5-CYCLE, 3-PSLOW

Single-line-to-ground faults:

- Circuit-breaker single pole trip – single pole auto-reclose (single-pole dead time) – three pole trip – three pole auto-reclose (three-pole dead time, dependent on the spring rewind time) – three pole

trip and lock-out.

Multi-phase faults

- Circuit-breaker three pole trip – three pole auto-reclose (three-pole dead time) – three pole trip and lock-out.

Single mechanism circuit-breaker (three pole tripping only) auto-reclose mode selections:

Mode selections	**Description**
ARC(ON)	Auto Reclose ON Selection with Indication
ARC(OFF)	Auto Reclose OFF Selection with Indication

Auto Reclose ON selection:

Three phase auto-reclose permitted.

Auto Reclose OFF selection:

Three phase auto-reclose not permitted. All tripping from the main protection and back-up protection shall initiate auto-reclose lock-out.

4.3.11 Synchronism Check – RSYN

The main protection device shall include a synchronism check function for the circuit-breaker. All three-pole auto-reclose and manual close commands (both local and remote) shall be supervised by the circuit-breaker synchronism check function. The circuit-breaker shall utilise the selected busbar VT and the line VT for synchronism check purposes.

The synchronism check function shall measure slip, and only allow closing if the two voltages are within allowed slip limits. The two voltages are also required to be within angular difference limits, within amplitude difference limits and with each voltage being above the set 'live' voltage threshold.

Closing shall only be permitted if the actual system conditions correspond to one of the set conditions for closing (separately settable for manual closing/three-pole (slow) automatic reclosing), i.e. if the actual system conditions do not correspond to one of the set conditions for closing, closing shall not occur. If the synchronism check option is implemented, closing/reclosing, for actual live busbar/line live conditions, shall only occur, with live busbar/line live set for closing/reclosing, following successful confirmation of synchronism. Once initiated, checking for synchronism shall continue until synchronism is confirmed, and closure occurs, or the overall time elapses, at which time the checking for synchronism shall reset. When this occurs, the closing device shall revert to the lockout state.

For manual closing of the circuit-breaker, with the actual system conditions, other than live busbar/line live, corresponding to one of the set conditions for closing, the close output shall be issued without delay provided that no other constraint exists to prevent closing. For live busbar/line live conditions and with live busbar/line live set conditions for manual closing, checking for synchronism shall commence with commencement of the manual closing cycle. The close output shall be issued immediately following confirmation of synchronism provided that no other constraint exists to prevent closing. If such a constraint exists, e.g. circuit-breaker not charged, closing shall not occur until the constraint is removed. If, once removed, synchronism is still confirmed, closing shall occur without further delay. If synchronism is no longer confirmed, closing shall only occur once synchronism has been re-confirmed.

For the circuit-breaker three-pole automatic reclosing, with the actual system conditions, other than live busbar/line live, corresponding to one of the set conditions for three-pole reclosing, the close output shall be issued without further delay following expiry of the dead time provided that no other constraint exists to prevent closing. For live busbar/line live conditions (established on reclosure of the remote-end), and with live busbar/line live a set condition for three-pole reclosing, checking for synchronism shall commence immediately upon expiry of the dead time. If the dead time has already elapsed, with live busbar/line live the only set condition for reclosing, checking for synchronism shall commence immediately upon detecting live busbar/line live conditions. The close output shall be issued immediately following confirmation of synchronism provided that no other constraint exists to prevent closing. If such a constraint exists, e.g. inhibit reclosing signal, circuit-breaker not charged, closing shall not be effected until the constraint is removed. If, once removed, synchronism is still confirmed, closing shall occur without further delay. If synchronism is no longer confirmed, closing shall only occur once synchronism has been re-confirmed.

It shall be possible to disable the synchronism check via IED settings in applications not requiring this functionality.

For live busbar/line live conditions, three-pole automatic reclosing of the circuit-breaker shall only occur, with live busbar/line live set for reclosing, following successful confirmation of synchronism.

The following setting options are required, separately for manual closing and automatic reclosing of the circuit-breaker, to select the permitted closing options:

- dead bus/dead line;
- dead bus/live line;
- live bus/dead line; and,
- live bus/live line.

The block synchronism check release input shall be initiated whenever the synchronising voltage is unhealthy. The synchronising voltage unhealthy (SVUNH) GOOSE messages will be sent from the circuit-breaker PIU when:

- the selected busbar voltage is absent due to the tripping of MCB (within busbar 1 VT JB);
- the line voltage is absent due to the tripping of MCB (within line VT JB);
- the selected busbar voltage is unhealthy due to the loss of any one of the phases (unhealthy condition shall be measured within the main protection device); and,
- the line voltage is unhealthy due to the loss of any one of the phases (unhealthy condition shall be measured within the main protection device).

4.3.12 Synchronising VT supply monitoring

Monitoring for VT supply failure conditions, plus the associated supply failure logic, is required to ensure that the synchronism check function remains secure, i.e. that it does not incorrectly release a three pole close command, for the loss of any number of VT inputs.

To prevent maloperations, blocking of all the specific synch functions shall occur immediately on detection of a supply failure condition by the supply failure monitor. Establishment of supply failure (one, two or three phase supplies) shall only occur for genuine supply failure conditions. Once established, supply failure shall be sealed-in, and blocking of the synchronism check functions shall not be released, until the supply is restored. Reset of the supply failure shall occur automatically with restoration of the VT supply. The following VT supply failure detections are required (independent per synchronising voltage input):

- Input from the specific MCB auxiliary monitoring contact (GOOSE signal from PIU); and,
- Unbalance voltage detection done within the main protection device (delayed to prevent unwanted blocking and alarming during the single pole dead time).

4.3.13 VT Fuse failure

The failure of one or more fuses (or single phase MCBs) will affect the behaviour of the voltage dependent protection function. This condition shall be detected by and additional functional element which then interacts with all the voltage dependent protection functions to effect blocking of these protection functions for loss of voltage.

Monitoring for VT supply failure conditions, plus the associated supply failure logic, is required to ensure that the distance and other voltage function remains secure, i.e. that it does not over operate, either for load conditions or adjacent line fault conditions, for the loss of any number of VT inputs.

To prevent over operation, blocking of all the voltage dependent measuring functions (e.g. impedance and other voltage dependent functions) shall occur immediately on detection of a supply failure condition by the supply failure monitor. Establishment of supply failure (one, two or three phase supplies) shall only occur for genuine supply failure conditions, and not for open pole conditions (one- or three-pole), or for faults on the protected line (weak infeed), or for faults on adjacent networks. A time delay may therefore be necessary before establishment of supply failure. This time delay shall be no longer than that required to ascertain a supply failure condition. Subsequent current detection within the time window following detection of the supply failure condition, but before establishment of supply failure, shall release the blocking of the voltage dependent measuring functions, allowing their operation. Establishment of supply failure shall occur if the detected supply failure condition persists for the duration of the time delay. Once established, supply failure shall be sealed-in, and blocking of the voltage dependent measuring functions shall not be released, until the supply is restored. Reset of the supply failure shall occur automatically with restoration of the VT supply.

On blocking of the distance function following the detection of a supply failure condition, or establishment of supply failure, it is not a requirement that the relay shall switch to an alternate function.

The VT fuse failure alarm (local and remote) shall be delayed as to prevent unnecessary alarming due to unequal operation of the circuit-breaker poles.

4.3.14 Buszone trip input

The main and back-up protection devices shall provide for a buszone trip input function derived from the buszone protection scheme (connected zone). The interface between the line protection scheme and the busbar protection scheme (own zone) shall be a hardwire interface.

The zone buszone trip input shall:

- Trip the circuit-breaker trip coils directly. This tripping shall be independent on the TNS selection;
- Initiate the direct transfer trip send function (user selectable);
- Trip the circuit-breaker three pole via the main protection IED (PTRC1 - with trip seal-in in accordance with the trip seal-in logic) and block auto-reclosing. The outputs from PTRC1 shall trip the circuit-breaker and initiate the circuit-breaker's breaker fail function;
- Buszone trip signal shall be connected to the IED internal disturbance recorder function (RBDR); and,
- Buszone tripping shall be reported to the gateway and station HMI.

4.3.15 Circuit-breaker status

The circuit-breaker status is required within the main protection device. The circuit-breaker statuses (52a and 52b contacts) information shall be received via GOOSE data from the specific circuit-breaker PIU.

4.3.16 Line isolator status

The line isolator status is required within the main protection device. The line isolator statuses (M and N contacts) information shall be received via GOOSE data from the specific circuit-breaker PIU. The following line isolator status GOOSE data shall be subscribed to:

- Line isolator normally open (M) auxiliary contact;

- Line isolator normally closed (N) auxiliary contact;

The required line isolator auxiliary contact information is required to fulfil the following functions, implemented within the line protection device:

- Transfer (where applicable);
- Line isolator status (open and closed) shall be connected to the IED internal disturbance recorder function (RBDR); and,
- Line isolator status (open and closed) shall be reported to the gateway and station HMI.

4.3.17 Transfer isolator status

The transfer isolator status (where applicable) is required within the main protection device. The transfer isolator statuses (M and N contacts) information shall be received via GOOSE data from the specific circuit-breaker PIU. The following transfer isolator status GOOSE data shall be subscribed to:

- Transfer isolator normally open (M) auxiliary contact;
- Transfer isolator normally closed (N) auxiliary contact;

The required transfer isolator auxiliary contact information is required to fulfil the following functions, implemented within the line protection device:

- Transfer functionality (where applicable);
- Transfer isolator status (open and closed) shall be connected to the IED internal disturbance recorder function (RBDR); and,
- Transfer isolator status (open and closed) shall be reported to the gateway and station HMI.

4.3.18 Busbar isolator status

The busbar isolator statuses (busbar 1 & 2 and HV & MV) is required within the main protection device. The busbar isolator statuses (M and N contacts) information shall be received via GOOSE data from the specific circuit-breaker PIU. The following busbar isolator status GOOSE data shall be subscribed to:

- Busbar isolator normally open (M) auxiliary contact;
- Busbar isolator normally closed (N) auxiliary contact;

The required busbar isolator auxiliary contact information is required to fulfil the following functions, implemented within the line protection device:

- Busbar voltage selection (where applicable);
- Busbar isolator statuses (open and closed) shall be connected to the IED internal disturbance recorder function (RBDR); and,
- Busbar isolator statuses (open and closed) shall be reported to the gateway and station HMI.

4.3.19 Circuit-breaker trip counting

The main protection module shall be fitted with a counter per circuit-breaker (per phase) that may be user-configured either as a trip counter (i.e. counting circuit-breaker operations) or a fault counter (i.e. counting protection trips and supervised with opening of the circuit-breaker). The trip/fault counter shall be integrated into the IED and shall be accessible by no more than two keystrokes on the IED front panel. The integrated trip/fault counter shall be provided in non-volatile memory and shall include the facility to pre-load any number of operations (e.g. so as to continue from a previous counter value). Trip/fault counting shall be inhibited when the TNS is not selected the NORMAL position (or when the HV feeder is on transfer). It shall be ensured that only one count (per phase) takes place for a single trip event. The counter value shall be reported remotely by the supervisory system.

4.4 Control Functions (Group C)

Isolating switches/functions shall be provided for each scheme to isolate certain protection functions as required. Typical functions that must be isolated are SEF, ARC, AVR, over current protection, and teleprotection. Where provided using an IED's internal latching logic, the statuses of the protection functions ("ON" or "OFF") shall be stored in non-volatile memory such that they are maintained at the previous position upon power-up of an IED following a loss of auxiliary supply. The status of the protection functions shall be maintained using mechanically latching, electrical reset auxiliary relays if they have to be provided outside of the protection IED/s.

Refer to each detailed functional standard for the detailed control functional and interface requirements.

4.4.1 Alarm Handling – CALH

The CAHL logical node shall be used for the creation of group alarms and group events. This logical node shall be used to calculate new data out of individual data from different logical nodes.

4.4.2 Interlocking – CILO

All interlocking rules referring to a bay are included in this logical node. Releases or blockings of requested commands are issued. In the case of status changes affecting interlocking, blocking commands are issued. The bay interlocking is required to safeguard all affected equipment as well as maintenance personnel against the incorrect operation of primary plant.

The following general rules are applied:

- No earth may be applied when the plant on either side has not been isolated;
- No isolator may be closed when an earth is applied on either side and the circuit-breaker is open;
- No isolator may be opened when the circuit-breaker is closed;
- All position indicators for the primary plant shall be handled by a double point indication;
- All interlocking circuits shall be fail safe. In case of interlocking supply loss or broken conductor(s), no interlocking release shall be issued; and,
- Interlocking shall be applied at the lowest level to ensure that bypassing of the required interlocking cannot be performed from the clients.

The interlocking rules per primary plant item shall be finalised and implemented during the product development phase.

4.4.3 Switch Controller – CSWI

The switch control CSWI logical node handles all switchgear operations from the operators and from related automatics. It checks the authorization of the commands. It supervises the command execution and gives an alarm in case of an improper ending of the command. It asks for releases from interlocking, synchrocheck and auto-reclosure.

The switch control CSWI logical nodes shall be located within the main protection device and shall be controlled by the relevant supervisory isolating switch.

4.4.4 Supervisory Isolating Switch

The Supervisory Isolating Switch (SIS) provides for the selection between local (OFF selected) and remote (ON selected) controls. The SIS selection shall preferably be provided as an integrated function of the single IED on a protection module, activated by on-board push buttons. It may alternatively be implemented via a two position rotary switch located on the front of the panel. The enabling and disable of the relevant functions, as per the table below, shall be done within the IED. The OFF selection shall be remotely reported (station HMI and control centre). The circuit-breaker emergency trip shall be independent on the SIS selection.

The SIS shall isolate supervisory control of the circuit-breaker, SEF, ARC, and AVR functions.

Description	Selection between local control and remote.
OFF	Enable local control from IED HMI or front panel controls: • Auto-reclose ON/OFF and auto-reclose mode selections; • Transfer permission key selections; and, • Tap changer raise and lower commands. Disable remote controls from the station HMI and control centre: • Open and close commands to all the isolators and the circuit-breaker; • Auto-reclose ON/OFF and auto-reclose mode selections; • Transfer permission key selections: and, • Tap changer raise and lower commands.
ON	Enable remote controls from the station HMI and control centre: • Open and close commands to all the isolators and the circuit-breaker; • Auto-reclose ON/OFF and auto-reclose mode selections; • Transfer permission key selections: and, • Tap changer raise and lower commands. Disable local control from IED HMI or front panel controls: • Auto-reclose ON/OFF and auto-reclose mode selections; • Transfer permission key selections; and, • Tap changer raise and lower commands.

4.4.5 Test Normal Switch

The Test Normal Switch (TNS) provides isolation of the trip outputs to the circuit-breaker(s) and/or the circuit-circuit-breaker fail inputs or output contacts for test purposes and permits or not auto-reclose initiation where applicable.

The TNS shall always be provided as a physical rotary switch, external to any IED.

Where the TNS only isolates the circuit-breaker fail trip output, it shall be termed the circuit-breaker Fail Isolate (BFI) switch. A BFI switch has two positions labelled ”NORMAL” and “BFI”.

A TNS which isolates both breaker fail and trip outputs shall have three positions labelled “NORMAL”, “BFI” and “TEST”. The functionality of this switch is that “BFI” physically interrupts the breaker fail output from the module, as well as any associated GOOSE messages. The “TEST” position additionally blocks physical and GOOSE circuit-breaker trips, auto reclose initiation and trip counting.

The TNS provided on busbar arc detection and bus zone schemes shall have three positions, labelled "Normal", "Circuit-breaker Fail Isolate" (BFI) and "Bus Zone Isolate" (BZI). The TNS is termed the Bus Zone Isolate (BZI) switch. The BFI position shall isolate the circuit-breaker fail bus strip input contacts from being actioned by the scheme and the BZI position shall isolate the trip outputs, the circuit-breaker fail circuitry being restored to normal. It shall be acceptable for the BFI and BZI functions to be provided on two separate two-position switches.

On certain line differential schemes the communications channel is an inherent feature of the scheme and cannot be interrupted because the channel must be in-service to test the scheme. On such schemes, a facility shall be provided whereby a signal is sent to the remote IED to inhibit it from tripping when the TNS on the local panel is switched to the “TEST” position.

The “BFI”, “TEST” and/or “BZI” position selection shall be remotely reported to the station HMI and remotely via the gateway.

Each main/back-up protection system/module shall have its own independent Test Normal Switch.

The “NORMAL” position shall be on the left, and the “TEST” position on the right when viewed from the front of the switch. The TNS shall not isolate teleprotection communications between the local end and the remote end; this function is catered for by the TPIS. The TNS shall raise the “Protection system not healthy” alarm when in any position other than “NORMAL”.

4.4.6 Lamp check

The lamp check pushbutton shall be provided for to verify the health of the panel/module lamps, this includes both D.C. and A.C. powered lamps. Where possible, this function shall also cause all IEDs’ integrated indications to be illuminated. The lamp check function may be implemented via a programmable push button on the IED.

4.5 Generic Functions (Group G)

4.5.1 Generic Process IO – GGIO

Outputs not covered by the defined logical nodes are required for MMS and GOOSE data. The Generic Logical Node GGIO is used to represent a generic primary or derived data within the IEDs.

4.5.2 Generic Security Application – GSAL

Logical Node GSAL shall be used to monitor security authorization violations.

4.6 Interfacing and Archiving Functions (Group I)

The following Logical Node and Data Attributes shall be available to the Eskom System Configurator for modelling Interfacing and Archiving functions relative to the functions and/or remote process I/O provided by the IED concerned.

4.6.1 Human Machine Interface – IHMI

This Logical Node shall be available as an operator interface to execute controls, display measurement quantities and to display visual alarms at bay level as required by the Eskom System Configurator.

4.7 Measurements Functions (Group M)

The main and back-up protection IED HMIs shall be used for local measurements display without human intervention to view the values. Measurements quantities shall be provided as per the requirements of the detailed functional standards.

Remote analogue indications shall be provided via Ethernet communication (IEC61850) from the IEDs.

The measurements quantities shall be derived from protection class CTs and dual protection/measurement rated VTs.

The measurement for each quantity shall be measured separately and continuously. Integral dead-band reporting shall preferably be used for local and remote reporting (Station HMI and control centres). The measured value is reported if the time integral of all changes exceeds a pre-set limit. A minimum settable value shall be possible for all the measured quantities, typical 5% for currents, active power, reactive power and apparent power, and 3% for voltage and frequency. Conventional dead-band reporting with settable thresholds is also acceptable.

4.7.1 Measurements – MMXU

The IED HMI shall have the capability to display and remote reporting of the following measurements quantities:

- Three Phase Active Power (P);
- Three Phase Reactive Power (Q);
- Power factor (PF);
- Frequency (F);
- Phase-phase voltages (R-W, W-B and B-R); and,
- Phase currents (R-N, W-N and B-N).

The sign convention for real and reactive power flows shall be such that flows away from the busbar have a positive sign, and flows towards the busbar have a negative sign. As an example, an inductive load supplied from a line connected to a source-side busbar shall be measured by the line protection IED as +P +JQ.

The measurement accuracy class shall be Class 0.5 for currents and voltages, Class 1 for power measurements, 10mHz for frequency measurement and one degree for angles.

The IED HMI shall have the capability to display and remote reporting of the following synchronism check measurements quantities (when applicable):

- Voltage difference (ΔV);
- Frequency difference (ΔF); and,
- Angular difference (ΔΦ).

All measurement quantities shall be reported locally and remotely scaled in primary units.

4.8 Sensing and Monitoring Functions (Group S)

The following Logical Nodes and Data Attributes shall be available to the Eskom System Configurator for modeling Sensors and Monitoring functions relative to the functions and/or remote process I/O provided by the IED concerned.

- Multiple instances of the same Logical Node class shall be possible; and,
- Multiple instances of data within the Logical Node shall be possible.

4.8.1 Insulation Medium Supervision (Gas) – SIMG

4.8.1.1 Circuit-breaker SF_6 gas monitoring

SIMG logical nodes shall be located within the circuit-breaker PIUs to assimilate circuit-breaker SF_6 gas low alarms for communication to the main IED via GOOSE. A separate low gas alarm shall be hardwired to back-up IEDs. A single alarm contact may be provided for all three phases of single phase circuit-breakers.

The circuit-breaker SF_6 gas insulation medium monitoring device(s) low signals (per circuit-breaker) shall be:

- Reported locally at the IED HMI;
- Reported locally via the “Circuit-Breaker Not Healthy Alarm”;
- Reported remotely via the gateway; and,

Reported to the station HMI.Current transformer SF_6 gas monitoring

The CT SF_6 gas insulation medium monitoring device(s) low and critical signals (per CT) SIMG logical nodes shall be located within the circuit-breaker PIUs and be send via GOOSE to the main protection IED that houses the circuit-breaker closing functions.

The CT SF_6 gas insulation medium monitoring device(s) low and critical signals (per CT) shall:

- Reported locally at the IED HMI;
- Reported locally to the back-up protection (closing) system unhealthy indication;
- Reported remotely via the gateway; and,
- Reported to the station HMI.

4.8.1.2 Current transformer SF_6 gas monitoring

An additional SIMG logical node instance shall be available in the circuit-breaker PIUs so as to assimilate current transformer SF6 gas low alarms (where applicable). Alarms from the three phases shall be paralleled.

4.8.2 Trip circuit supervision

Trip circuit supervision shall continuously monitor each phase of the trip circuit of the circuit-breaker. The trip circuit supervision shall be integrated within the protection IED and shall monitor the circuit-breaker in the closed and open positions. Trip circuit supervision shall be alarmed, local and remote. The trip circuit supervision shall not adversely affect the dependability and security of the trip circuit.

The quiescent DC current through each of the circuit-breaker's tripping coils introduced by Trip Circuit Supervision may not exceed 10mA at the maximum DC supply voltage.

The design shall be such as not to issue Trip Circuit Supervision alarms during conditions of long duration or latched trip commands to the circuit-breaker (which short out the Trip Circuit Supervision binary inputs).

Trip circuit supervision shall:

- Monitor each phase of the circuit-breaker trip circuit independently;
- Block closing of the circuit-breaker if the trip circuit has failed.
- Reported locally at the main protection and back-up protection IED's HMIs;
- Reported locally to the main protection or back-up protection system unhealthy indications; and,
- Reported remotely via the gateway; and,
- Reported to the station HMI.

4.8.3 Circuit-breaker charging fail

A circuit-breaker spring charging failed timer (delay-on-pick-up) shall be provided to raise an alarm in the event of a failure of the circuit-breaker charging mechanism and shall be integrated within each IED with close control capability (manual/automatic).

The circuit-breaker charging fail:

- Shall be connected to the IED internal disturbance recorder function (RBDR);
- Shall be displayed on the IED HMI; and,
- Shall be reported to the gateway and station HMI.

4.8.4 Circuit breaker not healthy

Any condition implying that the circuit-breaker is not capable of performing its intended function shall herald a "circuit-breaker not healthy" alarm.

The following features are considered to be the minimum requirements to indicate a "circuit-breaker not healthy" condition:

1) "SF6 gas low "for SF6 circuit-breakers;

2) "Air pressure low" for air blast circuit-breakers;
3) Spring Charge Fail
4) Scheme Shell spring rewind MCB auxiliary contact indicating the tripped state;
5) Circuit-breaker mechanism box common alarm: local/remote switch or spring rewind MCB tripped.

Note that mechanism box heater fail alarms are not to be included in the "Circuit-breaker not healthy" alarm.

4.8.5 IEC61850 communications failure

IEC61850 communications failure that affects the GOOSE signals shall be monitored by the main protection device and:

- Reported locally at the protection IED HMI;
- Reported locally to the protection unhealthy indication;
- Shall select three pole tripping (TNS 'Normal' and 'Test 1');
- Shall not cause an unwanted or overtrip; and,
- Reported remotely and to the station HMI.

4.8.6 Protection not healthy

Any condition implying that the protection system is not capable of performing its intended function shall raise the "Protection not healthy' alarm.

The following features are considered to be the minimum requirements to indicate a "Protection not healthy" condition:

1) Protection fail (see below)
2) TPIS selected to "OFF";
3) TNS not selected to "Normal";
4) VT supply fail;
5) VT supply MCB tripped; and
6) trip circuit supervision indicating a failed tripping circuit (any circuit).

The PNH function shall be indicated locally via an Amber coloured lamp connected to the scheme's 230V A.C. circuit.

The PNH indication lamp shall be positioned at the top left-hand corner of the scheme's "control area" (i.e. the location of all switches, lamps etc.).

4.8.7 Protection fail

Protection fail is an alarm which indicates a protective IED failure either due to a hardware failure or due loss or failure of its auxiliary DC supply.

The protection fail alarm shall be provided via a change-over "watchdog" contact on the IED. The protection fail alarm will be hardwired to an adjacent protection module for reporting to the substation HMI and gateway.

The protection fail alarm shall be indicated on the local panel via the Protection Not Healthy Alarm.

The protection fail alarm indicates unavailability of a protective device which could not be reported via IEC 61850 communication to the substation HMI and gateway.

The protection IED's DC power supply shall be wired from the last wire loop in the module such that the relay will be disconnected for any break in connection of either supply rail.

4.9 Switchgear Functions (Group X)

The following Logical Nodes and Data Attributes shall be available to the Eskom System Configurator for modeling Switchgear functions relative to the functions and/or remote process I/O provided by the IED concerned.

- Multiple instances of the same Logical Node class shall be possible; and,
- Multiple instances of data within the Logical Node shall be possible.

4.9.1 Circuit-Breaker – XCBR

The logical node “circuit-breaker” covers the circuit breakers, i.e. switches able to interrupt short circuits. An AC circuit-breaker is a device that is used to close and interrupt an AC power circuit under normal conditions or to interrupt this circuit under fault or emergency conditions (IEEE C37.2-1996). If there is a single-phase breaker, this logical node has an instance per phase. These three instances may be allocated to three physical devices mounted in the switchgear.

The switch control logical node handles all switchgear operations from the operators and from related automatics. It checks the authorization of the commands. It supervises the command execution and gives an alarm in case of an improper ending of the command. It asks for releases from interlocking, synchrocheck, auto-reclosure, etc. if applicable.

The main protection device shall subscribe to the following XCBR data, the XCBR logical nodes shall be within the circuit-breaker PIUs and MV circuit-breaker PIUs:

4.9.2 Circuit Switch – XSWI

The LN “switch” covers the switching devices not able to switch short circuits. Line switch is a switch used as a disconnecting, load-interrupter, or isolating switch on an AC or DC power circuit (IEEE C37.2-1996). If there is a single-phase switch, this LN has an instance per phase. These three instances may be allocated to three physical devices mounted in the switchgear.

The switch control logical node handles all switchgear operations from the operators and from related automatics. It checks the authorization of the commands. It supervises the command execution and gives an alarm in case of an improper ending of the command. It asks for releases from interlocking, etc. if applicable.

The main protection device shall subscribe to the following XSWI data, the XSWI logical node shall be within the breaker PIUs and MV breaker PIUs:

4.10 Transformers Functions (Group Y)

The following Logical Nodes and Data Attributes shall be available to the Eskom System Configurator for modeling Power Transformer functions relative to the functions and/or process I/O provided by the IED concerned.

- Multiple instances of the same Logical Node class shall be possible; and,
- Multiple instances of data within the Logical Node shall be possible.

4.11 Mechanical and non-electric primary equipment (Group K)

This group of logical nodes does represent various devices (mechanical and non-electric primary equipment) that can be supervised, controlled or operated but that are not primarily of electrical nature. This group includes devices like tanks, valves, fans etc.

4.11.1 Heater, cubicle heater – KHTR

This logical node represents a heater, cubicle heater or any other heater that can be controlled. The heater information is not used within the protection device and shall be sent from the relevant circuit-breaker PIU via the main protection device to the gateway for remote and station HMI reporting.

The following primary plant heater data shall be reported:

5. Tests

The applicable type and routine tests required by Eskom shall constitute the type and routine tests acceptable on all devices, relays and the complete protection scheme/module. The successful tenderer(s) are responsible for the implementation of the required tests and the production of the necessary report documentation. The successful tenderer(s) shall compile a detailed test plan, and shall be agreed between the supplier and the Eskom representative prior to the commencement of any of the required tests. It shall be noted that an Eskom representative shall witness all of the tests.

5.1 Prototype tests

The purchaser's engineers will carry out type and functional tests once the prototype scheme is completed.

5.1.1 Environmental testing

Type tests shall be carried out by the successful tenderers (possibly with the involvement of a third party test organisation) and shall be witnessed by Eskom's representative. These tests may be destructive in nature and as such, any product or device, which has undergone any of these tests, shall not be used in any production scheme.

Unless specified to the contrary, type testing shall consist of performing the required tests on at least one sample of the design. Tests shall be performed on equipment which has not been the subject of previous type testing or, at Eskom's discretion on equipment which has been the subject of any modification which could affect the performance of the equipment.

Normal performance tests shall be performed before any type tests for comparison to determine damage.

Subject to Eskom's approval, evidence of equivalent tests performed on substantially similar equipment may be accepted provided that the test results are available in the form of a fully detailed certified test report.

When relevant, a check shall be made before the commencement of type testing, to ascertain that the equipment as supplied, inspected and adjusted from the production line, is correctly set up. Any differences found between the equipment as supplied and as required by its standard shall be recorded. The measurements taken to establish this shall also be recorded.

If during testing any further adjustments are required, such adjustment shall only be made with Eskom's approval and repetition of some of the previous tests may be required.

The supplier shall submit a detailed schedule of the proposed tests for approval before the commencement of the tests. This schedule shall be complete and include the following information:

- Date and place of test;
    - Details of the equipment to be tested, such as standard, type and serial numbers, contract reference and all relevant drawings and documentation;
    - A list of all test equipment which may be used, and performance standards of each test equipment listed, clearly showing that the stability, resolution, accuracy range, capacity, etc. ratings of the chosen equipment are more than adequate for the test performance requirement. When such information is not known, for instance when test equipment has to be specially manufactured, it shall be demonstrated that such equipment performs in the way intended so that its use is acceptable to those witnessing the tests;
- Details of usage and test equipment and the test methods, together with the connection diagrams and other related data;
- Description of measurements and observations to be made together with their intended number, frequency, sequence and time duration for each test; and,
- Documentation to be used for the recording of all results of testing and also the format of the certifying test documents.

If during the tests any failure occurs, any adjustments are made, or the equipment design is changed, Eskom shall be informed and may require the previous tests to be carried out again.

Where equipment is designed to be connected to other equipment at remote sites where different environmental conditions such as temperature and supply voltage can prevail, tests may be required to demonstrate that these differences do not adversely affect the compatibility of the equipment.

5.1.1.1 Insulation resistance (across isolating barrier) test

When a barrier is used to provide isolation from external circuits, its insulation resistance shall be measured. If the barrier is required to withstand high voltage stresses, then it shall be stressed at the specified voltage to demonstrate its withstand capability and a further insulation resistance test shall be made to ascertain that it has not been significantly degraded as a result of the stress being applied. The tests shall be performed in accordance with IEC 60255-5. Test details are given below.

The insulation of all circuits which include contacts of switches, relays or contactors for isolation functions shall be tested for insulation resistance. This shall be not less than 20 MΩ when measured at d.c. 500 V.

For circuits intended for connection to a.c. 100 V or d.c. 100 V and above, 2 kV r.m.s. shall be applied for 1 min and this shall be followed by a further insulation resistance test.

For circuits intended to provide isolation against large differences in earth potential as in class IV electrical environment, the barrier shall, after the initial resistance measurement, be stressed to the design voltage and this shall be followed by a further insulation resistance test.

NOTE:

a) Resistance measured at a potential of d.c. 500 V applied across the isolating barrier.
   - R = R1 > 20 MΩ

b) For switches, relays and contactors 500 V is to be applied between
   - The opposite ends of each circuit with contacts in open position.
   - Both ends of each circuit to earth with contacts in closed position.

c) Circuits intended for connection to 100 V (a.c. or d.c). and above to be stressed to a.c. 2 kV for 1 min after initial resistance measurements. Stress to be applied between:
   - The individual circuits of this type
   - Each circuit of this type and all other circuits including earth. These other circuits can be strapped together electrically for the purpose of this test.

d) Final insulation resistance shall be such that
   - R = R2 > 20 MΩ; or,
   - R2/R1 > 0,7.

e) Barriers to provide protection against large rises in earth potentials to be stressed across barrier at design voltage for 1 min after initial isolation resistance measurement. Final insulation resistance test as above.

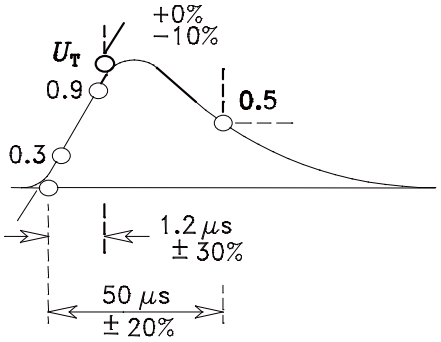
5.1.1.2 Electrical impulse test 1, 2/50 μs

This test is to demonstrate that the equipment has been correctly designed to withstand, without damage, the electrical stresses to which it might be subjected in practice.

The test to be applied is based upon IEC 60255-5. The impulse wave form is an aperiodic transient voltage without appreciable oscillations having a 1,2 μs rise time and an exponential decay to half amplitude in 50 μs.

When a large number of identical interface circuits are used, this test may be restricted to a representative sample, the proportion being to Eskom's approval.

A suggested circuit for the production and application of the test waveform is given in IEC 60255-5.



NOTE:

a) Source energy 1/2 joule for 1,0 kV to 5,0 kV.

b) Source energy 1/8 joule for 0,5 kV.

c) Source energy 1/12 joule for 0,25 kV.

d) Source impedance 500 Ω.

No less than 3 positive and 3 negative pulse each applied at intervals of not less than 5 s.

Application Method	**Test voltage 'V' (kV)**		
	Class II	**Class III**	**Class IV**
a)	-	1,0	5,0
b)	-	1,0	5,0
c)	0,25	0,5	1,0
d)	1,0	1,0	1,0

NOTE:

Method of application - Test voltage 'V' shall be applied between:

a) Each terminal and the safety earth (common mode).

NOTE: Where practicable all terminals may be connected together.

b) Individual terminals of all independent circuits (including power supplies). Where practicable the terminals of each independent circuit may be connected together (common mode between separate circuits).

c) Signal terminals of the same circuit (series mode).

d) Power supply terminals of battery powered equipment (external supply) (series mode).

NOTE: A terminal is defined as any connection to or from the equipment including those to power supplies.

5.1.2 Functional testing

The purchaser's engineers will carry out functional tests to verify the scheme wiring, relay configurations and overall scheme functionality. These tests shall be performed on the deemed prototype scheme, devices and shall include, but not be limited to, the following:

- Secondary injection tests to prove correct functional operation and to check the functional accuracy and calibration of the units; and,
- Type testing of scheme and devices.

Any specific test which shall prove, to the purchaser's satisfaction, the required performance aspects of the protection scheme and devices which may be impacted by minor equipment modifications, refinements or development work.

The supplier(s) shall develop and verify the required test routine prior completion of the proto-type testing. The test routine shall be for the test equipment being utilised by Eskom.

5.1.2.1 Initial visual inspection

The initial visual inspection shall be performed to ensure that the equipment is of sound construction and, so far as can be ascertained, meets the requirements of this standard, schedule A of the enquiry document and the offered equipment within the tender submission documentation.

5.1.2.2 Initial performance test

The initial performance test shall be carried out on the completed proto-type scheme and prior to any type testing and shall consist of a comprehensive series of measurements of the characteristics of the equipment to demonstrate that its performance is in accordance with its functional requirements, including the detailed requirements of schedule A of the enquiry document and with this standard. This test shall normally be performed at an ambient temperature of 20 °C ± 5 °C while supplied at 120% of the normal DC voltage.

5.1.2.3 Final performance test

The final performance test shall be carried out after completion of type testing and shall consist of a comprehensive series of measurements and observations of the characteristics and performance of the equipment to demonstrate that no unacceptable deterioration has occurred as a result of previous tests. The test shall normally be performed at an ambient temperature of 20 °C ± 5 °C. The equipment shall be tested while supplied at normal supply voltages and subsequently with worst case combinations of supply voltages (80% and 120% nominal DC voltage).

5.1.2.4 Final visual inspection

The final visual inspection shall be performed to check whether any damage exists or deterioration has occurred as a result of any of the previous tests or activities. Eskom will determine the action which is necessary as a result of any findings of the inspection, which shall be made known as soon as possible.

5.2 Testing of production schemes

5.2.1 Routine testing

The successful tenderers shall, in conjunction with the purchaser, compile the required routine tests. These tests constitute the minimum routine tests acceptable on all devices, relays and the complete protection scheme. The successful tenderers are responsible for the production of the routine test report. The successful tenderers shall compile a detailed functional test report template for approval by Eskom's representative. These tests shall be done on each production unit and produced during QA inspection. The required tests can be modified by the Eskom representative, if deemed necessary; to ensure that only the required site tests are outstanding prior delivery to site.

Routine testing shall comprise a series of tests to confirm that individual production equipment has been correctly manufactured and set up. The quality assurance shall be subject to Eskom's approval and Eskom reserves the right to witness any or all of the tests. An inspection of manufacturing processes such as plating, encapsulation, welding, etc., and separate checks and proof of adequate quality control may be required.

The details of routine testing shall be agreed between the supplier and Eskom prior to the commencement of manufacture of the equipment concerned. If the production equipment differs in any respect from the equipment upon which the type testing was performed, Eskom shall be informed and may require a repetition of those tests which might have been made invalid by the changes in the design of the equipment.

The successful tenderers shall, in conjunction with the purchaser, compile a test certificate, indicating clearly the successful completion of all the required routine factory tests. As part of the QA requirements, a copy of the completed certificate shall accompany each production unit.

5.2.1.1 Visual inspection

The visual inspection shall be performed to ensure that equipment complies with the requirements of this standard and the approved bill of material (equipment type and versions), and the equipment is properly installed.

Eskom will determine the action necessary as a result of any adverse finding of the inspection, which shall be made known as soon as possible.

5.2.1.2 Performance test

This test shall be performed to check that the equipment is capable of performing all its specified functions and is still within calibration. The calculated site specific settings shall be applied and tested (with test routine).

5.2.2 Site testing

Where site testing related to interfacing is required, it shall be performed unless otherwise approved, with the equipment correctly installed in its final location.

5.2.2.1 Visual inspection

Inspections will be performed by Eskom to establish that the equipment has been delivered to site and installed correctly and without damage. Such inspections shall be called for by the installation contractor before another contractor is allowed access to the equipment. This practice shall be enforced whenever two or more contractors require access to equipment to carry out their contract work.

5.2.2.2 Performance test

The performance test shall be done with the equipment fully installed and supplied from the specified sources and correctly interfaced with all its associated plant and equipment. It shall be established that all associated plant and equipment has undergone separate tests before conducting the final system tests.

The following sequence is required as it ensures the availability of specific functions at appropriate times:

- Deliver, erect and install scheme at substation;
- Cable contractor installs and terminates all cabling as per application drawings. For refurbishment projects the cable termination's must be coordinated with outage of existing scheme;
- Verify all scheme and external cable wiring as per application drawings and energise external power supplies to scheme;
- Verify and commission all interfaces to the primary equipment and to other scheme/modules, this include GOOSE data verification.
- Complete commissioning tests for protection equipment, apply and verify all subsequent setting changes. Protection personnel that are trained on the applicable equipment items must conduct these tests;
- Verify and commission all interfaces between the various disciplines. These tests will be conducted jointly by protection, telecommunications, measurements and control personnel that are trained on the applicable equipment;
- Verify and commission with higher level devices. Personnel that are trained on the SCADA equipment must conduct these tests. All measurement quantities, plant status, scheme/module selections, alarms and controls shall be tested to all clients;
- End-end verification of binary and analogue quantities; and,

- On energising of the relevant bay equipment, final commissioning and on-load checks must be conducted by the various responsible personnel.

The detailed testing requirements will be within the detailed functional standards

5.2.3 Test template

The supplier(s) shall develop and verify the required test template(s) prior completion of the proto-type testing. The test routine shall be for the test equipment being utilised by Eskom.

The test routine shall be designed for use by the commissioning and maintenance staff with minimal experience.

The tenderer shall ensure that regular and suitable training and transfer of knowledge is available for the usage of this test template, on the functioning of each of the IED functions and on how such functions need to be tested to yield the desired response.

The test template shall operate and be made available for test equipment hardware and software platforms commonly used within Eskom Distribution.

The test template shall make provision for a full 'commissioning' test (where all enabled functions are tested thoroughly) as well as a scaled down 'routine maintenance' test, where the user can manually select which functions he would like to test.

The test template shall provide for a dual end-end test as well as a local end test (i.e. testing the scheme on its own). The dual end-end test for a line differential scheme requires a GPS synchronisation between the two remote end test sets. The local end test of a line differential scheme requires 'dummy' IEDs connected 'back to back' at the same location, with all IEDs injected from the same test equipment.

The IED settings shall be imported automatically from the settings database and/or settings template into the test template without any user interaction. Note that the settings shall not be downloaded from the IED and then be dumped into the test template. Also no manual typing in of settings or any other form of manual interference is permissible while the settings are imported into the test template.

The test template shall be interactive and prompt the user with specific and complete instructions (e.g. 'Connect binary input 1 to relay panel terminal X4.1') whenever any action needs to be taken by the user, any wiring changes need to be made to the test set up. The test template shall be non-intrusive, no settings changes or disabling/enabling of functions shall be permitted. The test execution shall be paused for any such user interaction, and the user must acknowledge having completed such instruction (e.g. click on 'OK' or 'Continue') before the test template shall continue execution.

If a function is disabled (not-used) in the IED via settings, the test template shall automatically disable all the tests associated with such a function.

When printing a test report, only the enabled test modules shall be printed.

If no automatic feedback can be obtained from the IED (e.g. if no pick-up contact is available / if only an indication on the HMI is given or a LED lights up), the user shall be prompted with a specific instruction for such manual feedback (e.g. 'Read XYZ on HMI and enter the value in this dialogue', before clicking on 'Continue').

All IEDs shall be tested by the use of IEC 61850 GOOSE messages. The test template shall make use of a 'TEST' GOOSE to 'trigger' for a specific test, i.e. the feedback from the IED to stop injection. The TEST GOOSE shall contain the pick-up (Instantaneous and delayed) of all functions within the IED. The benefit will be must faster testing by using instantaneous pick-up GOOSE messages as well as un-ambiguous results as one triggers on the GOOSE message issued by a specific logical node.

The purpose of testing is, that for each IED function the settings associated with this function needs to be 'checked' with a test at 10% below and 10% above the setting, i.e. to confirm that the settings have been entered and downloaded correctly to the IED. A test is assessed as passed if these two tests result in a definite pick-up for inside the zone and no pick-up for outside the zone, and failed if any of these two tests do not result in the expected response from the IED. Please note that no search test to find the actual level of pick-up (e.g. zone reaches for an impedance element) as well as no type tests (e.g. 'plotting' the whole impedance characteristic of an impedance element) should be conducted.

In addition to checking the pick-up setting, the trip time for each IED function shall be measured, compared to the nominal timer setting of this function and assessed for pass or fail.

The test report shall provide a summary of the number of test modules, number of test modules tested, number of passed tests, number of failed tests, number of tests with errors (e.g. no connection to test set / manual assessment).

The test template shall include an application oriented power system test, i.e. to ensure that the IED operates for all types of in zone faults and stabilized for all types out of zone faults. For example this kind of test would simulate a transmission line with the appropriate source impedance and ensures that the IED pick-up and trips instantaneously for all types of fault on the primary transmission line and stabilizes (or trips in back-up time) for faults beyond the primary transmission line. Purpose of this kind of test is to not only verify the settings application process, but also the settings calculation process.

6. Tender requirements

6.1 Tender completion requirements

The tenderers are to take cognisance of the following:

- An incomplete tender submission will be deemed as non-compliant.
- An alternative offer shall only be considered if the main offer is compliant.
- Technical schedule A: The Purchaser's Requirements.
- Technical schedule B: Guarantees and Technical Particulars (to be completed by tenderers).
- The tenderers shall not change the content of this document.
- The tenderers shall clearly, for each clause that requires a statement of compliance in the A/B schedules, respond by either stating "Comply" or "Do not Comply" and state deviation details.
- If a clause in the A/B schedule requires a statement of compliance and additional information, the tenderers shall state clearly "Comply" and shall provide detail information or state "Do not Comply" and shall provide detail information.
- If a clause in the A/B schedule requires information only, the tenderers shall provide the necessary information.
- All additional options shall be detailed.

6.2 Tender evaluation criteria

The tender evaluation will take the form of a:

- Desktop review of submitted documentation (A/B schedules); and,
- Hands-on demonstration of the offered products by the vendors. The hands-on demonstration will include, but not be limited to:
    - All IEDs offered are successfully demonstrated to meet Eskom's minimum IEC 61850 function and interoperability requirements (as per the Eskom standard; and,

- The IED interface software user friendly and operates on Eskom-standard laptop computers (Windows XP, Windows 7 and Windows 8), and all IEDs are demonstrated to be accessible via such a computers/software to upload, download and compare settings and configuration files and to retrieve event records and waveform recordings (comtrade export capability).

6.3 Product development process

The project shall comprise two phases; an engineering/development phase and a production phase. The purchaser will sign a development contracts for the engineering/development phase with the successful vendors. The engineering/development phase ends with the awarding of production contracts for the required scheme solutions and spare items. Vendors who have been awarded development contracts shall be accountable for producing deliverables according to the project schedule.

The product development phase is the detailed engineering phase in which:

- Proto-type scheme design diagrams, based on Eskom's design standards and formats, is finalised;
- Proto-type scheme is developed and built;
  - The prototype scheme is tested for compliance against this standard document;
- Type testing requirements verified and done (if so required);
- IED configurations finalised and verified;
- IED and relay Eskom default settings and settings templates finalised;
- IEC61850 configuration finalised and verified;
- Scheme permutations and complete list of scheme spares including pricing finalised;
- Specialised training; and,
- The technical and SHEQ documentation is finalised and approved by the purchaser.

All relevant information regarding the configuration/marshalling of the protection devices shall be supplied to the purchaser one month after contract award. The purchaser reserves the right to call for further information at any time during the development of the prototype scheme.

The purchaser will be an active participant during this phase. The purchaser has the option to either purchase the proto-type scheme or the first production unit.

6.3.1 Proto-type scheme design diagrams

During the initial part of the engineering development phase, only drawings shall be produced and no panel manufacturing shall take place. The tenderers shall provide in-depth details of their equipment's interfaces with applicable substation equipment, for the purpose of producing the prototype drawings. The drawings shall be produced on the purchaser's CAD system, standard drawing symbols and standard layouts. Thereafter, preliminary drawings will be supplied bearing the label "PROTOTYPE". Only drawings so sourced, and bearing the prototype label will be regarded as valid. The purchaser shall assume overall responsibility for the production of scheme drawings.

The prototype design freeze follows the approval, by the responsible Eskom representative, of the prototype drawings as per the development program. The approval of the drawings shall take place before the scheduled design freeze date.

The product development phase shall last for a period of no more than 1 year from product development contract award. The purchaser shall be an active participant during this phase. During this phase, the scheme design shall be completed, the documentation and drawings shall be finalised and approved, all type testing, functional testing and Model Power System simulator testing (where applicable) shall be completed to the purchaser's approval, the specialised training requirements shall be fulfilled and the first production unit (prototype scheme – including primary plant simulator) shall be completed.

The successful tenderers shall, within two weeks of contract award, supply the purchaser with a set of comprehensive equipment documentation, setting guidelines and the operating/analysis software. Each device shall be equipped with the hardware and firmware version that will be supplied during the production phase. The operating and analysis software version shall be the version that will be required to communicate with the production phase devices.

6.3.2 Proto-type scheme development and built

The purchaser will determine the exact composition of the prototype.

Eskom technical staff will interact directly with the contracted vendors in the development of detailed designs, prototypes and associated tests. This is different to the tender stage where all correspondence with vendors is channelled via the purchaser's representative. Any correspondence relating to contract pricing will still be communicated with the vendor by the purchaser's representative.

The Eskom technical team will:

- Act as moderators between vendors, endeavouring to ensure that competing products are equally flexible and user friendly, thereby reducing the possibility of strong user preferences for one product over the other during the production phase of the contracts;
    - Ensure that standard gaps identified during the product development stage are addressed. They will document such decisions for incorporation into a future revision of the standard;
- Compile a buyer's guide drawing for codification of items on SAP;
- Develop the buyer's guide drawing into a scheme ordering schedule;
- Convert/update the vendor's scheme Master drawings into the standard Eskom format, with application detail as applicable;
- Develop IED-specific settings philosophies;
- Sign off all project deliverables including scheme manuals and procedures; and,
- Conduct and sign off all scheme prototype tests.

6.3.3 Design freeze for the production phase

Once the product development phase is completed, a design freeze shall come into effect. No further changes shall be permitted to the scheme, the scheme components or the scheme drawings.

6.3.4 Production phase

During the production phase, the schemes is ordered, manufactured, tested, QA inspected, delivered, offloaded and erected in position at site.

The successful tenderers shall, in conjunction with the purchaser, compile a test plan with QA inspection holding points.

6.3.5 Production scheme delivery

The production schemes shall be delivered to site with:

- As built drawings;
- QA inspection report;
- All IEDs and relays shall have the purchaser's (Eskom) application-specific settings applied. The settings, as applied by the supplier prior to shipment of the scheme, shall also be provided to the purchaser;
- All IEDs shall be fitted with the final IED configuration;
- All IEDs shall be configured with the IEC61850 SCD and SED (where applicable);

- IED project file that include the Eskom default settings, configuration/marshalling and IEC61850 engineering (station final SCD file imported to the IED and GOOSE receive signals configured),
- Ethernet switch(s) configured; and,
- Production unit routine test report.

6.4 Price schedule categories

The main scheme components (typically imported IEDs or custom components) shall be included as separate price schedule items in a product standard. Vendors shall tender spares prices against these items for inclusion in the overall evaluated price of the offer. The detail per product will be provided in Annexure B.

During the product development phase, the detail of these items (main and spare) shall be finalised for codification on SAP and will be available for order via the contract.

6.5 Engineering fees and provision of prototypes

For products for which the vendors will be paid engineering fees and/or prototypes purchased, this will be done under a signed development contract. The vendor engineering fees shall include:

- Engineering services for the development of Eskom-specific intellectual property: master drawings, IED configuration settings, documentation.
- Costing for simulator testing of the prototype (where required). This shall exclude expenses for Eskom staff to witness such testing.
- Costs for advanced/expert engineering software for Eskom product custodians as recommended by the vendor for the development or management of the products.

The following vendor expenses (where applicable) will be absorbed into the product pricing:

- Costs relating to the development of product production facilities.
- A corporate licence for IED interface software meeting Eskom's minimum requirements.

Prototype schemes shall be purchased by Eskom at the tendered price of a production scheme (plus applicable optional items). The vendor will undertake any re-engineering of the prototype as may be required (at his cost) such that it has identical wiring and functionality of a production unit.

6.6 Warrantees, spares and support

6.6.1 Warrantees

The supplier shall provide a minimum of a 10 year warrantee on the IEDs provided in the scheme. The warranty shall include the repair of all failures due to latent defects (i.e. excluding failure due to mishandling or misuse of the equipment by Eskom or Eskom appointed representatives). Any charges associated with the repair/replacements and shipping of the defective equipment from the local supplier's office to and from the works of the overseas principal shall be for the supplier's expense.

The supplier of IEDs for protection schemes shall undertake, in writing, to support each product for a minimum period of 15 years from the date of contract signature. Product support shall include services to repair or replace any damaged or failed IED that falls outside the terms of the abovementioned warrantee. Eskom shall be liable for all costs associated with these services. Replacement IEDs shall preferably be of the same type, model number and firmware as the failed IED, but alternative products of substantially similar physical dimensions and terminal layouts offering the same or increased functionality shall be accepted in fulfilment of this requirement.

The supplier shall notify Eskom of the planned discontinuation of any IED used in a current or previous national contract.

6.6.2 Spares

The Supplier shall supply a comprehensive list of spares that shall, at minimum, include one of the devices/relays used, as well as MCB's, switches, lamps, empty sub-racks and any consumable items. The Supplier shall also include on the list of spares any other recommended spares necessary for the proper maintenance of the protection scheme. The spares items shall be priced individually and the list shall include a description of the item, a reference number, the pricing details and the guaranteed delivery time. All spares shall be delivered in approved cases suitable for storing such parts over a period of 10 years without damage or deterioration.

Spare devices shall be available from the tenderers for a period of at least 10 years subsequent to the expiry of the contract. Spares shall be carried at the tenderers's local works according to the following amount of schemes in service:

Table 1: Spares requirements

Number of schemes in service	Available immediately (within 24 hours of order)	Additionally available on demand within 72 hours
1 to 20 schemes	1 spare of each device	A maximum of 2 spares of each device
21 schemes and more	2 spares of each device	A maximum of 3 spares of each device

The successful tenderers shall maintain an up-to-date register of at least three contact persons who may be contacted regarding spares. This information shall be communicated to the purchaser when any of the details contained therein are altered.

The purchaser shall annually audit the spares holding as per the requirements of this standard.

6.6.3 Repairs

The tenderers shall provide a schedule detailing the guaranteed turnaround time for the repair of faulty equipment. The turnaround time shall include any international transport and customs clearance times as applicable. If the turnaround times differ for different equipment, the schedule shall include these details. The tenderers shall also state the extent to which repairs can be effected at the tenderers's local works, including the capability and equipment that the tenderers possesses in order to effect such repairs. The tenderers shall, for all repair work, inform the purchaser of the exact nature of the failure, how such failure was remedied and how these failures, and other similar failures, can be prevented. The solutions to the identified failures/deficiencies shall also be implemented to all the in-service and spare devices. The implementation will be governed by the availability of the devices due to power network constraints.

6.6.4 Support

The purchaser requires a maximum transfer of technology from the supplier's principals to enhance the local support capabilities. The tenderers shall indicate in his offer how he intends committing to this requirement.

The transfer of technology shall include, but shall not be limited to:

- Operating and analysis software;
- IED functions (detailed description and explanations); and,
- Compilation of standard IED (Eskom) templates that also include the IEC61850 engineering.

6.7 In-service experience requirements

The tenderers shall provide details of their device's operating record and installation details with their offers. The tenderers shall also provide details on all offered IEDs, the firmware upgrades made in the past 3 years. The Purchaser will use protection devices that satisfy the following conditions:

- Available 'off-the-shelf';

- Have a proven track record in terms of an acceptable in-service record on networks 132kV and less in utilities world-wide. The tenderers shall provide proof of track record by documentation and reference to buyers and/or utilities world-wide;
- Have a minimum in-service experience of 50 equipment-years, at time of tender closure, with at least 25 devices/relays having an in-service record of more than 6 months. This shall apply to the same or similar production unit version of device/relay that the Purchaser would employ;
- Successfully pass required model power system simulator testing;
- Successfully pass all functional testing; and,
- Successfully pass all specified environmental type tests.

Cumulative years of service are only based on an in-service period of identical hardware and firmware versions.

7. Documentation

7.1 Scheme manual requirements

The required documentation shall include a full description of the scheme including the detailed information/manuals on all scheme components and devices. Also required are the complete drawings for each of the scheme permutations. The scheme manual shall include the product configuration and a hard copy of the scheme drawings. All documentation called for shall be finalised and approved before the engineering/development phase ends and awarding of production contract phase.

The documentation shall be clear, concise and to the point. The supplier shall compile all documentation and a complete documentation set (printed and bounded and in electronic format *.doc(x)) shall be submitted to the purchaser on conclusion of the engineering/development phase.

The scheme manual shall have as a minimum the following chapters:

Chapter 1 General Description

1.1 Basic description of the scheme and devices

1.2 Intended area of application

1.3 Brief description of the protection and closing functions

1.4 Contract/agreement data

1.5 Device configuration (logic diagrams)

1.6 Drawing set (scheme)

Chapter 2 Mechanical Construction

2.1 Mechanical drawings

2.2 Construction details

Chapter 3 Controls, Indications and Test Facilities

3.1 List of controls and indications

3.2 Detailed description of functions

3.3 General operational data

3.4 Test facilities

Chapter 4 Protection Functionality

4.1 Detailed description of protection functions

4.2 Scheme protection philosophy

4.3 Scheme logic

4.4 Application guidance

4.5 Burdens

Chapter 5 Substation automation integration

5.1 MMS data sets with data attributes (also the subscribers to the data)

5.2 GOOSE data sets with data attributes (also the subscribers to the data)

Chapter 6 Installation, Commissioning and Testing

6.1 Installation procedure/requirements

6.2 Commissioning guidelines

6.3 Routing testing guidelines

Chapter 7 Maintenance

7.1 Maintenance requirements

7.2 Recommended "In-service" checks

7.3 Cross-referencing to relay manual

7.4 Audit intervals and scope

7.5 Physical replacement / refurbishment procedure

Chapter 8 Parts List

8.1 Parts list (Bill of material)

Chapter 9 Associated Publications

9.1 Information about all equipment used in scheme

Chapter 10 Document Control

10.1 Revision control

Chapter 11 Software and firmware

11.1 Hardware, firmware and software version control procedure

11.2 History of updates (Include ordering codes)

11.3 Upgrade procedure

11.4 Communication software

11.5 Relay to Data Communications Equipment protocol

Chapter 12 Peripheral Equipment

12.1 Relay to PC requirements (port, cable, etc.)

12.2 Relay to Data Communications Equipment requirements (port, cable, etc.)

12.3 Printer requirements

12.4 PC requirements

7.2 Settings guide

The settings guide shall include a comprehensive set of blank and example setting details to cover all user settable functions in the scheme and devices shall be provided. A list of the settings, as set by the supplier prior to shipment of the scheme, shall also be provided to the purchaser. The supplier shall provide the recommended setting limits to ensure that the required protection performance is obtained. A list of settings (including the Eskom default settings) and settings guidelines shall be provided for all functional elements and shall indicate any setting limitation and any possible conflict with any other setting.

The settings guide (in electronic format *.doc(x)) shall be finalised, approved and submitted to the purchaser before the engineering/development phase ends and awarding of production contract phase.

The Supplier shall provide Microsoft Excel-based setting sheets for all IEDs offered with separate columns for the setting name, actual setting and setting range and step sizes. The Excel worksheet shall be equipped to export settings into a format suitable for direct import into the IED setting/configuration software. In addition to this requirement, the Supplier shall provide, for each type and model of protective IED offered, setting templates for application with DigSilent StationWare settings management software.

7.3 Scheme selection and application guide

The scheme selection and application guide shall include a complete description of the different scheme permutations and selection thereof for specific applications. The application section of the guide shall include a full description and the physical interfacing of the scheme with components external to the scheme (e.g. DC board, CTs, VTs, JB, substation automation, etc.).

The scheme selection and guide (printed and bounded and in electronic format *.doc(x)) shall be finalised, approved and submitted to the purchaser before the engineering/development phase ends and awarding of production contract phase.

7.4 Scheme drawings

The scheme drawings shall be as per the drawing standard. The supplier shall be accountable for the compilation of drawings in Bentley Microstation *.dgn format for all scheme/module permutations.

8. Training

The tenderer shall include proposals for the training of Eskom personnel. The following item shall be quoted:

- The local specialised training of selected Purchaser protection engineers (not more than 6) by an expert(s) from the tenderer's principal works. The price shall be quoted on a per week basis. Details of the specialised training will be negotiated during the development phase of the contract. The required training shall include, but not be limited to, an in-depth working knowledge of all devices and products (hardware, firmware and software functionality), the relay operating and analysis software, setting and application, commissioning, maintenance and first-line fault finding.
- Operating Unit staff training at the tenderer's local works. The price shall be quoted on a per week basis. Details of the training will be negotiated during the development phase of the contract. The required training shall include, but not be limited to, a working knowledge of all devices and products (hardware, firmware and software functionality), the relay operating and analysis software, setting and application, commissioning, maintenance and first-line fault finding.

9. Authorization

This document has been seen and accepted by:

Name and surname	Designation
Vincent Jansen van Rensburg	Chief Technologist
Bongani Qwabe	Chief Technologist
Joe Fisher	Chief Technologist
Asad Ally	Senior Engineer
Stuart van Zyl	Chief Engineer
Andrew Craib	Chief Engineer
Paul Gerber	Senior Technologist
Peter Almeida	Senior Advisor

10. Revisions

Date	Rev.	Compiler	Remarks
Jan 2016	2	T Bower	Sections removed and moved to the detailed specifications. Provision made for dual main protection.
April 2015	1	T Bower	New document based on 240-65336348, TST 41-1062, DST 34-462, DST 34-464 and DST 34-465.

11. Development team

This document was developed by Thys Bower.

12. Acknowledgements

Stuart van Zyl

Annex A – Impact assessment

(Normative – for Eskom internal use only)

Impact assessment form to be completed for all documents.

1 Guidelines

- All comments must be completed.
- Motivate why items are N/A (not applicable)
- Indicate actions to be taken, persons or organisations responsible for actions and deadline for action.
- Change control committees to discuss the impact assessment, and if necessary give feedback to the compiler of any omissions or errors.

2 Critical points

2.1 Importance of this document. E.g. is implementation required due to safety deficiencies, statutory requirements, technology changes, document revisions, improved service quality, improved service performance, optimised costs.

Comment: This standard is required to document the generic requirements for Distribution protection & control schemes.

2.2 If the document to be released impacts on statutory or legal compliance - this need to be very clearly stated and so highlighted.

Comment: No statutory or legal compliance required.

2.3 Impact on stock holding and depletion of existing stock prior to switch over.

Comment: No impact.

2.4 When will new stock be available?

Comment: Not applicable.

2.5 Has the interchangeability of the product or item been verified - i.e. when it fails is a straight swop possible with a competitor's product?

Comment: Not interchangeable.

2.6 Identify and provide details of other critical (items required for the successful implementation of this document) points to be considered in the implementation of this document.

Comment: This document must be used as reference when compiling the bay specific protection & control scheme standards for application to Distribution stations.

2.7 Provide details of any comments made by the Regions regarding the implementation of this document.

Comment: (N/A during commenting phase)

3 Implementation timeframe

3.1 Time period for implementation of requirements.

Comment: The generic requirements will be implemented during compilation of the detailed specifications.

3.2 Deadline for changeover to new item and personnel to be informed of DX wide change-over.

Comment: No changeover required, new standard.

4 Buyers Guide and Power Office

4.1 Does the Buyers Guide or Buyers List need updating?

Comment: No.

4.2 What Buyer's Guides or items have been created?

Comment: N/A

4.3 List all assembly drawing changes that have been revised in conjunction with this document.

Comment: N/A

4.4 If the implementation of this document requires assessment by CAP, provide details under 5

4.5 Which Power Office packages have been created, modified or removed?

Comment: N/A

5 CAP / LAP Pre-Qualification Process related impacts

5.1 Is an ad-hoc re-evaluation of all currently accepted suppliers required as a result of implementation of this document?

Comment: N/A

5.2 If NO, provide motivation for issuing this specification before Acceptance Cycle Expiry date.

Comment: N/A

5.3 Are ALL suppliers (currently accepted per LAP), aware of the nature of changes contained in this document?

Comment: N/A

5.4 Is implementation of the provisions of this document required during the current supplier qualification period?

Comment: N/A

5.5 If Yes to 5.4, what date has been set for all currently accepted suppliers to comply fully?

Comment: N/A

5.6 If Yes to 5.4, have all currently accepted suppliers been sent a prior formal notification informing them of Eskom's expectations, including the implementation date deadline?

Comment: N/A

5.7 Can the changes made, potentially impact upon the purchase price of the material/equipment?

Comment: N/A

5.8 Material group(s) affected by specification: (Refer to Pre-Qualification invitation schedule for list of material groups)

Comment: N/A.

Impact assessment completed by:

Name: Thys Bower

Designation: Senior Consultant

Annex B – Price Schedule Items

(Normative)

The scheme/module permutations will be within the detailed functional standards. Listed are typical price schedule items, the items shall be independently priced:

Item	Description
1.1	Scheme Engineering
1.2	Test equipment – test routine
1.3	Scheme/module permutations (independently priced)
1.4	Circuit-breaker process interface unit (PIU)
1.6	Specialised training (per week)
1.7	Grid staff training (per week for 12 people)
1.8	Scheme documentation
1.9	Application guide
1.10	Settings guide
1.12	Main scheme components (IEDs etc. independently priced)
1.13	Site commissioning per scheme/module

Annex C – Performance Questions

(Normative)

Tenderers are required to submit in writing, with their offer, answers to performance questions. Any technical documentation which might assist the answers must be provided. The answers to the questions will be taken into account in evaluating the offers. The performance questions, as applicable, shall be answered for each protection device offered. Actual performance to be stated and not general information on a product range, but specific to the offered product. Performance questions will be within each detailed functional standards.

Annex D – Drawing set

(Normative)

A typical drawing set shall be included, per permutation, within the detailed functional standard.