Eskom	Standard	Technology

Title: **SPECIFICATION FOR TRANSMISSION AND DISTRIBUTION PROTECTION SCHEMES: TRANSFORMERS AND REACTORS**

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This document is **STABILISED.** The technical content in this document is not expected to change because the document covers: *(Tick applicable motivation)*

1	A specific plant, project or solution	
2	A mature and stable technical area/technology	
3	Established and accepted practices.	✓
Notes:	This document is stabilised until such time that a task manual is compiled to supersede it.	

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1. Introduction

This document defines technical requirements for an Eskom wires business transformer and reactor protection schemes for the protection and control of Eskom wires business power transformers of nominal capacity from 10MVA up to and including 800MVA.

The existing National Contract for Distribution transformer protection schemes expires in March 2014 and Transmission's existing National Contract for transformers and reactor protection schemes expires in May 2014. The existing Distribution National Contract will be extended until end-December 2015 so as to allow development period. The enquiry process for the next transformer protection scheme contract will cover both Distribution and Transmission, using this single consolidated specification. The validity period of the existing Distribution specification is to be extended until November 2013, by which time the new consolidated specification should be finalised. This revision of the specification serves as an update to include all features presently provided on the Distribution protection scheme on National Contract as well as it includes Transmission's present and future requirements outlined in the Technology vision of PTM&C.

Transformer protection schemes shall be provided for two main application groups:

- Protection for coupling and /or distribution transformers installed on the network, where the HV potential of these transformers is normally higher than 132 kV
- Protection for regional distribution transformers normally with HV potential lower than or equal to 132 kV.

The transformer protection schemes related to both application groups make provision for the following fault conditions:

- Faults within the transformer protection zone, i.e. faults between the transformer HV and MV CT's.
- Faults between the HV CT and HV breaker and between MV CT and MV breaker.
- Overheating.
- Un-cleared HV or MV system faults.

2. Supporting clauses

2.1 Scope

This functional specification document is applicable to the Eskom wires business operating unit's transformer protection schemes for application on power transformers of nominal capacity from 10MVA up to and including 800MVA excluding Breaker and Half installations.

2.1.1 Purpose

This document provides the functional and performance requirements for a transformer and reactor protection schemes as required by Eskom's wires business operating units. This document provides potential suppliers with a framework against which their offered products may be adjudicated. Further, this document shall be the technical basis for any supply contract so awarded. It details the functions necessary to ensure an optimal scheme design.

This document is the more technical response onto the IED requirements document "240 – 64685228".

2.1.2 Applicability

This functional specification document is applicable to the Eskom wires business operating unit's transformer protection schemes for application on power transformers of nominal capacity from 10MVA up to and including 800MVA excluding Breaker and Half installations.

A separate common requirements standard document (240-65336348) which outlines the common systems required will accompany this document.

Another document accompanying this document shall provide the requirements with regard to a protection and control system for a transformer on –load tap changers. The system shall make provision for parallel control of up to four transformers of nominal capacity of up to 800MVA each.

The transformer protection scheme is required for application on the following transformer types:

- Auto – transformers.
- Two- or three-winding transformers.
- Traction transformers – single phase units
- Shunt reactor
- Shunt Reactor with tap changer and tertiary winding (optional)
- Transformer-feeder application or Feeder-transformer (optional)
- Double bank transformers (optional).

In three-winding transformer applications, the third winding, namely the tertiary winding, will only supply substation auxiliaries. However in some Transmission applications, the tertiary winding is connected to a reactor unit for voltage control and the reactor capacity can be up to 45 MVAr.

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

ISO 9001 Quality Management Systems.

The following documents contain provisions that, through reference in the text, constitute requirements of this standard.

Parties using this standard shall apply the most recent edition of the documents listed below: This standard makes references to and should be read in conjunction with the following documents.

Information on currently valid national and international standards and specifications can be obtained from the Information Centre and Technology standardisation Department at Megawatt Park or Hyper wave database.

2.2.1.1 International document(s)

IEC 60255	Electrical relays (all parts).
IEC 60898	Electrical accessories – Circuit-breakers for over current protection for household and similar installations.
IEC 60947-2	Low-voltage switchgear and control-gear – Part 2: Circuit breakers.
IEC 60947-3	Switches disconnectors Switch-disconnectors and fuse combination units.
IEC 61850 (All parts)	Communication networks and systems in substations.
Cigre WG B5.37 Final draft 2012	Protection, Monitoring and Control of Shunt Reactors.
Cigre WG 5 3.36	Applications for Protection Schemes based On IEC 61850 Protocol.
C37.90-1989	IEEE standard for relays and relay systems
C37.21-2005	IEEE standard for control switchboards

2.2.1.2 South African National document(s)

Network Code	The South African Grid Code (Revision 8.0)
Act no. 85 of 1993	Occupational Health and Safety Act of the Republic of South Africa or the latest updated and approved sub clause s.
Act no. 73 of 1989	Regulations under the Environment Conservation Act of the Republic of South Africa.
SANS 1091	National colour standard.

2.2.1.3 Eskom national document(s)

ESKPBAAH5: REV1	The control of numerical/software driven products used in the protection field with respect to version changes in the software firmware or hardware of the device and to any associated technical pc software.

2.2.1.4 Eskom Divisional document(s)

2.2.1.4.1 Distribution document(s)

DSP 34-253	Distribution specification for electrical terminal blocks.
DSP 34-462	Generic Specification for Distribution protection schemes.
DSP 34-464	Distribution specification for a swing frame panel (19 inch rack) and blanking plates.
DSP 34-465	Generic requirements with regard to Distribution protection equipment enquiries and contracts.
240-709752231	Specification for Current and Voltage Transformer Test Blocks.
DSP 34-2093	Generic Specification for protective IEDs and tripping relays.
DSP 34-543	Specification for a Distribution Transformer On-load Tap change Protection and Control Scheme.
DISASABI2	Distribution Group's specific requirements for standard drawing practice for Control Technologies.
DISSCAAK9:Rev.3	Specification for labels on control panels, relay panels and other indoor and outdoor equipment.
SCSSCAAP9 (future DSP 34-1658)	Corrosion protection specification for new indoor and outdoor distribution equipment manufactured from steel.

2.2.1.4.2 Transmission standards/ Group Technology

TRMSCABN3	Technical Specification Phase V Transformer and Reactor Protection Schemes for 132 to 765kV Applications
240 – 46264031	Fibre Optic Design Standard: Part 2 substations.
240–42066934	IEC 61850 protocol implementation document for the purposes of substation Automation (Revision 0)
240-62629353	Specification for panel labelling
240-64100247	Standard for panel earthing

240-64636794	Standard for wiring and cable marking in substation
240-62773019	Specification for low voltage auxiliary electrical components
240-64038621	Remote Device Communication standard for Data Retrieval and Remote Access
240-68107841	IEC61850 Standard requirements for PICS, PIXIT, and TICS
TST41 – 1062	Standard for electronic protection and fault monitoring equipment for power systems.
TST41 – 120	Environmental requirements for procurement of assets goods and services (Revision 1)

2.2.2 Informative

Document number	Document title	Preparer/author	Revision or date of issue
32-9	Definition of Eskom documents	Eskom Document Centre	Latest
32-644	Eskom documentation management standard	Eskom Document Centre	Latest
474-65	Operating manual of the Steering Committee of Technologies (SCOT)	Vinod Singh	Latest

2.3 Definitions

2.3.1 General

Double bank Transformer:	Two transformers that share an HV circuit-breaker and HV CTs, but which are provided with dedicated MV circuit-breakers and CTs.
Feeder-transformer	A transformer with a remote HV/primary-side circuit-breaker.
Main IED	The single numerical intelligent electronic device providing current, voltage and frequency based protection, local and remote controls and indications.
Transformer – Feeder	A transformer with a remote MV/secondary –side circuit-breaker.
Traction Transformer	A transformer that connects to railway feeder.

2.3.2 Disclosure classification

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

2.4 Abbreviations

AC or ac:	Alternating Current
AT	Auxiliary Transformer

AUX	Auxiliary Contact
BCD:	Binary Coded decimal
BFI:	Circuit-Breaker Fail Isolate
BUCH. T	Buchholz Trip
BT	Breaker Trip
BZ	Bus Zone
CAD:	Computer Aided Testing (Eskom Working Group)
CB:	Circuit-Breaker
CT:	Current Transformer
CBCS:	Circuit-Breaker Control Switch/integrated function
CBF:	Circuit-Breaker Fail
BFBS:	Breaker-Fail BusStrip
CBNH:	Circuit-Breaker Not Healthy
CTTB:	Current Transformer Test Block
DC or dc:	Direct Current
DCF:	Direct Current (supply) Fail
DCS	Digital Control System?
DGA	Dissolved Gas Analyser
DIFF	Differential
DPMCB:	Double –Pole Miniature Circuit-Breaker
DTL:	Definite Time Lag
E/F	Earth Fault
EHV	Extra High Voltage
ETPB	Emergency Trip push Button
EXT.T	External Trip
HMI	Human Machine Interface
Hi SET	High Set

HV:	High Voltage
IED:	Intelligent Electronic Device
IDMTL:	Inverse Definite Minimum Time Lag
IDMT	Inverse Definite Minimum Time
INST:	Instantaneous
LAP	List of Approved Products
LCD:	Liquid Crystal Display
LCS:	Lamp Check Switch/integrated function
LED:	Light Emitting Diode
LV	Low Voltage
MCB:	Miniature Circuit-Breaker
MK:	Marshalling Kiosk
MMS	Manufacturing Message Specification
MTR	Master Trip Relay
MV:	Medium Voltage
NEC/R:	Neutral Electromagnetic Coupler with integral Resistor/Neutral Earthing Compensator
NR	Neutral Reactor
OC	Over-current
OU's:	Eskom's Operating Units e.g. Distribution or Transmission
OTT:	Oil Temperature Trip
OLA:	Oil Level Alarm
PB	Push Button
PC:	Personal Computer
PDT	Pole Discrepancy Trip
PIU	Process Interface Unit
PNH:	Protection Not Healthy
PAC:	Protection, Automation and Control

PRT	Pressure Relief Trip
REF:	Restricted Earth Fault
RPRR:	Rapid Pressure Rise Relay
RST:	Reset Push Button
r.m.s:	root mean square
RTC:	Real-Time Clock
RTU:	Remote Terminal Unit
SFT	Sustained fault Timer
SIS:	Supervisory Isolate Switch/Integrated function
SLD	Single Line Diagram
ST	Surge Trip
T	Transformer
TCS:	Trip Circuit Supervision
TNS	Test-Normal Switch
TER	Tertiary
VSR:	Voltage Selection Relay
VT:	Voltage Transformer
VTTB:	Voltage Transformer Test Block
WTT:	Winding Temperature Trip
WTA:	Winding Temperature Alarm

2.5 Roles and Responsibilities

None

2.6 Process for Monitoring

The status of compilation and completion of this document was monitored through the Protection, Automation and Control Study committee (PASC) process and was registered on Group Technology (BOC) activities.

2.7 Related/supporting documents

Mozina, C.J. "Protection practices to avoid transformer failures and improve protection". A paper presented at the 2006 Southern African Power System Protection Conference, Eskom Convention Centre, Midrand, and October 2006.

Subramanian,S. & Varghese, A. "Condition Monitoring and Protection". This article was published in the PAC World magazine issue of September 2011.

Soveig Ward,& IEEE PSRC, WG 1 19 members. "Redundancy and reliability of Protection and control systems: Considerations for protective Relay Systems". This article was published in the PAC World magazine, March 2010.

E3 GROUP ON IEC 61850, Minimum common specification for SAS equipment in accordance with the IEC 61850 Standard Edition 3

3. Requirements

3.1 Introduction

In order to achieve the necessary Eskom performance requirements at all voltage levels, protection of the network shall follow the philosophy whereby no single failure of protection and its associated systems shall permit a fault to remain connected to the primary system. In this context, failure shall mean failure to operate, or failure to operate within a specified maximum operating time, or in a time whereby other protection, which should not normally have operated, has sufficient time to perform a correct back-up.

To implement this philosophy, it is necessary to ensure that all faults are detected by at least two separate independent high speed protection systems (referred as Main 1 and Main 2 or/ and Back-Up protections), the outputs of which are selectively allocated to independent tripping systems with separate D.C. supplies. These protection systems shall operate from same principles and shall be of same hardware platforms and shall have the same functionality and Input/output provisions.

Circuit-breaker fail protection shall be provided to cater for failure of circuit-breakers and associated tripping circuits. The function shall be duplicated and integrated within both main protection systems.

For low MVA applications, a single main protection system shall be provided unless otherwise specified by Eskom. In addition, Back-Up protection independent of the main protection shall be provided.

This dual main design shall facilitate that a complete main protection may be removed from service without requiring an outage of primary plant equipment, and with no risk of tripping the primary equipment. The Main 1 and Main 2 protection systems shall be redundant in all protection and circuit-breaker control functions. Controls within disconnectors shall be duplicated, but provision shall be made for these to be operated by both mains (possibly via master – slave arrangement).

The design shall be such that one main or panels containing one main each can be located either next to each other or may be in another control room or even further each other within the same control room.

Redundancy of critical functions (e.g. tripping) shall be achieved via hardwired signals in parallel with IEC 61850 based protocol. Collection of Input/output per bay side shall be done via digital process interface units located in the substation yard.

The interface between the yard digital process interface units (PIU) and the substation control room equipment shall be fibre plus copper for trip signals. The survivability of the digital process interface units in the harsh environment of the substation yard is very critical. The digital process interface units shall be installed in yard junction boxes with a view to migrating these into circuit-breaker and power transformer mechanism boxes in future. Disconnectors shall be wired to the digital process units installed within a junction box.

The yard installed digital process interface units shall be plug-gable so as to be easily replaced by a device from any vendor without the need to re-cable the enclosure. The junction box shall include separate sub clause s for Main 1, Common and Main 2 functions. Common functions include Circuit-Breaker closing, earth switch and isolator controls. Separate cables shall be used for Main 1 and Main 2 between primary equipment and junction boxes, and between junction boxes and control room/s.

Physical separate process-level LANs shall be provided for Main 1 and Main 2.

Eskom requires that all IED's, modules and equipment to be used in the development of the protection and control scheme must have a proven service experience of at least one-to-two years and no less than fifty equipment years (+/- one hundred).

3.2 Scheme variants & model numbers

Six scheme options shall be provided for Transformers, and referenced as indicated below:

1) Two-winding transformer protection scheme including biased differential protection: **6TM*100**.

2) Two-winding, transformer scheme with or without MV Circuit breaker (CB on customer side): **6TM*200**.

3) Two-winding, Mobile transformer scheme up to 140MVA: **6TM*150.**

4) Three winding (auto) EHV transformer protection scheme including three-winding biased differential protection: **6TA*300**

5) Single phase transformer protection scheme including biased differential protection with no Restricted earth fault protection: **6TT*100**.

6) Three winding (auto) EHV transformer protection scheme including three-winding biased differential protection: **6TA*200**

Note: Represents manufacturer code.*

Four scheme options for the Reactors, and referenced as indicated below:

7) Normal Shunt Reactor: **6SR*100**

8) Shunt Reactor with Tertiary winding and Tap-changer: **6SR*200**

9) Single - phase unit Series Reactor: **6SR*300**

3.2.1 Scheme Identification

The transformer protection schemes are to be identified by a 7- or 8-digit code or more as follows as outlined in the common specification document sub clause 3.2.1 (240-65336348):-

3.2.1.1 Transformer Identification

6	TM	*	1	00	-					

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)	HV Motorized Isolator = (0= not selected, 1 = selected)	MV Motorized Isolator selected (0= not selected, 1 = selected)		Option n selected (0= not selected, 1 = selected)

3.2.1.1.16 TM-#100

This scheme is designed to cater for the protection and control of HV transformers up to and including 160 MVA. It shall be a versatile scheme in that the functionality and the way in which the scheme is configured allow it to be applied to auto-transformers as well as star/delta and star/star two winding transformers.

The scheme shall include on the HV side option to have motorised isolators, as well as option for indications only and with MV side indication as standard feature.

The schemes are to be housed in a single free-standing panel or two panel suites for transmission applications which allows for the mounting of 19” inch rack equipment.

Two versions of scheme construction are required: one using a swing frame panel with only front access, the other using a fixed frame panel with front and rear access. This is to cater for the following applications:

1) Where space is a premium and panels need to be mounted either back to back or against the wall

2) Where there is enough space to allow front and rear access and thus make working within the panel considerably easier.

If possible, these two versions of housing should not necessitate two wiring standards. The one standard scheme wiring should be adaptable to suit both methods of housing.

This scheme shall provide a variant where application in brown station with legacy control equipment and its associated interfaces are present. Allowance must be made for this. This option is necessary for legacy substations where the technology is not ready for HMI interface. The Ethernet-switch though shall be standard.

Each main protection shall be identical in all respects and independent of each other. Each main panel shall comprise of the following:

- Ethernet switch
- Bay control device
- Main protection
- Breaker control switches (HV, MV and or LV)(open /Close)
- SIS switch
- Lamp check push button
- Test normal pushbuttons(Normal, test 1 and Test 2) separate
- MCB’s as per scheme /panel drawing
- Panel not healthy lamp
- Etc.

For this scheme it is possible that the customer owns the MV/LV circuit breaker, in that case Eskom have to supply a potential free contacts, which the customer uses to trip the circuit breaker via his D.C. supply.

An additional requirement for this scheme is the provision of second MV/LV isolator indication option, this is necessary when the customer requires an isolator on his side. This isolator shall be indicated in the HMI and remotely indicated.

See typical single line layout in figure 1 in the list of attached figures (appendix)

3.2.1.1.26TM-#200 (Station Transformer)

This scheme is designed to cater for the protection and control of station-transformer configurations. It is intended to be a cost effective scheme which includes the minimum protection functions which Eskom would be comfortable with under these conditions of application. This is a two winding transformer scheme with differential protection and back-up protection.

The scheme shall have an option for circuit-breaker located on the customer side and provision for control to be from power station control system (DCS). Interlocking of controls between the two control centres shall be taken into account. Possibility of different technologies applied between the interface/ control systems (e.g. IDF versus IEC 61850). This necessitates an option in the scheme for legacy control equipment. Allowance must be made for this. The Ethernet-switch shall be standard.

For this scheme it is possible that the customer owns the MV/LV circuit breaker, in that case Eskom have to supply a potential free contacts, which the customer uses to trip the circuit breaker via his D.C. supply.

An additional requirement for this scheme is the provision of second MV/LV isolator indication option, this is necessary when the customer requires an isolator on his side. This isolator shall be indicated in the HMI and remotely indicated.

See typical single line layout in figure 2 in the list of attached figures (appendix)

3.2.1.1.36TM*150 (Mobile Transformer)

This scheme is designed to cater for the protection and control of mobile substations and smaller HV transformers (< 40MVA). It is intended to be a cost effective scheme which includes the minimum protection functions which Eskom would be comfortable with under these conditions of application.

The transformer protection scheme shall include the following: differential, three phase HV O/C, HV and MV REF (High Impedance), HV and MV E/F (IDMTL or DTL) and OLTC O/C blocking. If critical alarms are not acknowledged (e.g. Buchholz, Oil level, protection not healthy, and DC fail), the scheme should initiate a trip of both HV and MV TRFR breakers (Master trip) after a set time delay.

The measurement for SCADA indication will be derived from the protection schemes via IEC61850, alternatively DNP3 protocol.

This scheme may or may not be equipped with (IEC61850) and/or a bay processor and its associated interfaces. Allowance must be made for this. The Ethernet-switch shall be optional.

3.2.1.1.46TA*300 (Auto-Transformer)

This scheme is designed to cater for the protection and control of EHV auto-transformers for both common tank and segregated tank versions. The scheme shall have both EHV and MV side provided with motorised isolators, with MV having option for non- motorised isolators. This caters for application where the MV voltage is below 220kV and no motorised isolators applied.

The scheme is intended for use on three and two windings applications at EHV level i.e. applications for transformers above 160 MVA capacity. The

These schemes are to be housed in a suite of two panels which allow for the mounting of 19” inch rack equipment and which have front and rear access. Each main protection shall be identical in all respects and independent of each other. Each main panel shall comprise of the following:

- Ethernet switch

- Bay control device
- Main protection
- Breaker control switches (HV, MV and or LV)
- SIS switch
- Lamp check push button
- Test normal pushbuttons(Normal, test 1 and Test 2) separate
- MCB's as per scheme /panel drawing
- Panel not healthy lamp
- Etc.

The protection panel shall have front and rear doors, and the interface panel shall only have a rear door.

The scheme shall be equipped with an Ethernet-switch for integration with substation automation devices.

See typical single line layout in figure 3 in the list of attached figures (appendix)

3.2.1.1.56TT- #100 (Traction Transformer –Feeder)

The scheme is designed to cater for the protection of single phase traction transformers. The scheme is to be housed in a single free-standing panel which allows for the mounting of 19" inch rack equipment and have front and rear access. This shall include protection for the traction feeder with reclosing facilities.

The scheme shall be equipped with an Ethernet-switch for integration with substation automation devices.

The schemes shall be supplied complete with MCBs (Curve C) to protect and isolate the following circuits:

3.2.1.1.6 6TA*200 (Auto-Transformer)

This scheme variant is required to interface with the existing protection schemes installed which ranges from phase 1 (electromechanical) phase 2 (electronic) and phase 3 (first numerical relays) , the tap-changer control interface is hardwired via bus-wiring.

The scheme shall be similar and identical with existing scheme attached or shall make interfacing easier without any addition modifications to the existing.

Attached is the typical scheme drawings applied. 0.52/30xxx

3.2.1.1.76SR*400 (Shunt-Reactor)

This scheme variant is required to be installed in substations where the old control systems are still in place

The scheme shall be similar and identical with existing or shall make interfacing easier without any addition modifications to the existing.

Typical scheme drawings available on request. 0.52/30316

3.2.1.2 Reactor Identification

6	SR	*	1	00	-					
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)	HV Motorized Isolator selected (0= not selected, 1 = selected)	Busbar or Line type(0= Busbar application, 1 = Line Application)		Option n selected (0= not selected, 1 = selected)

3.2.1.2.16 SR-#100 (Normal Shunt Reactor)

The scheme is designed to cater for the protection and control of EHV Busbar Shunt Reactors (phase segregated and common tank).The Shunt Reactor schemes are to be housed in a suite of two panels which allow for the mounting of 19" inch rack equipment and which have both front and rear access.

The protection panel shall have a front and rear door whereas the interface panel shall have a rear door. The scheme shall be equipped with an Ethernet-switch for integration with substation automation devices.

The scheme shall be configured such that it can be used for line reactor applications.

Each main protection shall be identical in all respects and independent of each other. Each main panel shall comprise of the following:

- Ethernet switch
- Bay control device
- Main protection
- Breaker control switch (HV)
- SIS switch
- Lamp check push button
- Test normal pushbuttons(Normal, test 1 and Test 2) separate
- MCB's as per scheme /panel drawing
- Panel not healthy lamp
- Etc.

A module for Point-on-Wave interfacing shall be provided in the Junction box. Therefore the closing device designs shall include the closing of the circuit breaker via this device.

3.2.1.2.26 SR*200 (Shunt Reactor with Tertiary winding and Tap changer)

The scheme is designed to cater for the protection and control of EHV Line Shunt Reactors (phase segregated and common tank).The Shunt Reactor schemes are to be housed in a suite of two panels which allow for the mounting of 19" inch rack equipment and which have both front and rear access.

The protection panel shall have a front and rear door whereas the interface panel shall have a rear door. The scheme shall be equipped with an Ethernet-switch for integration with substation automation devices.

The scheme shall be equipped with an Ethernet-switch for integration with substation automation devices.

The scheme shall be configured such that it can be used for line reactor applications.

Each main protection shall be identical in all respects and independent of each other. Each main panel shall comprise of the following:

- Ethernet switch
- Bay control device
- Main protection
- Breaker control switch (HV)
- SIS switch
- Lamp check push button
- Test normal pushbuttons(Normal, test 1 and Test 2) separate
- MCB's as per scheme /panel drawing
- Panel not healthy lamp
- Etc.

A module for Point-on-Wave interfacing shall be provided in the Junction box. Therefore the closing device designs shall include the closing of the circuit breaker via this device.

The scheme shall provide interfacing with the tap change protection scheme the same way as it would be applied for a transformer.

3.2.1.2.3 6SR*300 (Single - phase unit Series Reactor)

The scheme is designed to cater for the protection and control of EHV Line Reactors (phase segregated).The Line Reactor schemes are to be housed in a suite of two panels which allow for the mounting of 19" inch rack equipment and which have both front and rear access.

The protection panel shall have a front and rear door whereas the interface panel shall have a rear door. The scheme shall be equipped with an Ethernet-switch for integration with substation automation devices.

The scheme shall have redundant protection scheme which identical in all functionality and provides flexibility for work to be carried out on one main with little or no impact on the other main. Any design should support simple replacement of relays in the future.

The two identical relays shall be installed into two independent panels. The scheme shall provide option to be applied on station with motorised and non-motorised isolators.

The design of the scheme will resemble a two winding transformer, in the sense that two circuit breaker controls shall be provided.

The scheme shall be equipped with an Ethernet-switch for integration with substation automation devices.

The scheme shall be configured such that it can be used for line reactor applications.

Each main protection shall be identical in all respects and independent of each other. Each main panel shall comprise of the following:

- Ethernet switch
- Bay control device
- Main protection
- Breaker control switches (HV_1 & HV_2)

- SIS switch
- Lamp check push button
- Test normal pushbuttons(Normal, test 1 and Test 2) separate
- MCB's as per scheme /panel drawing
- Panel not healthy lamp
- Etc.

A module for Point-on-Wave interfacing shall be provided in the Junction box. Therefore the closing device designs shall include the closing of the circuit breaker via this device. Each circuit breaker will interface the scheme via Point-On-Wave.

3.2.2 Generation of scheme

The transformer scheme generation would follow the criteria identified in the common specification document (240 65336348, sub clause 3.2.2) hence a 6th generation would be applied for this development.

The 6th generation is classified by the implementation of IEC 61850 goose for tripping and mms data as well human machine interface (HMI) for controls.

3.2.3 Scheme Group Code

The following group of schemes would be applicable to the transformer and reactor protection schemes.

- 6TA-XXXX - Auto transformer application for three windings.
- 6TM-XXXX – power transformer applications for two-winding medium and low MVA
- 6TT-XXXX – single phase traction transformers
- 6SR-XXX - shunt reactor /series reactor

3.2.4 Manufacturing code

The manufacturing code specified in the standard for transmission and distribution common specification requirements document (240 – 65336348, sub clause 3.2.4) shall be provided.

3.2.5 Series number (Scheme type)

The series numbers used shall be as stipulated in the standard for transmission and distribution common requirements specification document unique identifier: 240-65336348.

3.2.6 Major revision number (Scheme design revision)

The major revision number shall be as stipulated in the standard for transmission and distribution common requirements specification document unique identifier: 240-65336348.

3.2.7 Voltage level

The voltage level shall be as stipulated in the standard for transmission and distribution common requirements specification document unique identifier: 240-65336348.

3.2.8 Option 1 selection

This option shall be selected as stipulated in the standard for transmission and distribution common requirements specification document unique identifier: 240-65336348.

3.2.9 Option 2 selection (0=not selected; 1=selected)

This option selection shall be as stipulated in the standard for transmission and distribution common requirements specification document unique identifier: 240-65336348.

3.2.10 Option "n" selection (0=not selected; 1=selected)

The option selection shall be as stipulated in the standard for transmission and distribution common requirements specification document unique identifier: 240-65336348.

3.3 Performance requirements

The transformer and reactor protection system shall have a low incidence of non-system fault tripping. The protection shall remain stable for all load conditions, charging and discharging arrangements, harmonic currents, oscillatory currents, resonant effects, or travelling wave effects caused by the transmission system or caused by primary transducers. The protection equipment shall be designed so that a minimum or no routine maintenance is required, in terms of total accumulated time and frequency.

For high equipment availability, the design should allow fault location, rectification (possibly by replacement sub-units) and returning to service to be performed as quickly as possible, preferably with the equipment in service and in situ. Provision of spare fibre cables shall be considered to allow rapid repairs if problems arise.

The environmental requirements of the relays shall comply with the Generic Specification for Intelligent Electronic Devices (IEDs) Standard, Unique Identifier 240-64685228.

3.3.1 Sensitivity

The sensitivity of the protection shall be as specified in the standard for transmission and distribution common specification requirements document (240- 65336348, sub clause 3.3.1).

any limitation imposed by the protection equipment or its setting, such as maximum permissible load current or load profile shall be declared by the supplier.

3.3.2 Reliability: Security & Dependability

3.3.2.1 Reliability

To elevate reliability Eskom applies the redundancy philosophy. In this case two identical independent protection systems will be applied. The two systems shall be of equal performance.

The transformer protection equipment is often not required to operate for many years, but when a fault occurs, requiring its operation, it must operate correctly. The supplier shall specify the correct commissioning procedure so that the reliability of the protection is maintained.

The failure of one system shall not influence the other system and to ensure that the failures are not triggered by common cause.

3.3.2.2 Security

The protection system security shall be as described in the standard for transmission and distribution common specification requirements document (240-65336348, sub clause 3.3.2.1).

3.3.2.3 Dependability

The protection system dependability shall be as described in the standard for transmission and distribution common specification requirements document (240-65336348, sub clause 3.3.2.2).

3.3.2.4 Directionality

The protection system directionality shall be as described in the standard for transmission and distribution common specification requirements document (240-65336348, sub clause 3.3.2.3).

3.3.2.5 Speed

To avoid damage to transformer, the protection IED used should operate as quickly as possible. The speed of operation should not compromise the selectivity capability of the IED. Preference will be given to relays with fast tripping times.

It is essential that, under internal fault conditions, the power transformer be isolated from the network in a minimum time. It is imperative therefore that any relay element placed in series with the unit protection be extremely fast acting. The overall tripping times for any relay or unit /non unit protection are expected to meet times stipulated in the A/B schedules per IED or functional element.

3.3.2.6 Longevity

All tenderer's equipment shall be designed for a minimum working lifetime (minimum life expectancy) of 20 years. Written guarantees to this effect shall be made available on request. The failure rate of the protection IEDs in the scheme shall be less than 0.5% per annum. The failure rate of other equipment in the scheme shall be less than 1% per annum. Tenderers are therefore required to provide details of their equipment operating record with their offer.

3.4 Scheme interfaces

3.4.1 Auxiliary supplies

Auxiliary supplies shall be as specified in the standard for transmission and distribution common specification requirements (240-65336348, sub clause 3.4.1)

3.4.1.1 230 A.C. supply

AC supply shall be as specified in the standard for transmission and distribution common specification requirements (240-65336348, sub clause 3.4.1.1). Additional to that, the following should apply.

A.C. supplies shall be 230 V phase-to-neutral and 400 V phase-to-phase. The frequency shall be 50 Hz nominal, variable between 47 Hz and 51 Hz. Total harmonic distortion including all harmonics up to the order of 40, shall not exceed 8 %.

A.C. supply shall be provided for each scheme for the "Protection not healthy" indication circuit, for transducers, and for mechanism box heaters.

The incoming A.C. supply shall be routed through a 10A single pole (SP) and neutral (N) or double pole (DP) MCB (curve C) for isolation and protection purposes. The 10A rating provides co-ordination with upstream 20A devices and proves adequate protection for 1.5mm^2 and 2.5mm^2 panel wiring.

The A.C. supply to the heaters in associated primary equipment interface enclosures shall be supplied from the same A.C. supply. Each heater supply shall be provided with a 5A SP + N or DP MCB (curve C) for protection and isolation purposes. The 5A MCB will provide adequate grading with the 10A MCB on the incoming supply.

A.C. MCBs shall have rated breaking capacities of 5kA.

PNH indication lamp shall be supplied directly from the MCB. Transducers (where required) shall be supplied via sliding link isolation terminals on the A.C supply (i.e. from the A.C. MCB).

The A.C. supply MCB shall be flush-mounted on the front panel of the scheme, adjacent to the DCI MCBs.

3.4.1.2 Main 1 and Main 2 D.C. supplies

Main 1 and Main D.C supplies shall be provided and shall be independently routed to main 1 protection scheme and main 2 protection scheme respectively. It shall be possible for each main supply to be switched –off without affecting any of the scheme circuits.

3.4.1.2.1 Tripping D.C. circuit

The requirements for dc supplies shall be as specified in the standard for transmission and distribution common specification requirements (240-65336348, sub clause 3.4.1.2). Direct tripping method shall be used.

Double-pole miniature circuit-breakers (DP MCBs) shall be provided for the protection and isolation of the D.C. supplies to each scheme. The DP MCBs shall be installed in the Main 1 tripping (M1), Main 2 (M2) or Back-Up tripping (BU).

Separate 16A DP MCBs (curve B) shall be applied to the main tripping circuit and the back-up tripping circuit as more than 80 % of secondary wiring faults are located within the circuit-breaker. The 16A rating will provide co-ordination with upstream 32A devices, and provides adequate protection for 1,5mm² and 2, 5 mm² panel wiring.

The auxiliary voltage for all tripping circuits shall be D.C. Two independent D.C. tripping circuits shall supply the independent protection schemes. It shall be possible to isolate one main supply without affecting any of the functions in the other protection scheme.

In order to minimize the effect of corrosion, relay coils should be permanently connected to the negative bus in dc control schemes. If moisture is present and the coil is directly connected to the positive bus, electrolytic corrosion may occur, causing the coil to become open-circuited and preventing the relay from operating.

Where the control circuit contacts are exposed to the environment, higher control voltages are required. Typically, 110 Vdc or 220 Vdc is selected. All binary inputs and outputs used in tripping circuit shall be of a nominal 110 Vdc or 220 Vdc.

These voltages shall be specified on ordering. Discrete supervisory controls, where required, shall operate using a 48V D.C. source.

In the event that the breaker is called on to trip at the same time a close signal is present, the breaker must always trip.

When a power circuit breaker is directly tripped by protective relays, care should be used to ensure that the trip circuit design is sufficient to provide maximum available current and voltage to the circuit breaker trip coil(s). Items of concern are the control circuit conductor size and length, number of terminal block connections in the circuit (these should be kept to a minimum), proper selection of the seal-in coil taps, the number of target and seal-in coils in series, and the rating of the relay contacts for tripping duty.

Trip circuit supervision (TCS) will be applied as a standard in all transformer protection schemes.

The scheme shall operate normally for variation in the auxiliary supply voltages within ±20% of nominal.

3.4.1.2.2 Closing D.C. circuit

The closing circuits should be included with the secure supply circuit within the junction box and shall be fused independently. If separate MCB's are employed for the close circuits, they should be located on the load side of the trip circuit protection. This ensures that at least one trip coil has control power when closing the breaker. The close circuit MCB's should be coordinated with up circuit MCB's.

Anti-pumping - In the event that a breaker is closed into a fault, while the operator is applying a close signal via a closed control switch, the circuit breaker should trip and prevent closing again until the closing circuit has been de-energized by the operator's releasing the control switch.

Closing circuits shall not be supervised via trip circuit supervision.

The DP MCBs will be designated as follows:

- HV Closing D.C. supply – DCI MCB (HVCL)
- MV Closing D.C. supply – DCI MCB (MVCL)

The scheme shall include terminals on the main or back-up D.C. circuit to accommodate the provision of an auxiliary D.C. supply to each circuit-breaker for SF_6 gas pressure monitoring etc. Where both main and back-up D.C. circuits are available, the circuit-breaker auxiliary supply shall be provided from a different supply to that feeding the circuit-breaker fail relay[1], this is applicable in cases, where circuit breaker function is not duplicated.

3.4.1.2.3 Secure Supply circuit

Secure supply shall be as specified in the standard for transmission and distribution common specification requirements (240-65336348, sub clause 3.4.1.3)

The DP MCBs will be designated as follows:

- Secure supply Main 1 D.C. supply – DCI MCB (SSM1)
- Secure Supply Main 2 D.C. supply – DCI MCB (SSM2)

Auxiliary DC supplies to the circuit-breaker mechanism boxes and MIB shall be provided via a secure supply circuit implemented via a chop-over between the Main 1 and Main 2 DC supplies. The main 1 DC supply circuit shall be the preferred supply, chopping over to the Main 2 circuit if the Main 1 DC supply voltage drops below 80% of rated. The chop-over relay shall include hysteresis to prevent contact bounce at the threshold of coil operation.

3.4.1.2.4 Spring Rewind and Motorized Isolator D.C. supplies

Spring Rewind and Motorized Isolator supplies shall be as specified in the standard for transmission and distribution common specification requirements (240-65336348, sub clause 3.4.1.4)

A 25A DP MCB (curve B) shall be applied to the spring rewind circuit. The DP MCB is provided to clear faults on the supply cable to the spring rewind motor. The 25A rating provides co-ordination with upstream 32A devices, and adequate protection to the outgoing 2, 5 mm^2 or 4 mm^2 cores.

DP MCBs shall be approved for use on nominal 110 V D.C and 220V D.C. systems and shall be rated to break 5kA (L/R = 4ms).

The DP MCBs will be designated as follows:

- Spring Rewind D.C supply – MCB(SR)
- Motorised Isolator D.C supply – MCB(MI)

The spring rewind and motorised isolators DC supplies will be supplied from the DC board to the JB. The failure of these supplies and MCB “off state” shall be reported locally with an LED indication or alarmed within the Bay Control Device and also remotely reported via MMS messaging through SCADA.

3.4.2 Current Transformer circuits

The standard current transformer secondary inputs are 1 Amp, with a continuous rating of 2 Amps. The standard practice is to earth the neutral (4th wire) where the CT cable is connected to the terminals within the panel. 4mm² wiring shall be used for all CT secondary connections within the panel. Each CT input shall have a dedicated four-way current transformer test block.

[1] Loss of the circuit-breaker auxiliary supply renders the circuit-breaker unable to trip or close. A fault occurring whilst the circuit-breaker D.C. supply is unavailable will be cleared by a back-trip of the upstream circuit-breakers via the circuit-breaker fail function (provided this relay is itself not affected by the D.C. supply failure).

Overcurrent protection of current transformer secondary circuits shall not be provided Wiring for current transformer and shunt trip circuits shall not be less than No. 14 AWG, regardless of load (IEEE C37.21-2005).

3.4.2.1 Protection CT Circuits

Separate CT circuits shall be provided for Main protection and Back-Up protection.

For each circuit the protection CT core shall feed onto standard terminals and then to the CT test block and IED measuring elements.

A PK2 4-way test block accepted by Eskom shall be used in the CT circuit for both the main and back-up circuits. Each test block shall include integral shorting of the incoming terminals when the cover is removed.

For this application, the CT circuits shall be used for the Differential, REF, Breaker-fail, and Over-Current, Earth Fault, and Instantaneous Over-current protection functions and for the Measurements functions.

Neutral CT inputs are required on the transformer's HV winding star-point, and on the neutral of an MV NEC/R. The latter shall be in addition to a neutral CT input required for low impedance REF. The NEC/R neutral CT will typically be connected to a 100/1 CT, whilst the REF will be required to use a higher ratio (e.g. 1000/1). A neutral CT input is required on the HV star-point where low impedance HV **REF** is offered.

Table 1: Primary Analogue input requirements for the main IED/s (Main 1 and/or Main 2)

CT Inputs	Main 1	CT Inputs	Main 2
3	HV Diff/OC/BF/EF	3	HV Diff/OC/BF/EF
3	MV Diff/OC/BF/EF	3	MV Diff/OC/BF/EF
3	HV REF- (Bushing)	3	HV REF - (Bushing)
3	MV REF (Bushing)	3	MV REF - (Bushing)
3	Tert. Diff/OC	3	Tert. Diff/OC
1	NECRT Neutral	1	NECRT Neutral
1	HV Neutral	1	HV Neutral
1	MV Neutral	1	MV Neutral

In integrated protection schemes, it shall be common for the Main and/or Back-Up IEDs to provide both protective and measurement functions.

The neutral of each CT circuit shall be earthed at one place only: on the incoming neutral terminal inside the protection panel. A sliding link terminal shall be provided on the earth connection for isolation proposes in order to facilitate insulation resistance testing.

3.4.2.2 Measurements CT Circuits

The CT connections shall be routed through two four-way current transformer test blocks; CTTB (HV) (MM#) and CTTB (MV) (MM#) .This implies a total of six terminals. A fourth sliding link terminal shall be provided for Earthing of the CT circuit.

CT Inputs	BCD
3	HV Current Measurements
3	MV Current Measurements

In other cases where a dedicated measurement transducer is supplied, this shall use a separate current transformer circuit, terminated as such.

The measurement CT shall be routed to bay control devices (BCD) and goosed to the Main 1 and Main 2 IEDs.

3.4.3 Voltage Transformer circuits

The standard voltage transformer secondary inputs are 63.5 volt per phase (110 volt, phase-phase). The standard practice is to earth the neutral (4th wire) in the VT JB. 4mm² wiring shall be used for all VT secondary connections within the panel.

The MCB protection of the line VT circuits shall be located within the VT JB. The VT JB will have single phase MCBs for connection to the protection IED that include also a neutral current for fuse fail detection.

3.4.3.1 Protection VT Circuits

The VT supplies for both the protection and measurements circuits shall be taken into the panel onto standard terminals and then to an optional voltage selection (VSR) relay (where applicable). Busbar VT selection shall be preferably done via logic within IEDs.

MV VT circuits shall be used for over-fluxing, under frequency and over voltage protection and as input to the tap change protection and control scheme.

Each main shall be provided with protection VT circuits

For the directional earth fault function, where a residual (3V0) voltage input is required for the 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.

The way in which the AC circuits are wired is essentially similar for all of the schemes. For those schemes applied to transformers with on load tap changing equipment, there shall be an AC supply circuit wired for the purpose of tap changer control and power supply to the tap position indicator. Also provision must be made for the voltage transformer secondaries to be routed to the voltage regulating relay.

3.4.3.2 Measurements VT Circuits

HV and MV VT circuits shall be provided for measurements in all the transformer variants.

HV and MV voltage transformer circuits shall be provided for all transformer and reactor schemes.

Where specified, an option shall be provided to allow voltage from the correct busbar VTs to be automatically selected depending which busbar the transformer is connected to. Two latching relays shall be offered to fulfil the voltage selection function. The VSR operate coils (set and reset) shall be wired to terminals to accept status contacts from the busbar isolators. The output contacts shall be arranged to switch the appropriate busbar VT supply to the protection and measurement functions. Enough contacts shall be provided to fulfil the intended functions.

VT Inputs	BCD
3	HV Prot/Meas
3	MV Prot/Meas

All VT supply circuits that are not fitted with a test block shall include isolation terminals at the connection point. The isolation terminals shall include test sockets. The VT supplies for both the protection and measurements circuits shall be taken into the panel onto standard terminals and then to an optional voltage selection (VSR) relay (where applicable).

VT MCBs shall be rated to break 4,5kA.

In the case of main and back-up protection IEDs that have to be supplied with voltage for protection purposes, and which use the VT same circuit, a means of selectively disconnecting the main and back-up circuits shall be provided. The terminal blocks used for disconnection shall include test sockets. This is in order to ensure that one of the IEDs can be tested while the other remains in service, in line with the TNS philosophy.

3.4.3.3 Synchronising VT Circuits

Not applicable to transformer and reactor schemes.

3.4.4 Binary signals

3.4.4.1 IED Binary Inputs

The IED binary inputs shall meet the requirements as specified in the Generic Specification for Protective Intelligent Electronic Devices (IEDs) Standard (240-64685228, sub clause 3.7).

The main IED is required to be provided with the status of all external plant, trips and alarms so as to relay this information to SCADA system via the serial and Ethernet communication links. This includes indication of each individual element that operates the Master Trip (relay) functionality. It is thus a requirement that the main IED has sufficient binary inputs to accumulate this data.

Changes in states of the inputs shall be logged by the IED's built-in sequence of event recorder function. All trips shall be used to start the IED's disturbance recorder.

The main protection IED shall include separate binary inputs for at least the functions indicated in Table 2 below. Some of the requirements of Table 2 may be waived, for example, if the relay includes user-programmable push buttons (e.g. obviating the need for discrete Supervisory Isolate Switch and Reset inputs).

Table 2: Binary input requirements for the main IED/s (Main 1 and/or Main 2)

Description	2 or 3 Winding transformer
External/HV Bus Zone Trip	1
External/MV Bus Zone Trip	1
MV circuit-breaker cable chamber arc sensor operated	1
HV REF Trip (External) – High Impedance	1
MV REF Trip (External) – High Impedance	1
Rural Feeder Circuit-breaker Fail	1
Supervisory Isolated	2
Local Reset/Lamp Test input	1
Emergency trip push button operated	1
Test Normal Switch – Normal position	1
Test Normal Switch – Test 1 position	1
Test Normal Switch – Test 2 position	1
DC Fail input	1
AC Fail input	1
HV Circuit-breaker initiate Manual closing	1
HV Anti-pump timer input	1
Other Main IED fail	1
HV VT MCB tripped	1
MV VT MCB tripped	1
Primary apparatus control executed	1
Trip circuit supervision	3
External Trip	1
Spares	**7**
Total count	32

Binary interfacing between the main protection device and the Bay Control Device shall be via GOOSE.

Binary interfacing between the main protection device and the PIU shall be via GOOSE.

3.4.4.2 IED Binary Outputs

The IED binary outputs shall meet the requirements as specified in the Generic Specification for Protective Intelligent Electronic Devices (IEDs) Standard (240-64685228, sub clause 3.8).

The schemes shall have the following outputs:

a) HV and MV Circuit-breaker trip (Main and Back-up tripping circuits);

b) HV and MV Circuit-breaker close;

c) Circuit-breaker spring rewind supplies;

d) HV and MV Circuit-breaker fail trip outputs to busbar protection;

e) DC supply for circuit-breaker mechanism (e.g. gas monitoring supply) and MIB (Temperature Instrument); and

f) Supervisory serial interface.

g) MV circuit breaker intertrip to customer protection system

h) MV Isolator status to customer

3.4.4.3 Goose Messaging

In order to ensure the satisfaction of general-purpose multicast communication needs in all installations, every IED shall be able to publish GOOSE with their respective Goose Control Block (GoCB) and to subscribe to publishers. All the available GoCB in an IED must be configurable.

Both the instantaneous and the delayed trip signals from all transformer protections to the Process interface Unit (PIU) shall be by GOOSE message. The CB trip and close commands from the PIU to the trip and close coils shall be hardwired.

The LAN that carries the goose messages must incorporate redundancy. For those critical tripping commands copper wiring shall back-up the goose messages. All the protection main relays shall be able to exchange goose messages through the switch. The protection scheme should include monitoring of alarms generated by switches.

The following data will be sent via goose messaging:

a) Main 1-to-Main 2 messaging

b) Any Main to Tap change voltage regulating relay

c) Primary plant statuses and report

d) Alarms from the plant and IEDs (Gas, liquid etc.)

e) Trip signals from the primary Protection (Buchholz, PRV, TC surge etc.). Tripping of the breaker will be via contact.

f) Trip and Block signals to the PIUs

g) Exchange of information between Tap-change controllers and between IEDs and PIUs

h) Measurement quantities data

i) Goose message for test points (for test-set).

The GOOSE messaging shall meet the requirements stipulated in the standard for Transmission and Distribution common requirements specification document unique Identifier: 240-65336348.

3.4.4.4 EHV Circuit-breaker Process Interface UNIT GOOSE and MMS Signals

The EHV Circuit-breaker Process Interface unit GOOSE and MMS signals shall meet the requirements stipulated in the standard for Transmission and Distribution common requirements specification document unique Identifier: 240-65336348.

The Process interface Unit shall perform the function of providing tripping and closing contacts to the tripping and closing circuits. The process Interface Unit shall gather information from the breakers and Isolators as well as send control commands to them. The PIU shall contain number of hardwire input/out contacts which enable it to communicate with the analogue circuit-breakers and isolators. These contacts shall permit the PIU to gather circuit-breakers and isolator status, circuit-breaker SF6 and some other information from these switchgears and also permit the trip and close commands to the circuit-breakers.

The PIU shall also be able to send plant information to the protection devices via IEC 61850. Meaning after the information is gathered from the plant it shall be converted from electrical analogue signals into digital signals and publish them at the bay level IEDs.

3.4.4.5 Transformer Process Interface Unit GOOSE and MMS signals

The Transformer Process Interface unit GOOSE and MMS signals shall meet the requirements stipulated in the standard for Transmission and Distribution common requirements specification document unique Identifier: 240-65336348.

The transformer bay shall consists of two transformer Process Interface Units (Main 1 and Main2).The Process interface Unit shall perform the function of providing inputs and outputs to be hardwired to the primary protection function. The process Interface Unit shall gather information from the transformer and tap changer units as well as send control commands to them. The PIU shall contain number of hardwire input/out contacts which enable it to communicate with the analog circuits. These contacts shall permit the PIU to gather Buchholz, Pressure Relieve Valve, Temperature instruments, liquid level instruments and Tap changer gas instrument status, and some other information from these switchgears and also permit the blocking commands to the tap changer.

The PIU shall also be able to send plant information to the protection devices via IEC 61850. Meaning after the information is gathered from the plant it shall be converted from electrical analogue signals into digital signals and publish them at the bay level IEDs.

3.4.4.6 Tap Changer Process Interface Unit GOOSE and MMS signals

The Tap Changer Process Interface GOOSE and MMS signal shall meet the requirements stipulated in the standard for Transmission and Distribution common requirements specification document unique Identifier: 240-65336348.

3.4.4.7 EHV Circuit-breaker Process Interface Unit Binary Signals

The process interface binary inputs/outputs signals shall meet the requirements stipulated in the standard for Transmission and Distribution common requirements specification document unique Identifier: 240-65336348.

3.4.4.8 Transformer Process Interface Unit Binary Signals

The process interface binary inputs/outputs signals shall meet the requirements stipulated in the standard for Transmission and Distribution common requirements specification document unique Identifier: 240-65336348.

3.4.4.9 Tap changer Process Interface Unit Binary Signals

The process interface binary inputs/outputs signals shall meet the requirements stipulated in the standard for Transmission and Distribution common requirements specification document unique Identifier: 240-65336348.

3.4.4.10 Interface Unit Bay Allocation

The interface junction box with a standard terminal layout that includes all transformer terminals and tap change drive terminals shall be provided. The standard layout required for transformers shall be as per table below:

X1 – terminal strip

Device	Terminal Strip number	Application
Gas and Oil relay	X1.1 –X1.2 X1.3 –X1.4	Trip 1 Alarm 1
Pressure Relief Valve	X1.5 –X1.6 X1.6 –X1.7	Normal open contact Normal closed contact
OLTC protection	X1.8 –X1.9 X1.9 –X1.10	Normal open contact Normal closed contact
Oil Temperature Indicator	X1.11 –X1.12 X1.13 –X1.14	Trip Alarm
HV Winding Temperature Indicator	X1.15 –X1.16 X1.17 –X1.18	Trip Alarm
MV Winding Temperature Indicator	X1.19 –X1.20 X1.21 –X1.22	Trip Alarm
Tertiary Winding Temperature Indicator	X1.23 –X1.24 X1.25 –X1.26	Trip Alarm
Oil Level Indicator	X1.27 –X1.28	High /Low alarm
Tap change Oil level Indicator	X1.29 –X1.30	High/Low alarm
	X1.31 –X1.32	Spare
Cooler Abnormal	X1.33 –X1.34	Common alarm for cooler
Fans/pumps/Thermometer	X1.35 –X1.38	3⌀ control supply
Fans/Pumps	X1. 39–X1.41	110/220Vdc cooler stop and thermometer supply
JB Heater/Earth leakage supply	X1.42 –X1.43	AC supply for JB/Plug socket
Drykeep Earth leakage supply	X1.44 –X1.45	AC supply for drykeep
Dissolved Gas Analyser Earth leakage supply	X1.46 –X1.47 X1.58	AC supply for DGA Earth terminal
Thermometer fail	X1.48 –X1.49	Thermometer fail alarm
Analogue output –Oil temperature (mA)	X1.50 –X1.51	Analogue output 4-20mA
Analogue output –HV Winding temperature	X1.52 –X1.53	Analogue output 4-20mA
Analogue output –MV Winding temperature	X1.54 –X1.55	Analogue output 4-20mA
Analogue output –Tertiary Winding temperature	X1.56 –X1.57	Analogue output 4-20mA

X2-terminal strip – CT & VT

Device	Terminal number	Wire markings	Application
HV "A" phase CT	X2.1 –X2.2	1AS1 – 1AS2	Protection
HV "B" phase CT	X2.3 –X2.4	1BS1 – 1BS2	Protection
HV "C" phase CT	X2.5 –X2.6	1CS1 – 1CS2	Protection
HV "a" phase CT	X2.7 –X2.8	1aS1 – 1aS2	Protection
HV "b" phase CT	X2.9 –X2.10	1bS1 – 1bS2	Protection
HV "c" phase CT	X2.11 –X2.12	1cS1 – 1cS2	Protection
HV Neutral CTs	X2.13 –X2.14 X2.15 –X2.16	1YNS1 – 1YNS2 2YNS1 – 2YNS2	Protection
MV Neutral CTs	X2.71 –X2.18 X2.19 –X2.20	1ynS1 -1ynS2 2ynS1 -2ynS2	Protection
Tertiary "a" phase CT	X2.21 –X2.22	1-3AS1 – 1-3AS2	Protection
Tertiary "b" phase CT	X2.23 –X2.24	1-3BS1 – 1-3BS2	Protection
Tertiary "c" phase CT	X2.25 –X2.26	1-3CS1 – 1-3CS2	Protection
MV "A" phase CT	X2.27 –X2.28	2AS1 – 2AS2	Protection
MV "B" phase CT	X2.29 –X2.30	2BS1 – 2BS2	Protection
MV "C" phase CT	X2.31 –X2.32	2CS1 – 2CS2	Protection
MV "a" phase CT	X2.33 –X2.34	2aS1 – 2aS2	Protection
MV "b" phase CT	X2.35 –X2.36	2bS1 – 2bS2	Protection
MV "c" phase CT	X2.37 –X2.38	2cS1 – 2cS2	Protection

X3 and X4 – terminal strip – Tap changer

Device	Terminal strip	Application
Motor supply	X3.1 –X3.4	3⌀ motor supply
BCD supply + Heater	X3.5 –X3.6	1⌀ Heater and encoder supply
DC supply (TC)	X4.1 –X4.2	Tap change control DC supply
Even Taps (PC)	X4.3 –X4.4	Parallel check for Even taps
Odd Taps (PC)	X4.5 –X4.6	Parallel Check for odd taps
LOR	X4.7 –X4.9	Local Control Switch
Raise Seal -in	X4.10 – X4.11	Seal-in for raise operation
Lower Seal -in	X4.12 – X4.13	Seal-in for lower operation
Raise command	X4.14	Initiate raise operation
Lower command	X4.15	Initiate lower operation
O/C block contactor	X4.16 – X4.17	Energise O/C block contactor
Motor supply MCB trip command	X4.18– X4.19	Trip motor supply MCB
Motor supply tripped	X4.20 – X4.21	Motor supply tripped alarm

In progress indication	X4.22 – X4.23 X4.25	Indication (Raise and lower) In progress
MRT	X4.24	Motor running timer
BCD output TPI	X5.1 – X5.6	BCD
BCD output -Remote	X5.7 – X5.12	BCD output for remote

X 11 - Additional functions

Device	Terminal strip	Application
2nd Gas and oil relay	X11.1 – X11.2 X11.3 – X11.4	Trip 2 Alarm 2
Rapid pressure rise relay 1	X11.5 – X11.6	Trip 1
Rapid pressure rise relay 2	X11.7 – X11.8	Trip 2
Conservator Bag leak detector	X11.9 – X11.10	Alarm
Sudden flow valve	X11.11 – X11.12	Alarm 1
2nd Pressure Relief Valve	X11.13 – X11.14	Normal open contact
2nd Pressure Relief Valve	X11.15 – X11.16	Normal closed contact
Dissolved Gas Analyser	X11.16 – X11.17	Unhealthy alarm
Dissolved Gas Analyser	X11.18 – X11.19	Gas caution Alarm
Dissolved Gas Analyser	X11.20 – X11.21	Gas limit exceeded Alarm
Dissolved Gas Analyser	X11.22 – X11.23	AC fail alarm (NC)
Aux Trfr Gas and Oil Relay	X11.24 – X11.25 X11.6 – X11.27	Trip Alarm
Aux trfr Oil Temperature indicator	X11.28 – X11.29 X11.30 – X11.31	Trip Alarm

3.4.5 Human and machine Interface to the protection panel

3.4.5.1 Local Controls, Panel mimic, and HMI mimic

Where the local tripping control is provided via an integrated push button on an IED (i.e. a button whose operation is dependent on the IED's power supply etc.), an external, mechanical Emergency Trip Push Button (ETPB) shall be provided. The ETPB shall operate the back-up trip coil of the circuit-breaker/s that is controlled by the scheme. A solution where the trip button is provided on the protection IED may be accepted without an Emergency Trip function if the trip button is wired independently of the IED logic. The wiring shall not be dependent on the microprocessor or any other electronic control in the IED, but shall be hardwired internally as if it is done externally to the IED.

The closing of the HV and MV circuit-breakers shall be prevented via software interlocks for any master trip operation or by any activated tripping function for that specific circuit-breaker. Thus the circuit-breakers can only be closed once the tripping conditions have been reset (e.g. a bus zone trip input). For the close blocking functions to be effective, it is imperative that the main IED is provided with information about all functions that can trip the circuit-breakers.

In the event that the circuit-breaker controls are implemented via push buttons on the main IED, an emergency trip push button shall be provided on the front panel of the scheme, and shall operate the back-up trip coils of both the HV and MV circuit-breakers, as well as activating an input of the main IED. The push button shall be fitted with a lockable cover

The following controls shall be provided, interlocked by the local SIS:

Control data point		Logical Node	PID (240-42066934)
a)	HV circuit-breaker Open	XCBR	6.11.1
b)	HV circuit-breaker Close	XCBR	6.11.1
c)	MV circuit-breaker Open	XCBR	6.11.1
d)	MV circuit-breaker Close	XCBR	6.11.1
e)	HV Busbar 1 isolator Open	XSWI	6.11.2
f)	HV Busbar 1 isolator Close	XSWI	6.11.2
g)	MV Busbar 1 isolator Open	XSWI	6.11.2
h)	MV Busbar 1 isolator Close	XSWI	6.11.2
i)	HV Busbar 2 isolator Open	XSWI	6.11.2
j)	HV Busbar 2 isolator Close	XSWI	6.11.2
k)	MV Busbar 2 isolator Open	XSWI	6.11.2
l)	MV Busbar 2 isolator Close	XSWI	6.11.2
m)	LV circuit-breaker Open (optional)	XCBR	6.11.1
n)	LV circuit-breaker Closed (optional)	XCBR	6.11.1
o)	LV isolator Open (optional)	XSWI	6.11.2
p)	LV isolator closed (optional)	XSWI	6.11.2

The following control functions shall be provided on the panel per module:

a) Supervisory control switch

b) Test-Normal switch

c) Master trip reset push button

d) Emergency trip push button/ Emergency CB trip and Close

e) Lamp check push button

The following control functions shall be provided on the HMI per module:

a) Circuit-breaker control

b) Isolator control

For mimic Single line Diagram (SLD) requirements, split between IED and station HMIs shall be provided.

Where there are two or more modules of the same functionality, adoption of the sequence to be used when issuing controls to the modules, i.e. master/slave sequence will be as described in the standard for Control philosophy document accompanying this document.

3.4.5.2 Local indications, Panel mimic and HMI mimic

The operation of all alarm and tripping functions such as differential, REF, over current protection etc. shall be clearly indicated locally to an operator via the main IED. Clear distinction shall be made between each function, namely “HV Hi-set OC”; “HV IDMT OC” etc. The indication shall be displayed on a LCD alpha numeric display using user-defined text messages or via a target LED and a user defined text label. Should this not be available, a separate alarm annunciator shall be provided. All trip and alarm indications shall remain displayed until reset by a push button.

It is preferred that the main IED should have sufficient target LEDs and a hand reset function, such that annunciation may be done on the IED. A combination of using the LEDs available on the main IED and an external alarm annunciator is permissible. All LED-type alarms that are latched shall be reset with one push button.

The indication device, where external to the main IED, shall be substation hardened, and shall conform to the same type test specifications as the main IED. The device shall have a track record for having been used in substation environments for enunciating protection trips and alarms.

The preference shall be to provide the requisite local analogue and digital indications via the main and/or back-up protection IED. Circuit-breaker position and healthy status indications may be provided off board of the IEDs for improved visibility.

The status of all circuit-breakers and /or spring /weight/motor operated disconnectors that can be electrically controlled by the scheme shall be provided as follows:

a) Discrete cluster-type LEDs or

b) As red and green coloured LEDs on the IED front panel.

The circuit-breaker/ disconnector status indication shall independently indicate the states “All Poles Open” and “All Poles Closed”. The one state shall not be derived from the logical inverse of the other.

It is not acceptable for the electrically controllable circuit-breaker/disconnector status only to be displayed in text on a LCD-type display, or for it to be provided using LEDs of alternate colours to those specified.

Local indication of the following alarms and trips shall be provided:

a) Transformer Buchholz Alarm

b) Transformer Buchholz Trip

c) OLTC Buchholz Alarm

d) OLTC Buchholz/Pressure relief Trip

e) Transformer tank over pressure Trip

f) Transformer Winding or Oil temperature Alarm

g) Transformer Winding temperature Trip

h) Transformer Oil temperature Trip

i) NECRT Oil Temperature, Buchholz or oil level Alarm

j) NECRT Buchholz or Oil Temperature Trip

k) Transformer Digital Temperature Instrument Fail Alarm

l) Transformer Oil Level (High/Low) or Cooler fail Alarm

m) Transformer Sump Water drain valve open Alarm

n) Sustained Fault Timer operated

o) Circuit-breaker mechanism box/MIB heaters fail common alarm.

p) Pole discrepancy trip for each breaker.

q) Pole discrepancy alarm for each Pantograph.

r) Bus zone trip for each busbar.

s) Charge-fail timer alarm for each breaker.

Three panel mounted cluster LEDs shall be provided per circuit-breaker providing the following DC-operated indications:

a) Circuit-breaker Open (Green)

b) Circuit-breaker Closed (Red)

c) CBNH (Amber)

The circuit-breaker indications and alarms above may be provided using separate LEDs on the main IED provided the indicated colours are respected.

The scheme shall include a 230Vac operated amber PNH cluster LED. DC operated red cluster LEDs shall be provided to indicate a Master trip (standard) and Customer Master Trip (when the customer master trip relay option is selected).

3.4.5.3 Remote controls

The scheme shall be able to accept supervisory control input signals via Ethernet SCADA interface. The controls shall be pulsed (not latched).

The following remote controls shall be provided:

a) Trip through both trip coils (no cross tripping applied)

b) Circuit-breaker Close (HV, MV, & LV)

c) Motorized Isolator Open command (where applicable)

d) Motorized Isolator Close command (where applicable)

e) Earth Switch Open command (where applicable)

f) Earth Switch Close command (where applicable)

The vendors shall use IEC61850 as purely as possible (e.g. defined logical node names and data attributes). This requires compliance to Eskom's IEC61850 standard requirements for PICS, PIXIT and TICS (240-68107841). This is for interoperability and future integration.

The scheme shall also provide at least single bit status of isolators and earth switches.

The control of the earth switches shall be applicable to both HV and MV. This is also applicable to HV and MV mixed technology circuit breakers.

3.4.5.4 Remote indications, info and status to be reported

The supervisory interface shall as a minimum provide the following alarms, indications and controls via the IEC-61850/Ethernet interfaces. The "Protection Not Healthy" alarm shall be provided via a potential-free contact wired to suitable insulation displacement connection terminal blocks, the only alarm to be provided in this fashion.

a) Supervisory Isolated

Discrete Main IED protection trip indications: e.g. Differential, Hi-set O/C, HV IDMT EF, Sustained Fault Timer, Over excitation etc.

a) Master Trip operated

b) Customer Master operated

c) Any Circuit-Breaker Trip circuit failed

d) Tertiary OC Trip (All modes) – where applicable

e) HV Circuit-breaker Not Healthy

f) MV Circuit-breaker Not Healthy

g) Transformer Buchholz Trip

h) Transformer Buchholz Alarm

i) OLTC Buchholz/Pressure relief Trip/Surge trip

j) OLTC Buchholz Alarm

k) Transformer tank over pressure Trip

l) Transformer Winding temperature Trip

m) Transformer Winding temperature Alarm

n) Transformer Oil temperature Trip

o) Transformer Oil temperature Alarm

p) NECRT Oil Temperature/Buchholz Trip

q) NECRT Oil Temperature/Buchholz Alarm

r) Transformer Digital Temperature Instrument Fail

s) Transformer Oil Level/Cooler Fail Alarm

t) Transformer Sump Water drain Valve Open

u) Transformer MIB or circuit-breaker mechanism box heater fail alarm

v) HV Breaker Fail Trip

w) MV Breaker Fail Trip

x) HV circuit-breaker Open

y) HV circuit-breaker Closed

z) MV circuit-breaker Open

aa) MV circuit-breaker Closed

bb) LV circuit breaker Open (optional)

cc) LV circuit-breaker Closed (optional)

dd) HV Busbar Isolator Open (per busbar)

ee) HV Busbar Isolator Closed (per busbar)

ff) MV Busbar Isolator Open (per busbar)

gg) MV Busbar Isolator Closed (per busbar)

hh) LV isolator Open (optional)

ii) LV isolator Closed (optional)

jj) Auxiliary DC supply low voltage alarm

kk) Auxiliary DC supply low voltage trip

1) MV circuit-breaker cable chamber arc fault trip

2) HV Busbar-side Earth switch Open

3) HV Busbar-side Earth switch Closed

4) HV Transformer-side Earth switch Open

5) HV Transformer-side Earth switch Closed

6) MV Busbar-side Earth switch Open

7) MV Busbar-side Earth switch Closed

8) MV Transformer-side Earth switch Open
9) MV Transformer-side Earth switch Closed
10) HV Bus zone trip
11) MV Bus zone trip
12) HV breaker Charge fail alarm
13) CT SF6 gas "Low"
14) CT SF6 gas "Critical"
15) HV breaker pole discrepancy trip
16) MV breaker pole discrepancy trip
17) HV pantograph pole discrepancy alarm
18) MV pantograph pole discrepancy alarm
19) Point on wave device unhealthy alarm (Rx)
20) Dry keep supply MCB OFF
21) Dissolved Gas Analyser Device unhealthy
22) Dissolved Gas Analyser limit exceeded
23) Dissolved Gas analyser Caution alarm

The following controls shall be provided, interlocked by the local SIS:

a) HV circuit-breaker Open
b) HV circuit-breaker Close
c) MV circuit-breaker Open
d) MV circuit-breaker Close
e) HV Busbar 1 isolator Open
f) HV Busbar 1 isolator Close
g) MV Busbar 1 isolator Open
h) MV Busbar 1 isolator Close
i) HV Busbar 2 isolator Open
j) HV Busbar 2 isolator Close
k) MV Busbar 2 isolator Open
l) MV Busbar 2 isolator Close
m) LV circuit-breaker Open (optional)
n) LV circuit-breaker Closed (Optional)
o) LV isolator Open (optional)
p) LV isolator closed (optional)

3.4.5.5 Testing facilities

Adequate test facilities shall be provided within the protection scheme, to enable commissioning and maintenance procedures to be carried out in a safe and convenient manner.

3.4.5.6 Goose data for testing

In order to test the IED, it is necessary to capture all the goose messages from the IEDs. These messages provide the information required to configure the test device.

The following goose messages from the function nodes shall be provided:

Protection Function	Logical Name Inside Functional Block	Logical Node	GOOSE Messages for Omicron
HV Inst O/C Trip	PIOC_50	PIOC	Op.general
HV Inst O/C Trip Start Line 1	-	-	Op.phsA
HV Inst O/C Trip Start Line 2	-	-	Op.phsB
HV Inst O/C Trip Start Line 3	-	-	Op.phsC
HV Idmt O/C Start	PTOC_51_67	PTOC	Str.general
HV Idmt O/C Trip	PTOC_51_67	PTOC	Op.general
HV Idmt E/F Start	PTOC_51N67N	PTOC	Str.general
HV Idmt E/F Trip	PTOC_51N	PTOC	Op.general
HV Inst E/F Trip	PIOC_50N	PIOC	Op.general
HV Over Excitation	PVPH_24	PVPH	Aln.stVal
MV Inst O/C Trip	PIOC_50	PIOC	Op.general
MV Inst O/C Trip Line 1	-	-	Op.phsA
MV Inst O/C Trip Line 2	-	-	Op.phsB
MV Inst O/C Trip Line 3	-	-	Op.phsC
MV Idmt O/C Start	PTOC_51_67	PTOC	Str.general
MV Idmt O/C Trip			Op.general
MV Idmt E/F Start	PTOC_51N67N	PTOC	Str.general
MV Idmt E/F Trip			Op.general
MV Inst E/F Trip	PIOC_50N	PIOC	Op.general
MV Over Excitation	PVPH_24	PVPH	Aln.stVal
Transformer Ref Line 1	PDIF_87N	PNDIF	Op.general
Transformer Ref Line 2	-	-	Op.general
Transformer Ref Line 3	-	-	Op.general
Diff Trip	PDIF_87T	PDIF	Op.general
Diff Start	-	-	Str.general
Diff Start Line 1	-	-	Str.phsA
Diff Start Line 2	-	-	Str.phsB
Diff Start Line 3	-	-	Str.phsC
2nd HARMONIC BLOCK	-	-	Blk2H.stVal
5th HARMONIC BLOCK	-	-	Blk5H.stVal
Wave Block	-	-	BlkWav.stVal
Open Ct Detection	-	-	OpnCT.stVal
Diff Trip Restrain	-	-	OpRst.stVal

Protection Function	Logical Name Inside Functional Block	Logical Node	GOOSE Messages for Omicron
Diff Trip Unrestrain	-	-	OpUnRst.stVal
LV Inst O/C Trip	PIOC_50	PIOC	Op.general
LV Inst O/C Start Line 1			Op.phsA
HV Inst O/C Start Line 2			Op.phsB
LV Inst O/C Start Line 3			Op.phsC
LV Idmt O/C Start	PTOC_51_67	PTOC	Str.general
LV Idmt O/C Trip			Op.general
LV Idmt E/F Start	PTOC_51N_67N	PTOC	Str.general
LV Idmt E/F Trip	-	-	Op.general
HV Circuit Breaker Trip	PTRC_94	PTRC	Op.general
MV Circuit Breaker Trip	PTRC_94	PTRC	Op.general
LV Circuit Breaker Trip	PTRC_94	PTRC	Op.general
HV Circuit Breaker Fail Busstrip	RBRF_50BF	RBRF	OpEx.general
MV Circuit Breaker Fail Busstrip	RBRF_50BF	RBRF	OpEx.general
LV Circuit Breaker Fail Busstrip	RBRF_50BF	RBRF	OpEx.general
Tap Change Under Current Block	GAPC_37	PTUC	Str.general
Overvoltage Start	PTOV_27	PTOV	Str.genaral
Overvoltage Trip	PTOV_27	PTOV	OpEx.general

3.4.5.7 Test points

Test points necessary to carry out normal testing of a protection shall be provided as described by the “standard for transmission and distribution common specification requirements document” (240-65336348, sub clause 3.4.6.2). The minimum isolation level shall be 1000 Vac.

All test points shall be clearly identified and labelled and be readily accessible to enable majority of commissioning and all maintenance to be carried out from the front panel.

The test points will be colour coded red and black according to the polarity of the point. Test points that are not live shall be coded yellow.

3.4.5.8 Current transformer test block

The CT test blocks shall be the isolation point between the plant AC analogue signals and the IED Analogue inputs. The isolation point shall preferably be securable, and accessible from the panel front. The test block shall be clearly identified and labelled. The test block shall be in accordance with 240-709752231.

Current transformer test blocks necessary for isolation of a protection shall be provided as described by the “standard for transmission and distribution common specification requirements document” (240-65336348, sub clause 3.4.6.2).

The transformer schemes shall have the following current test blocks:

1) 1 x Main protection - HV-test block (CTTB –M(HV))

2) 1 x Main protection – MV - test block (CTTB –M (MV))

3) 1 x Tertiary protection – Ter- test block (CTTB –M (T))

4) 1 x Rural feeder – RF - test block (CTTB –M (RF))

5) 1 x NEC/Neutral – REF - test block (CTTB REF (NEC/N))

6) 1 x Measurement – HV - test block (CTTB –Meas (HV))

7) 1 x Measurement – MV - test block (CTTB –Meas (MV))

3.4.5.9 Voltage transformer test block

A test block is optional or not required on the measurement circuit.

All VT supply circuits that are not fitted with a test block shall include isolation terminals at the connection point. The isolation terminals shall include test sockets.

From there the protection circuit shall be taken to standard terminals and then routed through a MCB (curve C) with a 2A rating to a PK2 4-way test block. The test block shall be in accordance with 240-709752231. The measurement circuit shall be routed to sliding link isolation terminals, then to a 2A MCB (curve C).

The transformer schemes shall have the following voltage test blocks:

1) 1 x Bay Control Device - HV-test block (VTTB –M(HV))

2) 1 x Bay Control Device – MV - test block (VTTB –M (MV))

3.4.5.10 Test block Types

Test block types used shall be as specified in the standard for transmission and distribution common specification requirements (240-65336348, sub clause 3.4.6.5).

3.5 Functional Element Description

It is preferred that the following functionality, as applicable per scheme option, is provided in a single current and voltage protection relay (the “main IED”).

A detailed description including formulae and flow diagrams, of the algorithms used to perform or execute the protection functions shall be provided to nominated Eskom protection engineers on request. The protection logic diagrams must be self-explanatory as to the functioning of the protection device. This information will be treated as strictly confidential and will only be further disseminated within Eskom on a ‘need to know’ basis.

The protection system shall include as a minimum requirement the following functionality.

3.5.1 Protection functions (Group P)

3.5.1.1 Biased Differential protection - PDIF (87T/PHAR)

The biased differential protection function is required to operate both the HV and MV circuit-breaker main and back-up trip coils, as well as the Master trip relay. A two or three element differential IED is required for all of the options except for the double bank scheme.The biased differential protection shall include the following features:

a) two-winding protection capability and optionally a three-winding protection capability;

b) transformer vector group and ratio correction without the use of interposing CTs;

c) through-fault restraint;

d) adjustable second harmonic restraint/blocking for transformer inrush current condition;

e) adjustable fifth harmonic restraint during periods of over-excitation;

f) separately adjustable unrestrained differential High-Set function;

g) DC off-set consideration – use of adaptive DC biasing is preferred.

The biased differential protection function shall be capable of being applied to transformers supplying special transformers such as electric arc furnace transformers. These are special in that they are tapped very frequently and often, on account of the extremely large LV CT ratio and respective change of ratio for one tap step, the actual LV CT ratio has to be altered or the differential protection has to somehow compensate for unbalance currents created.

a) The differential protection function shall operate the master trip relay function, which in turn activates the protection trip condition elements (PTRC 1 and PRTC 2 – with trip seal-in in accordance with the trip seal-in logic) that send via GOOSE message trip signals to the process Interface Unit which in turn activates output contacts hardwired to the trip circuit of the circuit-breakers (both HV and MV).

b) The differential protection function trip shall initiate breaker fail via master trip function operation.

c) The differential protection function start and trip outputs shall be connected to the IED internal binary disturbance recorder logical node (RBDR) phase segregated.

d) The differential protection function operation shall be reported locally via LED indication preferably in the front IED panel. This indication shall be latched.

e) The differential protection function operation shall be reported remotely as Master operated alarm.

f) The analogue signals to the differential protection function shall be recorded in the disturbance recorder analogue channel of the logical node (RADR) per phase.

g) The differential function trip category e.g. Restraint trip and unrestraint trip shall be recorded as such for easy of further analysis.

h) Increment the fault/trip counter

The following differential function features and outputs status shall be recorded in the internal disturbance recorder logical node and stored in the sequence of events log service file.

a) Second harmonic blocking status

b) Fifth harmonic blocking status

c) Wave blocking feature (if available)

The following differential function outputs magnitudes shall be recorded in the internal disturbance recorder logical node and stored in the sequence of events log service file.

a) Differential currents magnitude per phase.

b) Bias current.

c) Negative sequence magnitude (if available).

The operation of the differential protection shall only be resetted via reset master push button located in the scheme panel/module.

The tap changer position shall be received by the IED via GOOSE message for the differential function functionality.

3.5.1.2 Restricted earth fault protection – PDIF/PNDF (87N)

HV and MV REF shall operate the HV and MV main and back-up trip coils as well as the Master trip relay. In the case of the Auto transformer only one REF element is required, second element shall be provided if tertiary winding is available, whilst on the two-winding transformer scheme two REF elements shall be provided.

It is required that integrated HV and MV low impedance REF is offered as standard in the main IED. The low impedance REF shall operate for a secondary current of 50mA or less. The function shall have settings to allow application with dissimilar CT ratios. The low impedance REF shall include a CT saturation detection algorithm which would ensure stability under saturated CT conditions. The current transformer requirements should be clearly specified.

The Restricted Earth Fault (REF) function shall:

- Operate the master trip relay function, which in turn activates the protection trip condition elements (PTRC 1 and PRTC 2- with trip seal-in in accordance with the trip seal in logic) that send via GOOSE message trip signals to the process Interface Unit which in turn activates the same output contacts hardwired to the trip circuit of the circuit- breakers (both HV and MV) as other unit protections.
- Initiate breaker fail function integrated within the same IED (RBRF) via master trip operation.
- Have its start and trip outputs connected to the IED internal binary disturbance recorder logical node (RBDR).
- Shall have its operation reported locally via LED indication preferably in the front IED panel. This indication shall be latched.
- Shall have its operation reported remotely as Master operated alarm.
- The analogue signals to the REF protection function shall be recorded in the disturbance recorder analogue channel of the logical node (RADR) per phase.
- Have its trip output recorded as such for easy of further analysis.
- Increment fault/trip counter

The following REF function features and outputs status shall be recorded in the internal disturbance recorder logical node and stored in the sequence of events log service file.

- Direction status
- Second harmonic blocking status

The following REF function outputs magnitudes shall be recorded in the internal disturbance recorder logical node and stored in the sequence of events log service file.

- Differential current magnitude
- Bias current.
- Residual current magnitude

The operation of the REF protection shall only be resetted via reset master push button located in the scheme panel/module.

3.5.1.3 Optional high impedance Restricted Earth Fault protection

HV and MV high impedance REF relays are required as an ordering option, even where low impedance REF is offered as standard. These relays shall be separate external devices to the main IED with adjustable voltage settings on the relay and a metrosil for both the HV and MV relays. The relays shall operate the Master trip relay as well as binary inputs of the main IED for redundant tripping, and to start the main IED's disturbance recorder.

The high impedance REF shall operate for a secondary current of 20mA or less. The setting range shall be between 25 and 375 Volts; setting range negotiable within reason.

The setting on the high impedance relays shall be made via a dial on the relay, not via an external adjustable resistor.

REF relays shall have fast operating times (i.e. less than 20 ms at two times setting).

The relays and metrosils shall be adequately rated for an HV-earth fault current of at least 30A secondary and an MV fault current of at least 10A secondary. The metrosils shall clamp the secondary voltages to a value below 2.5kV.

For the High impedance relay external to the main IED, an input shall be provided in the main relay to allow for the following:

- Operate the master trip relay function, which in turn activates the protection trip condition elements (PTRC 1 and PRTC 2- with trip seal-in in accordance with the trip seal in logic) that send via GOOSE message trip signals to the process Interface Unit which in turn activates the same output contacts hardwired to the trip circuit of the circuit- breakers (both HV and MV) as other unit protections.
- Initiate breaker fail function integrated within the same IED (RBRF) via master trip operation.
- Have trip operation connected to the IED internal binary disturbance recorder logical node (RBDR).
- Shall have its operation reported locally via LED indication preferably in the front IED panel. This indication shall be latched. The relay shall have its own indication latch-able and reset facility if possible
- Shall be reported remotely as Master operated alarm.
- Increment fault/trip counter

The application of this relay (HIZ) will be optional, especially in cases where there is a long length of cable between the transformer and the MV circuit – breaker and/or cable between two circuit breakers in series.

3.5.1.4 Time delayed Overcurrent protection – PTOC (51)

The schemes shall include the following over current protection functions (as applicable):

HV and MV over current functions, tap change over current blocking

The HV IDMTL over current protection (PTOC 1) shall operate the MV circuit-breaker main and back-up trip coils. The MV IDMTL over current (PTOC 2) (where required) shall operate the MV circuit-breaker main and back-up trip coils.

Each phase PTOC logical node shall consist of three-elements: one element per phase. The over current fault functions shall be wired from the respective red, white and blue phase CTs. A start contact from a fourth HV over current protection element shall be used to provide a blocking signal to an external tap change control scheme.

A cold load pick –up feature shall be provided that allows user selectable modification of phase PTOC characteristic under conditions of system- energisation. The cold pick up function may be provided in one of the following ways:

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

The cold pick-up function shall include an output that may be used to block other fast PTOC and IOC elements.

Due to difficulties experienced currently to obtain proper back up grading due to network becoming interconnected. Some of the current overcurrent and earth fault functions applied today on the Eskom network cannot be directionalized due to no polarising quantity available. Some is available but there is uncertainty with regards to what happens when the polarising quantity is lost. Some revert to non-directional element and some might be completely blocked.

The transformer protection scheme should allow for multiple back up (O/C and E/F) steps that can be set independently (i.e. non-directional or direction – forward or reverse).

3.5.1.4.1 The HV overcurrent function (PTOC 1)

- Shall send trip signal to the MV protection trip condition element (PRTC 2- with trip seal-in in accordance with the trip seal in logic) that send via GOOSE message trip signals to the Process Interface Unit (PIU) which in turn activates a non-master trip output contact hardwired to the MV trip circuit of the circuit- breakers (MV).
- Shall starts sustained fault timer, which after set time will give an output. Sustained earth fault timer output will then sent via GOOSE message to the HV CB PIU and trip the HV circuit breaker.
- Shall initiate MV circuit breaker fail and HV breaker fail will subsequently be started by sustained earth fault timer
- Shall be reported locally via LED
- Shall be reported remotely as non-unit protection operated
- Shall be connected to the internal disturbance recorder (RBRB)
- Shall increment fault /trip counter

Fully flexibility of this function is required on all transformer schemes. Three stages in this function are required on the HV side and shall be configured as follows:

- One HV stage set to look toward the transformer.
- One HV stage set to look toward the HV busbar.
- One stage set non-directional.

3.5.1.4.2 The MV overcurrent function (PTOC 2)

- Shall send trip signal to the MV protection trip condition element (PRTC 2- with trip seal-in in accordance with the trip seal in logic) that send via GOOSE message trip signals to the Process Interface Unit (PIU) which in turn activates a non-master trip output contact hardwired to the MV trip circuit of the circuit- breakers (MV).
- Shall starts sustained fault timer, which after set time will give an output. Sustained earth fault timer output will then sent via GOOSE message to the HV CB PIU and trip the HV circuit breaker.
- Shall initiate MV circuit breaker fail and HV breaker fail will subsequently be started by sustained earth fault timer
- Shall be reported locally via LED
- Shall be reported remotely as non-unit protection operated
- Shall be connected to the internal disturbance recorder (RBRB)
- Shall increment fault/trip counter.

Fully flexibility of this function is required on all transformer schemes. Three stages in this function are required on the HV side and shall be configured as follows:

- One MV stage set to look toward the transformer.
- One MV stage set to look toward the MV busbar.
- One stage set non-directional.

Note: It should be possible for the settings engineer to also select which breaker each of the stages will trip.

For a transformer at a switching station the HV O/C stages should be possible to set to trip the MV circuit breaker and MV O/C stages should be possible to set to trip the HV circuit breaker.

For load supplying transformers, the HV and the MV O/C functions shall trip the MV circuit breaker.

3.5.1.4.3 The Tertiary (LV) overcurrent function (PTOC 3)

The tertiary IDMTL over current protection is required for applications with large transformers/auto-transformers having a tertiary winding. Where provided the tertiary over current protection function shall have three elements wired from red, white and blue phase CTs. The tertiary IDMTL over current shall operate the HV and MV circuit-breaker main and back up trip coils.

The production schematics supplied shall make provision for a tertiary IDMTL and instantaneous function to operate a tertiary circuit-breaker. This shall be achieved using two programmable output contacts that are wired to sets of sliding link terminal blocks in the junction box.

- Shall send trip signal to the LV protection trip condition element (PRTC 3- with trip seal-in in accordance with the trip seal-in logic) that send via GOOSE message trip signals to the Process Interface Unit (PIU) which in turn activates a non-master trip output contact hardwired to the LV trip circuit of the circuit- breaker (If available), if cases where is not available, shall trip both HV and MV trip coils.
- Shall starts sustained fault timer, which after set time will give an output. Sustained earth fault timer output will then sent via GOOSE message to the HV CB PIU and MV CB PIU and trip both circuit breakers.
- Shall initiate LV circuit breaker fail and HV/ MV breaker fail will subsequently be started by sustained earth fault timer.
- Shall be reported locally via LED
- Shall be reported remotely as non-unit protection (Non-master)operated
- Shall be connected to the internal disturbance recorder (RBRB)
- Shall increment fault/trip counter.

3.5.1.4.4 Instantaneous Overcurrent protection – PIOC (50/50N)

The instantaneous over current protection is required for applications with large transformers/auto-transformers having a tertiary winding.

This function shall provide fast protection for phase and earth faults between HV post CT and Transformer HV bushings (likewise for MV if installed on MV side).

The instantaneous over current element shall operate the Master trip relay in addition to the main and back-up tripping coils of both circuit-breakers.

All instantaneous functions applied shall be immune against inrush current and its resultant high harmonic levels of the transformer.

3.5.1.4.5 HV instantaneous overcurrent function (PIOC 1)

- Shall operate the master trip relay function, which in turn activates the protection trip condition elements (PTRC 1, PTRC 2 and PRTC 3 - with trip seal-in in accordance with the trip seal in logic) that sends via GOOSE message trip signals to the Process Interface Unit which in turn activates the same output contacts hardwired to the trip circuit of the circuit- breakers (both HV and MV) as other unit protections.
- Shall be reported remotely as Master operated alarm.
- Shall initiate breaker fail function integrated within the same IED (RBRF) via master trip operation.
- Shall have trip operation connected to the IED internal binary disturbance recorder logical node (RBDR).
- Shall have its operation reported locally via its own LED indication preferably in the front IED panel. This indication shall be latched.
- Shall increment fault/trip counter

3.5.1.4.6 MV instantaneous overcurrent function (PIOC 2)

- Shall operate the master trip relay function, which in turn activates the protection trip condition elements (PTRC 1, PRTC 2 and PRTC 3- with trip seal-in in accordance with the trip seal in logic) that send via GOOSE message trip signals to the process Interface Unit which in turn activates the same output contacts hardwired to the trip circuit of the circuit- breakers (both HV and MV) as other unit protections.
- Shall be reported remotely as Master operated alarm.
- Shall initiate breaker fail functions integrated within the same IED (RBRF) via master trip operation.
- Shall have trip operation connected to the IED internal binary disturbance recorder logical node (RBDR).
- Shall have its operation reported locally via its own LED indication preferably in the front IED panel. This indication shall be latched.
- Shall increment fault/trip counter

3.5.1.4.7 Tertiary (LV) instantaneous overcurrent function (PIOC 3)

- Shall operate the master trip relay function, which in turn activates the protection trip condition elements (PTRC 1, PRTC 2 and PRTC 3- with trip seal-in in accordance with the trip seal in logic) that send via GOOSE message trip signals to the process Interface Unit which in turn activates the same output contacts hardwired to the trip circuit of the circuit- breakers (both HV and MV) as other unit protections.
- Shall be reported remotely as Master operated alarm.
- Shall initiate breaker fail functions integrated within the same IED (RBRF) via master trip operation.
- Shall have trip operation connected to the IED internal binary disturbance recorder logical node (RBDR).
- Shall have its operation reported locally via its own LED indication preferably in the front IED panel. This indication shall be latched.
- Shall increment fault/trip counter

3.5.1.4.8 Time-delayed residual earth fault protection - PTOC (51N)

Use of a dedicated measuring element 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 (3Io).

Fully flexibility of this function is required on all transformer schemes. Three stages in this function are required on the HV side and shall be configured as follows:

- One HV stage set to look toward the transformer.
- One HV stage set to look toward the HV busbar.
- One stage set non-directional.
- One MV stage set to look toward the transformer.
- One MV stage set to look toward the MV busbar.
- One stage set non-directional.

The HV E/F function should trip the V circuit- breaker and the MV E/F function should trip MV circuit –breaker as the transformer itself is a source for earth fault current.

3.5.1.4.9 HV and MV residual earth fault functions - (PTOC 4 and PTOC 5)

It is required that a residual HV and MV earth fault function shall be available as part of the over current functions as described above. The time-current curves shall be as described for the HV and MV over current protection elements, but shall include the option of a DTL characteristic. The HV residual earth fault shall trip the HV circuit-breaker main and back-up trip coils. The MV residual earth fault shall trip the MV circuit-breaker main and back-up trip coils.

3.5.1.4.10 HV IDMTL earth fault function – (PTOC 6)

In addition to the HV residual earth fault elements above, the scheme shall include an HV neutral element that is selectable between an IDMTL and DTL characteristic. This HV IDMTL/DTL neutral function shall operate the HV main and back-up trip coils.

3.5.1.4.11 MV Sensitive earth fault function - (PTOC 7)

Sensitive earth fault is a low-set definite time protection function. At least two PTOC elements shall be provided for this function.

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 10 amps primary with a CT ratio of 300/1. This equates to an element with a minimum pick up of 30 milliamps. Should the IED not be able to achieve this, the scheme shall be engineered with an option to supply and fit a ratio correcting CT to obtain this sensitivity.

3.5.1.4.12 Overload protection – (49) PTTR

Thermal overload protection shall comply with the requirements of IEC 60255-8. The heating expression shall comply with the following equation (IEC 60255-8):

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

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
- Shall be reported remotely via SCADA (IEC 61850)

3.5.1.4.13 Voltage - based protection functions – (27) (59/59N) PTOV

These protection functions shall be suitable to protect power transformers in accordance with their over voltage and over flux withstand capabilities. The protection functions shall trip the MV circuit-breaker main and back-up trip coils unless indicated otherwise.

The following voltage-based protection functions shall be provided, normally utilising a three-phase or single phase VT supply from the secondary/load-side of the transformer:

3.5.1.4.14 Over excitation (V/Hz) protection –

- Shall have a selectable option to trip or not to trip, both trip coils of the HV and MV circuit-breakers.
- Also an alarm for this condition shall be provided and be reported remotely
- Local indication shall be provided
- Shall have trip operation connected to the IED internal binary disturbance recorder logical node (RBDR).

3.5.1.4.15 Over and under voltage elements –

- Shall preferably three phase/positive sequence.
- The time-delayed over voltage function shall initially trip only the main and back-up coils of the MV circuit-breaker,
- but shall operate the main and back-up coils of the HV circuit-breaker after a settable additional time delay.
- Shall have trip operation connected to the IED internal binary disturbance recorder logical node (RBDR).

3.5.2 Protection-related functions (Group R)

3.5.2.1 Circuit breaker-fail protection - (50 BF) CBRBF/RBRF

Circuit-breaker fail functionality shall be provided separately for HV and MV circuit-breakers. Breaker fail protection is required to achieve the clearance of a fault if the breaker fails to trip when called upon to trip.

The breaker fail element is to be initiated by any trip signal from associated protection. Four current detector elements (each for per phase and one element in the residual circuit) which provide a current check feature shall be provided. These current detection elements should have suitable operate current setting ranges and must be characterised by having a fast resetting/drop off time (+/-10ms).

The breaker fail logic shall be such that a trip input and the presence of current in any one phase starts the breaker fail timer. Provided the trip input and the current check condition remain picked-up for the entire duration of the breaker fail timer, upon expiry of the said time, the breaker fail element will issue a trip to the surrounding back up breakers.

Previously, Eskom designs had reinforcing feature implemented by means of cross-tripping. Now having removed cross tripping, it is necessary to have reinforcing feature included in the function. The breaker fail timer shall have a suitable operate time setting range as indicated in the respective A/B schedules. The element operation should be flagged and be possible to reset.

The HV “circuit-breaker fail” function shall be initiated by the HV earth fault function and by the master trip relay i.e. all unit protections, the sustained fault timer and the HV and MV bus zone. After the HV “circuit-breaker fail” time, a HV bus strip shall be initiated. The “circuit-breaker fail” function shall be supervised by an undercurrent element, except where the initiating signal is not current dependant (e.g. Buchholz trip). The latter shall use a circuit-breaker auxiliary contact for supervision.

The MV “circuit-breaker fail” function is used when there is MV Busbar protection and is initiated by the master trip relay, the sustained fault timer and MV bus zone. On timing out, it will initiate an MV Busbar protection trip and trip the HV “Circuit-breaker.

Note; For Transformer- feeder applications:

At the transformer -end of transformer-feeders:

1) Only ONE breaker fail function should be used per breaker. This is to prevent false breaker fail operation if the remote breaker happens to be slower than the local breaker and or when the fault occurs close to the transformer.

2) Overcurrent and earth fault elements of the breaker fail should be connected to the CT’s connected directly to the breaker.

3) Trip outputs of the line protection should be arranged to initiate this breaker fail.

The circuit-breaker fail function to be applied to protection functions that are not current-based (e.g. Buchholz, under voltage, under frequency etc.) shall use a circuit-breaker auxiliary contact in place of the over current supervision. Alternative methods of supervision will be subject to approval.

3.5.2.2 Pole discrepancy protection

The Pole Discrepancy input is initiated by a set of circuit breaker auxiliary contacts arranged in a manner that detects discrepancy. A pole discrepancy trip is initiated after a time delay (0.1 to 2 seconds for breakers and 1 to 10 seconds for pantograph isolators).

This method primarily covers a disagreement condition brought about by a failure in the electrical circuitry of the circuit-breaker e.g. open-circuited trip coil or close coil, dirty auxiliary contacts etc.

- One contact shall hit the main trip coils to cover a disagreement that occurs when tripping the breaker by control switch or supervisory control, which operate on the back up trip coils. Hitting the main trip coils will free the stuck pole.
- Another contact shall hit the back-up trip coils to cover and electrical failure on one of the main trip coils.
- Shall provide remote and local alarms respectively.
- Shall have trip operation connected to the IED internal binary disturbance recorder logical node (RBDR).

3.5.2.3 Buchholz protection - SIML

This is a non-electrical protection for transformers which detects gas generation and surges in the oil. The gas generation detection portion of the relay can detect very low intensity faults, which would not be detectable by other protection.

The surge detection portion of the relay will cause the extremely rapid tripping of the transformer breakers for heavy internal faults.

- Input for alarm stage and which shall be alarmed locally and remotely shall be provided in the process interface unit.
- Input for trip stage which shall be locally and remotely reported shall be provided.
- The buchholz trip signal should operate the master trip relay.
- Shall have trip operation connected to the IED internal binary disturbance recorder logical node (RBDR).

3.5.2.4 Pressure Relief valve protection device – (SIMG)

The use of this logical node is preferred; optionally the traditional way of using binary input would be acceptable.

- Input detecting pressure relief operation shall be provided.
- This input shall operate the master trip relay.
- This shall be reported locally and remotely.
- Shall have trip operation connected to the IED internal binary disturbance recorder logical node (RBDR).

3.5.2.5 Sudden pressure protection – (SIMG)

The use of this logical node is preferred; optionally the traditional way of using binary input would be acceptable.

- Input detecting the sudden pressure operation shall be provided in all schemes.
- This trip input shall operate the master trip relay.
- An option to use this function either for tripping or alarming only shall be provided.
- Shall have trip operation connected to the IED internal binary disturbance recorder logical node (RBDR).

3.5.2.6 Reactor overpressure protection – (SIMG)

The use of this logical node is preferred; optionally the traditional way of using binary input would be acceptable.

- Input detecting pressure relief operation shall be provided.
- This input shall operate the master trip relay.
- This shall be reported locally and remotely.
- Shall have trip operation connected to the IED internal binary disturbance recorder logical node (RBDR).

3.5.2.7 Winding temperature protection – (YPTR)

This protection provides overload protection of the transformer.

3.5.2.8 Oil temperature protection – (YPTR)

The oil temperature devices are so slow that by the time it has operated for a fault, the transformer will almost certainly damaged. For this reason, the oil temperature device shall cause complete isolation of the transformer.

3.5.2.9 Master trip function (Relay)

The Master trip relay shall be integrated within the main protection IED, electronically latching type element that will be electrically reset by operating a push button on the protection panel. Resetting of the master shall be done via the front of the scheme. The relay shall have clear indication on the scheme front panel that an operation has occurred. The Master trip element shall be operated by the following functions:

a) HV and MV Restricted Earth Fault (REF);

b) Differential High-Set and Restrained protection;

c) Transformer Buchholz trip;

d) Transformer over pressure trip;

e) Transformer oil temperature trip;

f) OLTC Buchholz trip;

g) OLTC pressure trip;

h) NEC/R oil temperature/Buchholz trip;

i) Sustained Fault Timer trip;

j) HV hi-set/instantaneous over current trip;

k) Tertiary hi-set/instantaneous over current trip, and

l) MV circuit-breaker cable chamber arc flash trip;

m) LV Breaker-fail;

n) OLTC-Surge trip;

o) MV hi-set/instantaneous over current trip;

The Master trip relay shall operate both HV and MV circuit-breaker main and back-up trip coils. A Master Trip contact shall trip the transformer cooler fans. On operation of the Master trip relay, inspection of the transformer shall be initiated before re-energizing the transformer; thus the HV and MV circuit-breaker closing circuits shall be interlocked with a Master trip normally-closed/reset contact.

3.5.2.10 Customer Master Trip Relay (ordering option)

The customer Master trip relay shall be a mechanically latching relay that will be electrically reset by operating a push button on the protection panel. The relay shall have clear indication on the transformer scheme control panel that operation has occurred.

The purpose of this relay is to prevent the customer from closing the MV circuit-breaker for any trip originating from the Eskom transformer protection scheme. One normally-open and one normally-closed contact from the customer master trip relay shall be wired to the terminal strip for circuit-breaker tripping and close blocking respectively. The two output contacts from the Customer Master Trip relay shall be wired to sliding link terminal blocks. The customer master trip operation shall be reported via the main IED locally and remotely. Any operation of this relay shall also be marshalled on the internal IED disturbance recorder.

3.5.2.11 The Sustained Fault Timer (SFT)

The sustained fault timer function is used to trip the transformer Master Trip relay for un-cleared HV and MV faults (i.e. non-unit protection trips). The sustained fault timer is initiated by the operation of the following protection functions:

a) MV over current and earth fault;

b) Transformer winding temperature trip;

c) HV over current and earth fault; and

d) Auxiliary Transformer Oil temperature trip

Winding temperature trip functions shall be logically "ANDed" with an MV circuit-breaker auxiliary contact before initiating the SFT to prevent timing out of the sustained fault timer for the latched/slow resetting trip signals.

The sustained fault timer shall be implemented using a programmable timer within the main IED.

On timing out, the sustained fault timer shall operate the master trip relay and initiate the HV and MV circuit-breaker fail functions. The ratings and ranges of the timers will be specified in schedule A of an enquiry document.

3.5.2.12 Point on wave Switching option – (POW)

All the Eskom shunt reactors are required to be switched in a controlled manner. The strategy for controlled opening is to select arcing times long enough to avoid re-ignition at de-energizing. The strategy for controlled closing is to energize at instants resulting in minimizing the inrush current and the risk of mal-operations due to zero sequence currents that result. The magnitude of the transients depends on the point of wave where closing or opening of the circuit breaker contacts occur.

The scheme shall provide, as a scheme option, the facility to implement a point on-wave circuit-breaker opening and/ or closing device. The type of synchronizing opening and closing device will be determined by the applied circuit breaker type, which will be a free issue item from Eskom when required. The application for the above facility shall be done in a universal fashion, in order to cater for all common relay makes and models.

The Point On-Wave device will be installed in the junction box closer to the breaker it controls. And its state of health will be alarmed both locally in the IED HMI and remotely via Ethernet.

3.5.3 Measurement functions (Group M)

The schemes shall be capable of providing power system measurements by the main IED to Supervisory via the serial/Ethernet interfaces.

3.5.3.1 Measurements (MMXU)

The logical node for measurements shall be provided as specified on the IEC 61850 standard.

The inputs shall be made available, on a real time basis. Inputs must be rated for accuracy class accepted for measurements.

The quantities that shall be measured per MV and HV winding (excluding tertiary windings) and the required accuracies are as follows:

a) the r.m.s. MV red-to-white phase voltage: ± 0.5 %

b) the r.m.s. MV white phase current, range 0 to 1.1 x full load: ± 0.5 %

c) the MV three-phase active power in kW: ± 0.5 %

d) the MV three-phase reactive power in kVARs: ± 0.5 %

e) the r.m.s. HV red-to-white phase voltage: ± 0.5 %

f) the r.m.s. HV white phase current, range 0 to 1.1 x full load: ± 0.5 %

g) the HV three-phase active power in kW: ± 0.5 %

h) the HV three-phase reactive power in kVARs: ± 0.5 %

i) the MV Frequency:± 0.5 %

The quantities shall have an update rate of at most 1 second, or shall use a settable dead-band.

The HV- and MV side phase currents shall be available as the default display on the main IED, thereby providing local indications without the need for external gauges. It shall be possible for the main IED or transducer to display the voltage and power measurements following at most two key presses from the default display.

3.5.4 Supervision and Monitoring functions (Group S)

3.5.4.1 Trip circuit supervision

This shall be made available on all circuit-breaker trip circuits. Each scheme shall be fitted with trip circuit supervision on both the main and the back-up trip circuits of each circuit-breaker.

The trip circuit supervision shall detect any discontinuity in the tripping circuit, with the circuit-breaker in the open or closed positions.

The trip circuit supervision function shall be integrated into the main or back-up protection IEDs. Where possible, the IED that includes the circuit-breaker manual and remote closure and/or ARC functions shall be used for the TCS function.

Failure of a tripping circuit shall herald the “Protection Not Healthy” alarm.

Manual, supervisory and automatic closure of the circuit-breaker shall be blocked if both tripping circuits have failed.

Trip circuit supervision shall continuously monitor each phase of the trip circuit of the circuit-breaker. The trip circuit shall be supervised with the circuit-breaker in the close and open positions. The trip circuit supervision shall be integrated within the protection IED. The trip circuit supervision shall not adversely affect the dependability and security of the trip circuit. Trip circuit supervision shall:

- Monitor each phase of the bay breaker trip circuit independently;
- Reported locally at the line protection IED HMI;
- Reported locally to the main # protection system unhealthy indication; and,
- Reported remotely via the gateway; and,
- Reported to the station HMI.

3.5.4.2 Circuit-breaker monitoring – (SIMG)

This shall be provided per HV and MV circuit-breaker.

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 “ and ” SF6 gas inhibit” for SF6 circuit-breakers;
2) “Air pressure low" and "Air pressure inhibit” for air blast circuit-breakers;
3) Spring limit switch (SLS) contact indicating that the spring is discharged. This function shall be provided with a settable time delay on pick-up, ranging from 0 to 40 seconds, such that the alarm may be raised only if the spring fails to charge or (with a 0 second delay) raised whenever the spring is discharged for any reason (as per Phase 1 scheme designs);
4) Protection scheme spring rewind MCB auxiliary contact indicating the tripped state;
5) Circuit-breaker mechanism box common alarm: local/remote switch or spring rewind MCB tripped.
6) Cable/Busbar earth applied for indoor switchgear transformer bay;
7) Mechanical earth links applied.
8) Closing and Control DC fail
9) The “circuit-breaker not healthy” function shall energize an amber “Circuit-breaker not healthy” indication lamp and provide a supervisory alarm.

3.5.4.3 Circuit-breaker charging fail

This timer should be a “delayed on pick up” type with a settable time delay. The output of the timer shall block the closing of the circuit breaker. The contacts used shall be rated for control/interlock duty.

3.5.4.4 Circuit-breaker SF6 gas monitoring – (SIMG)

All Transformer schemes shall feature a common SF6 low alarm activated by an SF6 low condition in either circuit-breaker. The scheme shall include a means to isolate each incoming alarm circuit so as to assist in fault finding.

3.5.4.5 Circuit-breaker trip counting

The counting of each circuit breaker tripping shall be integrated in the IED and be displayed on the IED’s HMI.

For the further trip counting requirements, the requirements shall be provided as described in the standard for transmission and distribution common specification requirements (240-65336348, sub clause 3.5.4.5).

3.5.4.6 Current transformer SF6 gas monitoring

The requirements shall be provided as described in the standard for transmission and distribution common specification requirements (240-65336348, sub clause 3.5.4.6).

3.5.4.7 Indications

The requirements shall be provided as described in the standard for transmission and distribution common specification requirements (240-65336348, sub clause 3.5.4.7).

3.5.4.8 Lamp check

The requirements shall be provided as described in the standard for transmission and distribution common specification requirements (240-65336348, sub clause 3.5.4.8).

3.5.4.9 Panel not healthy indication

The requirements shall be provided as described in the standard for transmission and distribution common specification requirements (240-65336348, sub clause 3.5.4.9).

3.5.4.10 Junction Box Not healthy indication

The requirements shall be provided as described in the standard for transmission and distribution common specification requirements (240-65336348, sub clause 3.5.4.10).

3.5.4.11 DC supply monitoring

The requirements shall be provided as described in the standard for transmission and distribution common specification requirements (240-65336348, sub clause 3.5.4.11).

DC monitoring feature shall be provided and result in tripping of MV CB should a certain settable level be reached.

3.5.4.11.1 DC supply low voltage monitoring and tripping.

The scheme shall include, either via integral monitoring in the main IED (preferred) or via an external monitoring relay with inputs into the main IED, a function to monitor the auxiliary DC supply voltage level. Independently settable alarm and trip thresholds and time delays shall be provided. The alarm stage shall raise a local and supervisory alarm. The trip stage shall trip the main and back-up trip circuits of the MV circuit-breaker as well as providing local and remote indication.

The DC monitoring elements are used to provide for tripping of the transformer's MV circuit breaker when the DC voltage level becomes critically low. This is used to provide safe disconnection of MV plant equipment in a decaying DC scenario caused by protracted loss of auxiliary AC supply or uncorrected battery charger failure. The MV busbar and associated feeders are often not backed-up by upstream HV network protection and pose the most significant risk upon loss of DC supply at a substation. By not tripping the transformer HV circuit-breaker, operators are able to more easily restore AC supply to the charger. The low DC voltage tripping function shall not operate for a complete loss of DC supply (e.g. in the event that a DC supply MCB trips).

This is a back-up to the low voltage alarm from the battery charger. A trip is issued to the MV circuit-breaker upon further decay in DC supply. For 110V systems using lead acid batteries, use a warning level of 100V, tripping at 92V. For NiCADs use a warning level of 98V, tripping at 85V. The warning has a 5 second delay on pick-up, whilst the trip has a 30s pick-up delay (both set via programmable logic).

3.5.4.12 AC supply monitoring

The requirements shall be provided as described in the standard for transmission and distribution common specification requirements (240-65336348, sub clause 3.5.4.12).

3.5.4.13 Through-fault monitoring

Means of monitoring and reporting through fault current shall be provided. On several occasions Transformers are subjected to high through fault resulting in early lifetime failure.

3.5.4.14 Temperature monitoring

The transformer temperature shall be monitored and reported remotely via milliAmp signal. The milliamp signal shall correspond to the rated quantity.

3.5.5 Control functions (Group C)

3.5.5.1 Supervisory Isolate

The supervisory isolating switch shall be provided as described in the standard for transmission and distribution common specification requirements (240-65336348, sub clause 3.5.5.1).

The "OFF" and "ON" positions of the switch/integrated function shall be provided to supervisory via an input in the IED for indication purposes, not for alarming.

The SIS shall preferably be provided as an integral function of the protection IED that executes the supervisory control functions.

a) ***Description***	Selection between local control and remote.
OFF	Enable local control from IED HMI or front panel controls: • 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; • Tap changer raise and lower commands. • Set tap changer to manual operation • Set tap changer to automatic operation
ON	Enable remote controls from the station HMI and control centre: • Open and close commands to all the isolators and the circuit-breaker; • Tap changer raise and lower commands. • Set tap changer to manual operation • Set tap changer to automatic operation

	Disable local control from IED HMI or front panel controls: • Tap changer raise and lower commands. • Set tap changer to manual operation • Set tap changer to automatic operation

3.5.5.2 Test-Normal selection

This push button shall be used for testing and isolating purposes for the main protection circuits. A 3-push button shall be made available per scheme module, meaning each main protection shall have its independent selection push buttons.

The TNS provides isolation of the trip outputs to the circuit-breaker and bus zone panel for test purposes.

A TNS shall be provided on all schemes that include bus strip outputs, The TNS shall be provided via a three push buttons that physically interrupts the applicable circuits, rather than an integrated function in an IED disabling certain relay logic.

The TNS function provided on Transformer schemes shall have three positions, labelled “Normal”, “Test 1 and Test 2.

In the Test 1 position the HV and MV circuit-breaker fail bus strip contacts to the Busbar protection schemes are isolated, but all other trip circuits are operative.

In the Test 2 position the HV and MV circuit-breaker fail bus strip contacts to the Busbar protection schemes and the protection trip contacts to the circuit- breakers are isolated, but shall allow energization of panel relays and test points.

The TNS shall raise the “Protection Not Healthy” alarm when selected to any position other than “Normal”.

b) ***Description***	Selection of the desired test option for the protection tripping, breaker failure signal.
NORMAL	Enable: • Tripping to the main # trip-coils; • Breaker trip counting; • Breaker fail to the busbar protection scheme; and, • Indications and alarms
TEST1	Enable: • Tripping to the main # trip-coils; • Breaker trip counting. • Indications and alarms Disable: • Breaker fail to the Busbar protection scheme;
TEST2	Enable • Indications and alarms Disable: • Tripping to the main # trip-coils; • Breaker trip counting; and, • Breaker fail to the Busbar protection scheme;

DC supplies shall remain on the relay to allow operation of the relay to be checked.

3.6 Programmable logic & tripping matrix

Common Key for tripping Logic diagrams – see logic diagrams on annexure?

Tripping matrix is based to Eskom transmission transformer philosophy as stipulated in the standard for transformer and reactor protection schemes – TSP41-831. The logical diagrams attached as annexure highlights the proposed interconnections between the IED functions and the Circuit breaker trip coils and alarm annunciations. The proposed tripping logic should assists in the development of the programmable scheme logic.

Common keys used in the diagrams are defined in the definition sub clause of the document.

3.6.1 Protection Functionality Matrix

	ITEM	**6TAx300**	**6TMx100**	**6TMx200**	**6TTx100**	**6SRx100**	**6SRx200**	**6SRx300**
A	Scheme Shell	x	x	x	x	x	x	x
B	Tap-change	x	x	x	x	-	x	-
C	Control Interface	x	x	x	x	x	x	x
	IEC 61850	x	x	x	x	x	x	x
	IDF interface	-	-	x	-	-	-	-
D	Bay Control Device	x	x	x	x	x	x	x
D1	Motorised Isol. Incl.	x	option	-	option	x	x	x
D2	No motorised Isol.	-	option	x	option	-	-	-
E	Dual Main Protection	x	x	Single + Back-Up	Single + Back-Up	x	x	x
F	**Main Protection Functionality**							
	Differential Prot. **(87T)**	x	x	x	x	x	x	x
	Restricted Earth Fault(Low-Z) -**87N or 87G**	x (3)	x (2)	x (2)	-	x (1)	x (1)	x (1)
	Restricted Earth Fault(High-Z) - **HIZ**	-	x(1)	x(1)	x (1)	-	-	-
	NEC Prot. option	-	x	x	-	-	-	-
	Over-fluxing - PVPH	x	x	x	x	x	x	x
	Thermal – PTTR - 49	x	x	x	x	x	x	x
G	**Back up Protection Functionality – Integrated in each Main**							
	Breaker-Fail- (**50BF)**	x (3)	x (2)	x (2)	x (2)	x (1)	x (1)	x (1)
	HV Inst O/C –(**50)**	x (1)	x (1)	x (1)	x (1)	x (1)	x (1)	x (1)
	MV Inst O/C – (**50)**	x (1)	x (1)	x (1)	x (1)	-	-	-
	LV Inst O/C – (**50)**	x (1)	-	-	-	-	-	-
	HV IDMT O/C – (**51)**	x (1)	x (1)	x (1)	x (1)	x (1)	x (1)	x (1)
	MV IDMT O/C – (**51)**	x (1)	x (1)	x (1)	x (1)	-	-	-
	LV IDMT O/C – (**51)**	x (1)	-	-	-	-	-	-
	HV IDMT E/F – (**51N)**	x (1)	x (1)	x (1)	x (1)	x (1)	x (1)	x (1)

	MV IDMT E/F –(**51N)**	x (1)	x (1)	x (1)	x (1)	-	-	-
	LV IDMT E/F – **(51N)**	x (1)	-	-	-	-	-	-
	HV Inst E/F – (50N)	x (1)	x (1)	x (1)	x (1)	x (1)	x (1)	x (1)
	MV Inst E/F – (50N)	x (1)	x (1)	x (1)	x (1)	-	-	-
	LV Inst E/F – (50N)	x (1)	-	-	-	-	-	-
	TC O/C Trip/block – (51)	x (1)	x (1)	- x (1)	- x (1)	-	-	-
	TC U/C Blocking-PUCP (37)	x (1)	x (1)	x (1)	x (1)	-	-	-
	Back – Up Protection - Standalone							
	Breaker-Fail- (**50BF)**	x (1)	x (1)	x (1)	x (1)	x (1)	x (1)	x (1)
	HV Inst O/C –(**50)**	x (1)	x (1)	x (1)	x (1)	x (1)	x (1)	x (1)
	MV Inst O/C – (**50)**	x (1)	x (1)	x (1)	x (1)	x (1)	x (1)	x (1)
	LV Inst O/C – (**50)**	x (1)	-	-	-	-	-	-
	HV IDMT O/C – (**51)**	x (1)	x (1)	x (1)	x (1)	x (1)	x (1)	x (1)
	MV IDMT O/C – (**51)**	x (1)	x (1)	x (1)	x (1)	-	-	-
	LV IDMT O/C – (**51)**	x (1)	-	-	-	-	-	-
	HV IDMT E/F – (51N)	x (1)	x (1)	x (1)	x (1)	x (1)	x (1)	x (1)
	MV IDMT E/F –(51N)	x (1)	x (1)	x (1)	x (1)	-	-	-
	LV IDMT E/F – (51N)	x (1)	-	-	-	-	-	-
	HV Inst E/F – (50N)	x (1)	x (1)	x (1)	x (1)	x (1)	x (1)	x (1)
	MV Inst E/F – (50N)	x (1)	x (1)	x (1)	x (1)	-	-	-
	LV Inst E/F – (50N)	x (1)	-	-	-	-	-	-
	HV IDMT-O/C Dlr - 67	x (1)	x (1)	x (1)	x (1)	-	-	-
	HV IDMT E/F Dir – 67N	x (1)	x (1)	x (1)	x (1)	-	-	-
	MV IDMT-O/C Dlr - 67	x (1)	x (1)	x (1)	x (1)	-	-	-
	MV IDMT-E/F Dlr – 67N	x (1)	x (1)	x (1)	x (1)	-	-	-

3.6.2 Plant Protection Auxiliaries Matrix

	ITEM	**6TAx300**	**6TMx100**	**6TMx200**	**6TTx100**	**6SRx100**	**6SRx200**	**6SRx300**
	Buchholz Trip	x (1)	x (1)	x (1)	x (1)	x (1)	x (1)	x (3)
	HV Winding Temp. Trip	x (1)	x (1)	x (1)	x (1)	x (1)	x (1)	x (3)
	MV Winding Temp. Trip	x (1)	x (1)	x (1)	x (1)	-	-	-

	LV Winding Temp. Trip	x (1)	-	-	-	-	-	-
	Pressure Relief Trip	x (1)	x (1)	x (1)	x (1)	x (1)	x (1)	x (3)
	TC Pressure Relief Trip	x (1)	x (1)	x (1)	x (1)	-	x (1)	-
	TC Surge Trip	x (1)	x (1)	x (1)	x (1)	-	x (1)	-
	Sudden Pressure Rise Trip	x (1)	x (1)	x (1)	x (1)	x (1)	x (1)	x (3)
	Oil Temp. Trip	x (1)	x (1)	x (1)	x (1)	x (1)	x (1)	x (3)
	Master Trip Relay	x (1)	x (1)	x (1)	x (1)	x (1)	x (1)	x (1)
	Aux Trfr Oil Temp Trip	x (1)	-	-	-	-	-	-
	Aux Trfr Buchholz Trip	x (1)	-	-	-	-	-	-
	NEC Buchholz Trip	-	x (1)	x (1)	-	-	-	-
	NEC Oil Temp Trip	-	x (1)	x (1)	-	-	-	-

3.7 Scheme composition

3.7.1 IEDs

The main scheme /module shall comprise no more than two IEDs, with excluding tap change controller. It is envisaged that the scheme will have main IED and Bay controller located in the relay panel. The requirements for the junction box interface units shall be as described in the standard for transmission and distribution common specification requirements (240-65336348, sub clause 3.7.1).

The IEDs shall meet the requirements as specified in the Generic Specification for Protective Intelligent Electronic Devices (IEDs) Standard (240-64685228).

3.7.2 Auxiliary components

For auxiliary components requirements, shall meet the requirements as described in the standard document, unique identifier (240- 62773019).

3.7.2.1 230 AC Supply MCB – (AC) (10 Amp)

One 2-pole MCB rated at 10 Amps shall be provided in all the scheme types. No auxiliary contact is necessary for the status of this MCB, the “OFF state will be monitored via the AC fail alarm of the circuit.

The MCB provided shall further meet the requirements stipulated in the standard for transmission and distribution common specification requirements (240-65336348, sub clause 3.7.2.1).

3.7.2.2 Main# DC Isolating MCB – DCI (M#) (16 Amp)

1 x 2-pole MCB, rated at 16 Amps shall be provided in all the scheme types. An auxiliary contact which is normally open when the MCB is ON shall be provided for the reporting of the abnormal state of the MCB (“OFF” state). This alarm shall drive the panel not healthy lamp.

The MCB provided shall further meet the requirements stipulated in the standard for transmission and distribution common specification requirements (240-65336348, sub clause 3.7.2.2).

3.7.2.3 Main# Secure supply DC Isolating MCB – DCI (SS) (M#) (16 Amp)

1 x 2-pole MCB, rated at 16 Amps shall be provided in all the scheme types. An auxiliary contact which is a normally open contact when the MCB is “ON” shall be provided for the reporting of the abnormal state of the MCB (“OFF” state). This alarm shall drive the panel not healthy lamp.

The MCB provided shall further meet the requirements stipulated in the standard for transmission and distribution common specification requirements (240-65336348, sub clause 3.7.2.3).

3.7.2.4 Main# Ethernet Switch DC Isolating MCB – DCI (ETHSW) (M#) (6 Amp)

1 x 2-pole MCB, rated at 16 Amps shall be provided in all the scheme types. No auxiliary contact shall be provided for the reporting of the abnormal state of the MCB (“OFF” state), the supply fail to the switch shall be monitored with the use of “watchdog” contact from the Ethernet switch. This alarm shall drive the panel not healthy lamp.

The MCB provided shall further meet the requirements stipulated in the standard for transmission and distribution common specification requirements (240-65336348, sub clause 3.7.2.4).

3.7.2.5 Main# Tele-protection DC Isolating MCB – DCI (TP) (M#) (6 Amp)

This MCB is not applicable in all the transformer schemes.

3.7.2.6 Circuit-breaker Closing DC Isolating MCB – DCI (CL) (16 Amp)

1 x 2-pole MCB, rated at 16 Amps shall be provided in all the scheme types. An auxiliary contact which is normally open when the MCB is “ON” shall be provided for the reporting of the abnormal state of the MCB (“OFF” state). This alarm shall drive the panel not healthy lamp.

The MCB provided shall further meet the requirements stipulated in the standard for transmission and distribution common specification requirements (240-65336348, sub clause 3.7.2.6).

3.7.2.7 Indication DC Isolating MCB – DCI (IND) (6 Amp)

1 x 2-pole MCB, rated at 6 Amps shall be provided in all the scheme types. An auxiliary contact which is normally open when the MCB is “ON” shall be provided for the reporting of the abnormal state of the MCB (“OFF” state). This alarm shall drive the panel not healthy lamp. The monitoring of this supply rail via auxiliary contact is optional; any other monitoring means will be accepted.

The MCB provided shall further meet the requirements stipulated in the standard for transmission and distribution common specification requirements (240-65336348, sub clause 3.7.2.7).

3.7.2.8 Circuit-breaker Spring Rewind DC Isolating MCB – DCI (SR) (25 Amp)

1 x 2-pole MCB, rated at 25 Amps shall be provided in all the scheme types. An auxiliary contact which is normally open when the MCB is “ON” shall be provided for the reporting of the abnormal state of the MCB (“OFF” state). This alarm shall drive the panel not healthy lamp.

The MCB provided shall further meet the requirements stipulated in the standard for transmission and distribution common specification requirements (240-65336348, sub clause 3.7.2.8).

3.7.2.9 Motorised Isolator DC Isolating MCB – DCI (MI) (25 Amp)

1 x 2-pole MCB, rated at 25 Amps shall be provided in all the scheme types. An auxiliary contact which is normally open when the MCB is “ON” shall be provided for the reporting of the abnormal state of the MCB (“OFF” state). This alarm shall drive the panel not healthy lamp.

The MCB provided shall further meet the requirements stipulated in the standard for transmission and distribution common specification requirements (240-65336348, sub clause 3.7.2.9).

3.7.2.10 IED DC Isolating MCB – DCI (IED) (6 Amp)

1 x 2-pole MCB, rated at 6 Amps shall be provided in all the scheme types. No auxiliary contact shall be provided for the reporting of the abnormal state of the MCB (“OFF” state); the supply fail to the IED shall be monitored with the use of “watchdog” contact from the IED. This alarm shall be reported as part of an IED fail status alarm.

The MCB provided shall further meet the requirements stipulated in the standard for transmission and distribution common specification requirements (240-65336348, sub clause 3.7.2.10).

3.7.2.11 VT Main Isolating MCB – MCB (VT) (2 Amp)

1 x 3-pole MCB, rated at 2 Amps shall be provided in all the scheme types. An auxiliary contact which is normally open when the MCB is “ON” shall be provided for the reporting of the abnormal state of the MCB (“OFF” state). This alarm shall be reported as VT MCB fail.

The MCB provided shall further meet the requirements stipulated in the standard for transmission and distribution common specification requirements (240-65336348, sub clause 3.7.2.11).

3.7.2.12 VT Sync MCB – MCB (SYNC) (6 Amp)

This MCB is not applicable in all the transformer schemes.

3.8 Physical construction

3.8.1 Safety and regulatory requirements

No approval given or implied by Eskom shall relieve the Tenderer of any statutory obligations regarding safety. Tenderers shall declare any information relating to any implosion or explosion risk or other hazards which may be associated with the equipment and which occur in use or in handling.

Tenderers shall supply products that comply with the general safety requirements as specified in the IEC 60255-27 standard.

- The equipment shall not jeopardize the safety of people and property.
- Users shall be protected against electric shock hazards by use of good constructional and engineering practice.
- Protection against contact with accessible hazardous live parts shall be provided.
- Earthing in equipment is required not only to reduce the effects of interference, but also, and more importantly, for reasons of personnel safety.
- Where there is any conflict between these two requirements, personnel safety shall always take precedence

3.8.2 Scheme housing and mounting

The scheme housing and mounting shall meet the requirements stipulated in the standard for transmission and distribution common specification requirements (240-65336348, sub clause 3.8.2).

3.8.3 Panel design

The panel design shall meet the requirements stipulated in the standard for transmission and distribution common specification requirements (240-65336348, sub clause 3.8.3).

The typical equipment layout is shown in the following diagram Figure 1 on sheet 75 of the document. The final layout of components will be completed during development engineering stage.

Two relays will be installed in the same panel. The two relays will be protection relay with all protection functions integrated, and the other relay would be for bay control functions.

3.8.4 Panel finishing

Panel finishing’s shall meet the requirements stipulated in the standard for transmission and Distribution protection schemes, common specification requirements, 240-65336348.

3.8.5 Component mounting and fixing

Component mounting and fixing shall meet the requirements stipulated in the standard for transmission and Distribution protection schemes, common specification requirements, 240-65336348.

3.8.6 Terminals

Terminals shall meet the requirements stipulated in the standard for transmission and Distribution protection schemes, common specification requirements, 240-65336348.

3.8.7 Terminal strips

Terminals strips shall meet the requirements stipulated in the standard for transmission and Distribution protection schemes, common specification requirements, 240-65336348.

3.8.8 Vertical and horizontal wiring trunking

Terminals shall meet the requirements stipulated in the standard for transmission and Distribution protection schemes, common specification requirements, 240-65336348.

3.8.9 Wiring supports

Wiring supports shall meet the requirements stipulated in the standard for transmission and Distribution protection schemes, common specification requirements, 240-65336348.

3.8.10 Wiring terminations

Wiring terminations shall meet the requirements stipulated in the standard for transmission and Distribution protection schemes, common specification requirements, 240-65336348.

3.8.11 Wiring identification

Wiring identification shall meet the requirements stipulated in the standard for transmission and Distribution protection schemes, common specification requirements, 240-65336348.

3.8.12 Earthing

Earthing shall meet the requirements stipulated in the standard for Earthing of protection equipment, document unique identifier- 240-64100247.

3.8.13 Labelling

Labelling shall meet the requirements stipulated in the standard for panel labelling, unique identifier 240-62629353.

3.8.14 Packaging for transport

Scheme modules are to be supplied loose in suitable crates or in swing frame or fixed frame panels as per specific order. The scheme, whether installed in a swing frame shall be packed in a high specification impact resistant corrugated cardboard box and /or a wooden crate.

The packaging shall be waterproof, and shall protect the contents from reasonable transport related wear and tear from supplier’s works to the end site.

3.8.15 Markings

The outside of the packaging shall be clearly marked indicating:

a) Substation Name:

b) Detailed delivery address:
c) Detailed content description as per order:
d) Dispatch date:
e) Eskom order number:

3.9 Tests

3.9.1 Prototype tests

Refer to sub clause 4.1, of document 240- 65336348.

3.9.2 Environmental testing

3.9.2.1 Insulation resistance (across isolating barrier) test

Refer to sub clause 4.1.1.1, of document 240- 65336348.

3.9.2.2 Electrical impulse test 1, 2/50µs

Refer to sub clause 4.1.1.2, of document 240- 65336348.

3.9.3 Functional testing

3.9.3.1 Initial visual inspection

Refer to sub clause 4.1.2.1, of document 240- 65336348.

3.9.3.2 Initial performance test

Refer to sub clause 4.1.2.2, of document 240- 65336348.

3.9.3.3 Final performance test

Refer to sub clause 4.1.2.3, of document 240- 65336348.

3.9.3.4 Final visual test

Refer to sub clause 4.1.2.4, of document 240- 65336348.

3.9.4 Model power system simulator testing

The model power system simulator (MPSS) testing shall meet the requirements specified in the standard for transmission and distribution common specification requirements (240-65336348, sub clause 4.1.3).

3.10 Testing of production schemes

3.10.1 Routine testing

Refer to sub clause 4.2.1, of document 240- 65336348.

3.10.1.1 Visual inspection

Refer to sub clause 4.2.1.1, of document 240- 65336348.

3.10.1.2 Performance test

Refer to sub clause 4.2.1.2, of document 240- 65336348.

3.10.2 Site testing

3.10.2.1 Visual inspection

Refer to sub clause 4.2.2.1, of document 240- 65336348.

3.10.2.2 Performance test

Refer to sub clause 4.2.2.2, of document 240- 65336348.

3.11 Tender requirements

3.11.1 Tender completion requirements

For this sub clause refer to requirements specified in the standard for transmission and distribution common specification requirements (240-65336348, sub clause 5.1).

3.11.2 Tender evaluation criteria

For this criteria sub clause refer to requirements specified in the standard for transmission and distribution common specification requirements (240-65336348, sub clause 5.2).

3.11.3 Product development process

Refer to sub clause 5.3, of document 240- 65336348.

3.11.3.1 Prototype scheme design diagrams

Refer to sub clause 5.3.1, of document 240- 65336348.

3.11.3.2 Prototype scheme development and built

Refer to sub clause 5.3.2, of document 240- 65336348.

3.11.3.3 Design freeze for the production phase

Refer to sub clause 5.3.3, of document 240- 65336348.

3.11.3.4 Production phase

Refer to sub clause 5.3.4, of document 240- 65336348.

3.11.3.5 Production scheme delivery

Refer to sub clause 5.3.5, of document 240- 65336348.

3.11.4 Price schedule categories

Refer to sub clause 5.4, of document 240- 65336348.

3.11.5 Engineering fees and provision of prototypes

Refer to sub clause 5.5, of document 240- 65336348.

3.11.6 Warrantees, spares and support

Refer to sub clause 5.6, of document 240- 65336348.

3.11.6.1 Warrantees

Refer to sub clause 5.6.1, of document 240- 65336348.

3.11.6.2 Spares

Refer to sub clause 5.6.2, of document 240- 65336348.

3.11.6.3 Repairs

Refer to sub clause 5.6.3, of document 240- 65336348.

3.11.6.4 Support

Refer to sub clause 5.6.4, of document 240- 65336348.

3.11.7 In-service experience requirements

Refer to sub clause 5.3.4, of document 240- 65336348.

3.12 Documentation

Documentation is deemed to be as important as the scheme itself and the documentation shall be developed in parallel with the protection scheme. Documentation shall be completed and approved before the first production unit is delivered to Eskom.

All documentation shall be supplied in *.pdf (acrobat) and editable Microsoft Word formats. Two complete documentation sets (printed and bounded, also on CD) shall be submitted to Eskom on conclusion of the development phase. Eskom shall have a right to freely copy and distribute the documentation by any means, whether it is by hardcopy or an electronic medium.

The documentation shall be comprehensive, clear, and concise and shall be supplied in accordance to **sub clause 6.1** of this document. The documentation shall be in the same format and use the same numbering system and headings indicated **sub clause 6.1** below and it shall include the following items:

Detailed technical manuals and specification sheets in searchable, indexed *.pdf format.

A detailed description of the application of the scheme, its operation and protection features.

The documentation supplied with all electronic equipment shall be in English and shall comply with requirements of IEC 61187. Unless agreed otherwise, the size of the manuals shall be A4.

For further requirements refer to **sub clause 6**, of document 240- 65336348.

3.12.1 Scheme manual requirements

Refer to sub clause 6.1, of document 240- 65336348.

3.12.2 Settings guide

Refer to sub clause 6.2, of document 240- 65336348.

3.12.3 Scheme selection and application guide

Refer to sub clause 6.3, of document 240- 65336348.

3.13 Training

Refer to sub clause 7, of document 240- 65336348.

3.14 Shunt Reactor Protection Technical Requirements

3.14.1 Application

The protection scheme described in this document is intended for application with high and extra high voltage reactors of rated capacities from 30 Mvar up to and including 400 Mvar. The protection scheme developed shall offer sufficient flexibility in application so as to cover Eskom's normal needs. Occasionally, a special application is required. There should be minimal amount of additional engineering required to produce a special scheme which suits the specific application.

The schemes shall be suitable for application in the following applications:

a) Busbar and Line reactor

b) Transformer Tertiary connected reactor

c) Variable reactor with tap-changer and auxiliary power winding

The schemes utilized shall seek to attain uniformity of design, incorporating possible protection IEDs of the same make and model number as the schemes used in the transformer protection, differing only in the application and in the IED configuration and labeling. In principle, the scheme philosophy is similar to that applied in transformers:

a) Duplicated protection systems

b) Speed of protection operation a priority

c) Master tripping

d) Bus-zone tripping

The protection system shall include as a minimum requirement the following functionality:

a) Biased Differential protection

b) Restricted earth fault protection

c) Time delayed Overcurrent protection

d) Instantaneous Overcurrent protection

e) Time-delayed residual earth fault protection

f) Circuit breaker-fail protection

g) Pole discrepancy protection

h) Buchholz protection

i) Sudden pressure protection

j) Reactor overpressure protection

k) Winding temperature protection

l) Oil temperature protection

All the other requirements for the reactor schemes will be exactly the same as required for the transformer schemes.

4. Authorisation

This document has been seen and accepted by:

Name	Designation
Richard McCurrach	Senior Manager - PTM & C
Graeme Topham	Protection & Automation Study Committee Chairman – (SCOT)

Name	Designation
Adam Bartylak	Corporate Specialist - Protection
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Prince Kara	Protection Manager – PTM&C
Phillip Groenewald	Smart Grid Manager – PTM & C
Thys Bower	Senior Consultant – PTM&C Protection
Ian Worthington	Southern Grid – Middle Manager Secondary Plant
Nelson Luthuli	North West Grid - Middle Manager Secondary Plant
Selby Mudau	Northern Grid – Middle Manager Secondary Plant
Avhapfani Luvhengo	Central Grid – Middle Manager Secondary Plant
Keneth Nhlapo	North East Grid – Middle Manager Secondary Plant
Anre Swart	Western Grid – Middle Manager Secondary Plant
Boitumelo Gcwabaza	Eastern Grid – Middle Manager Secondary Plant
Nombuso Ramaite	Apollo Grid – Middle Manager Secondary Plant
Paul Giewelaar	Northern Cape Grid – Middle Manager Secondary Plant
Humbulani Mutasah	Orange Free State Grid – Middle Manager Secondary Plant

5. Revisions

This revision cancels and replaces revision No. 0 of document No. DSP_34-467 and TRMSCABN3.

Date	Rev.	Compiled By	Remarks
March 2014	1	B.B. Qwabe	New Document compiled due to merge of Technology departments of Distribution and Transmission.

6. Development Team

The following people were involved in the development of this document:

Bongani Qwabe

Paul Gerber

7. Acknowledgements

None

Annex A – Price Schedule Items

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

Price schedule shall be broken down into four categories:

The scheme/module permutations are detailed in this standard document. Listed are typical price schedule items, and the items shall be independently priced:

Item	Description
1.1	**Scheme Engineering**
1.1.1	Design
1.1.2	Development
1.1.3	Model Power System Simulator Testing (refer to 4.1.3 of 240-65336348)
1.1.4	Factory Acceptance Testing (refer to 4.1.2 of 240-65336348)
1.1.5	Scheme Type testing (refer to 4.1.1 of 240-65336348)
1.2.	**Scheme documentation**
1.2.1	Settings guide (refer to 6.2 of 240-65336348))
1.2.2	Scheme selection and application guide (refer to 6.3 of 240-65336348))
1.2.3	Scheme manual (refer to 6.1 of 240-65336348))
1.2.4	Test Tools
1.3	**Scheme/module permutations (independently priced)**
1.3.1	Auto Transformer - 6TA #300
1.3.2	Auto Transformer - 6TA #200
1.3.3	Two Winding - 6TM #100
1.3.4	Two Winding - 6TM #200
1.3.5	Mobile transformer -6TM#150
1.3.6	Traction transformer - 6TT#100
1.3.7	Busbar reactor - 6SR#100
1.3.8	Busbar reactor with Tertiary winding 6SR#200
1.3.9	Series reactor - 6SR#300
1.3.10	Busbar reactor - 6SR#400 (For Brown stations with legacy communications)
1.4	**Process interface units**
1.4.1	Breaker PIU
1.4.2	Transformer PIU
1.4.3	Tap changer PIU

1.5	Substation automation engineering (SCD engineering etc.)
1.6	**Training**
1.6.1	Specialised Training per day (+/- 20 people) (refer to 7)
1.6.2	Product training for Grid staff per day (+/- 8 people) (refer to 7)
1.7	Site commissioning per scheme type
1.7.1	Auto Transformer - 6TA #300
1.7.2	Auto Transformer - 6TA #200 to interface with legacy schemes
1.7.3	Two Winding - 6TM #100
1.7.4	Two Winding - 6TM #200
1.7.5	Mobile transformer -6TM#150
1.7.6	Traction transformer - 6TT#100
1.7.7	Busbar reactor - 6SR#100
1.7.8	Busbar reactor with Tertiary winding 6SR#200
1.7.9	Series reactor - 6SR#300
1.7.10	Busbar reactor - 6SR#400 (For Brown stations with legacy communications)
1.8	**Spares – list and independently priced**

This is further subdivided into schemes.

This part of the document serves the purpose of clarifying what is required under the above categories and details any specific and general comments which are applicable to items listed on the price schedule.

B 1.1 .1 Design

Item 1.1.1 includes the following for the prototype and all other permutations:

- Panel Architecture,
- Scheme drawings,
- IEDs configuration,
- IEC 61850 bay engineering
- Process interface units engineering

This item further requires that the tenderer take the information which is given in the standard specification document for a specific portion of the scheme and implement it in hardware form, using specific protection products which are available to him.

The actual hardware of the prototypes shall be excluded from this price.

B 1.1.2 Development

Item 1.1.2 includes the following:

- structural design for the prototype and all other permutations
- Construct and build of the prototype scheme

B 1.2.4 Test Tools

Eskom would like to be able to make use of already developed automated test software produced by relay test set manufacturers. Eskom has invested large sums of money in the Omicron and Megger range of test sets, it would therefore necessary for automated test procedures to be developed and implemented via these test sets. These test procedures shall be written in such a manner that would assist in the training of the field and testing personnel. The test templates shall be owned and managed by Eskom during production phase.

These templates and routines shall be verified during the product development phase. The test routine shall include the verification of all settable settings and input/outputs (binary and IEC 61850).

Annex B– Performance Questions

Tenderers shall submit in writing with their offer the answers to the following questions. Any technical documentation that may support the answers shall be provided.

Comprehensiveness of the answers to the questions will be taken into consideration when evaluating the offer. Failure to answer the questions fully and in a technically competent manner may lead to the offer not being considered.

NOTE: Any comments pertaining to the suitability of the protection philosophy described for the intended application will be valued.

C1 General

C1.1 Give details on the operation of the event recorder.

C1.2 Give details on the operation of the fault/disturbance recorder.

C1.3 Give details on the operation of the local human-machine interface and PC with regard to settings of the IED.

C1.4 Give details on the level of integration of switches and auxiliary relays into the main and back-up relays.

C1.5 Give details on the communication facilities available on the IED.

C1.6 Does the IED have password protection? Give details.

C1.7 Give details on the metering/measurement function, if available in the IED. Describe what user actions are required to view measured quantities on the IED's LCD display.

C1.8 Provide details on the number binary inputs and outputs and whether they are configurable. Are the binary inputs able to reject high frequency noise (i.e. are they able to reject short duration spikes that may be induced into the wiring)? Is this settable?

C1.9 What is the time duration that each IED takes to be fully operative when the D.C. supply is switched on?

C1.10 What is the time duration that each IED takes to be fully operative when new settings have been transferred through the front communications port (measured from the time that the transfer is started)?

C1.11 Give a list (compulsory) of references for all equipment performance stating names, telephone numbers, addresses, etc.

C1.12 Give details on the operation of the trip circuit supervision function.

C1.13 Give details of the snubber circuit to be implemented.

C1.14 Give details of what happens when the IEDs in the scheme are subjected to a slowly decaying auxiliary DC supply as in the case of a substation battery charger fail. Will the IEDs power up normally once the DC is made normal again?

C1.15 On the IEDs where PC communication with the IED is possible, are direct online measurements by PC possible, or does one first has to download a file from the IED to the PC that is then evaluated off-line?

C1.16 Provide full details of self-monitoring features for all numerical IEDs offered.

C1.17 Please provide details of the manner in which tripping and alarm indications from external devices (e.g. transformer protection, external REF etc.) will be provided on the protection IED.

C1.18 Where separate from the protection IED, please provide details of the alarming unit/annunciator that is used for flagging external tripping and alarm devices inclusive of the high impedance REF. Is this unit widely used in substations for protection purposes? Please provide the necessary supporting documentation to support this.

C1.19 Is the date on which the last configuration or parameterization of the IED made recorded?

C1.20 Will the disturbance recording be configured by means of logical nodes?

C1.21 Will a disturbance record be recorded in COMTRADE format?

C1.22 Please provide details of different ways that may be used to download a disturbance record from an IED?

C1.23 Please state the capability for the output contacts/circuits not rated for tripping?

C1.24 Please provide preferably in your IED documentation/manual, the contact rating for all auxiliary relays, using the format of IEEE standard C37.90, table 5, 6 and 7. Note: Eskom uses 50Hz in all applications.

C1.25 Is the performance of the IED in anyway affected by the number of functions selected to be active in any given application? If not, how is the independence of the IED's performance with respect to the number of functions in-service achieved?

C1.26 Provide details of the main protection devices capability to provide condition based monitoring information e.g. circuit-breaker fault interruption statistics?

C1.27 Provide details of non-volatile programmable counters and latch logic within the main IED?

C1.28 Where the IED calculates and stores through –fault event data /statistics, please provide details?

C2 Biased differential functions

C2.1 Give details of operating (tripping) times of the proposed IED.

C2.2 Is it possible for the biased differential IED to be used on two and three winding transformers?

C2.3 Give details on the method used to provide internal compensation of different transformer vector groups (without the need for external interposing CTs)?

C2.3.1 If, the relay does have feature for compensation either ratio or /and vector group, what are the angular and scalar limits?

C2.4 State the method of measurement with regard to the biased differential protection.

C2.5 What effect do harmonics have on the biased differential protection function?

C2.6 How does the IED cope with CT saturation? What is the delay in IED operation caused by CT saturation? How are these problems overcome in the IED design?

C2.7 How is stability ensured for inrush (magnetising) currents?

C2.8 What are the CT requirements relay burden?

C2.9 Does the relay include any form of over-excitation protection?

C2.9.1 If so, please state what type?

C2.10 Does the relay include additional protection functions which have not been called for (e.g. through-fault monitoring)**?**

C2.10.1 If so, give the type and details?

C2.11 Please provide details on how the differential IED copes with furnace-type loads. Please indicate your level of confidence that the differential IED will not mal operate for the onerous conditions of supplying a furnace transformer. Please substantiate this with factual data, locations and customers who are successfully using the differential IED for such applications. Are there any special requirements to ensure total stability?

C2.12 Can the relay store data and event records which can be retrieved by means of supporting software or manual readout?

C2.12.1 If so, please supply details

C2.13 Does the relay have self-monitoring facilities?

C2.13.1 If so, please supply details.

C2.14 Is the flagging information stored in the event of a DC supply interruption (<100ms)?

C2.15 Is there support software available and what is PC compatibility required?

C2.15.1 If so, give details and list PC requirements.

C3 Back-up (over current) protection function

C3.1 Please detail for MV neutral element, how the minimum primary current sensitivity of 10 amps with a CT ratio of 300/1 will be achieved?

C4 Restricted Earth Fault protection

C4.1 Give details of operating (tripping) times of the proposed IED or IEDs. It is a requirement for the main IED to include low impedance REF and also that an option of a separate external HV and MV high impedance REF relay is made available, thus please discuss both devices for all questions.

C4.2 State the method of measurement with regard to the restricted E/F protection.

C4.3 What effect do harmonics have on the restricted E/F protection function?

C4.4 How does the relay cope with CT saturation? What is the delay in relay operation caused by CT saturation? How are these problems overcome in the relay design?

C4.5 How does the IED perform on-load directional checking to establish correct IED direction?

C5 Circuit –Breaker fail function

C5.1 Is the Circuit breaker-fail integrated in the Bay control IED?

C5.2 How is the fast resetting of the current detection elements achieved?

C5.3 What is done to prevent slow resetting on CT secondary current decay especially for the circuit breaker failure current elements?

C6 Miscellaneous protection functions

C6.1 Please provide full detail on the auxiliary DC supply low voltage monitoring and tripping function. Is this an integrated function of the main IED?

C6.2 Are plausibility checks performed on IED settings before these are allowed to be activated?

If yes, what checks are done and are settings conflicts detected and operator informed of such problems?

C7 Voltage and Frequency protection functions

C7.1 Please provide full details on the V/Hz function and the application and setting thereof. Is it feasible to implement the function using VTs on the MV (tap change voltage –regulated) side of the transformer?

C7.2 Please indicate whether or not the device offers under frequency and/or under voltage protection elements.

C7.3 Which VT input/phase is used for the frequency measurements?

C7.4 Does the IED perform averaging of the measured frequency?

C7.5 Does the device offer three phase/positive sequence under/overvoltage protection

Annex C – Drawing set

"Drawings shall be prepared so that they may be used for wiring and checking. The drawings shall show wire destination and equipment identification (C37.21-2005)."

Following is a typical Relay panel drawing set:

Scheme Name:	6TA-xxxx
Drawing Reference:	0.52/30387
Number of Sheets:	28

Following is a typical existing Protection scheme drawing set:

Scheme Name:	5TA-x200
Drawing Reference:	0.52/30397
Number of Sheets:	62

FIGURE 1 - 6TM-#100 PROTECTION BLOCK DIAGRAM

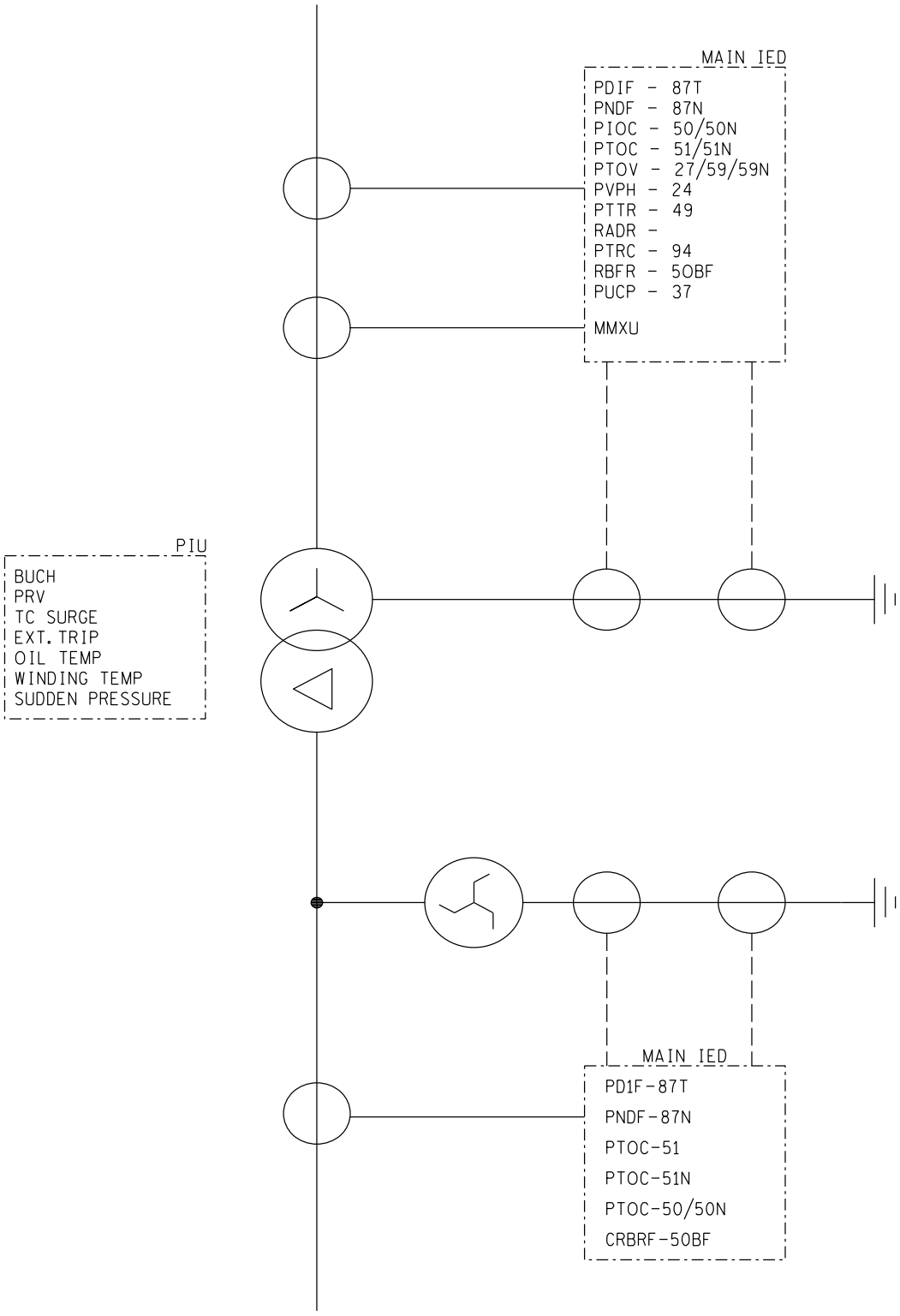

FIGURE 2 - 6TM-#200 PROTECTION BLOCK DIAGRAM

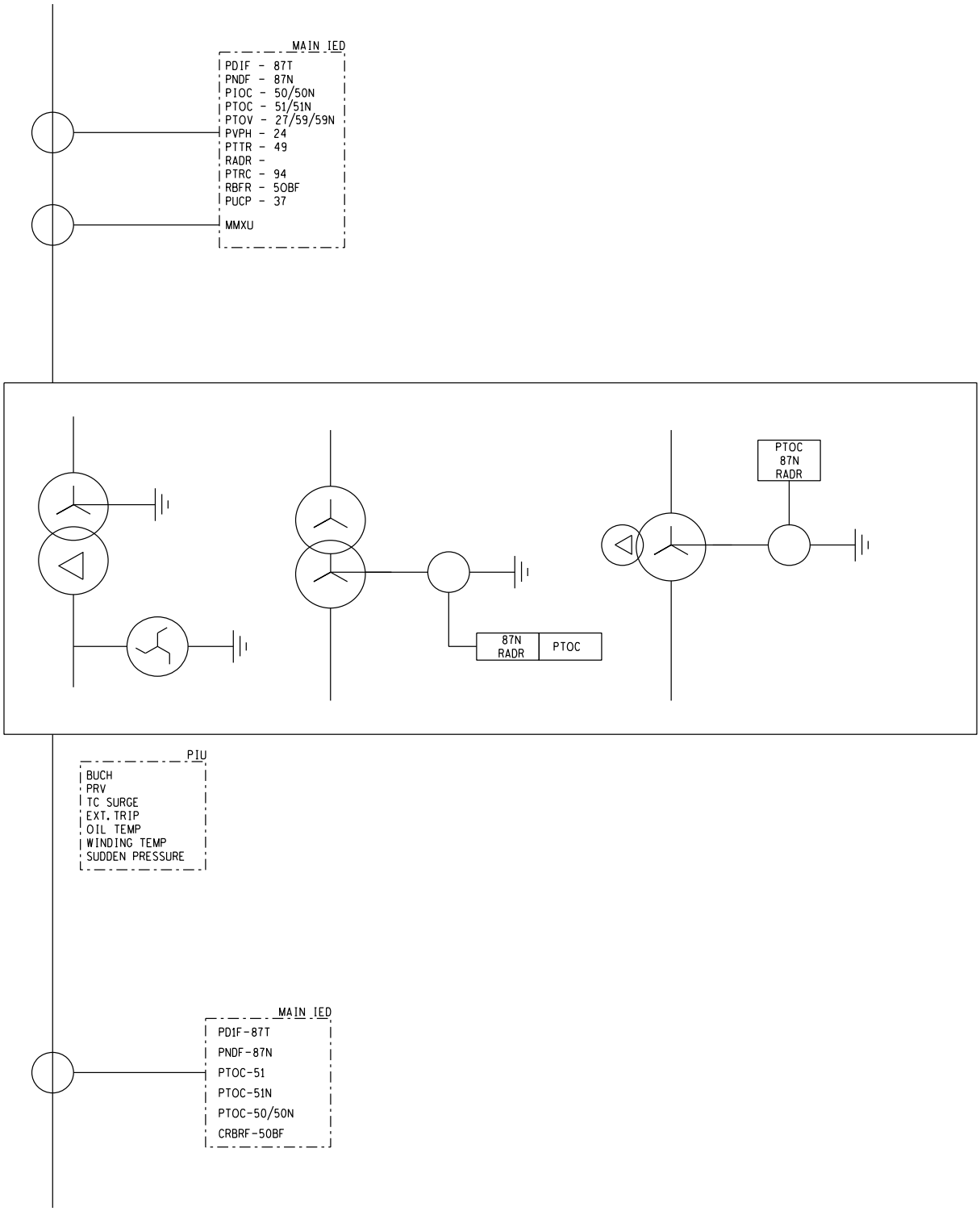

FIGURE 3 - 6TA-#300 PROTECTION BLOCK DIAGRAM

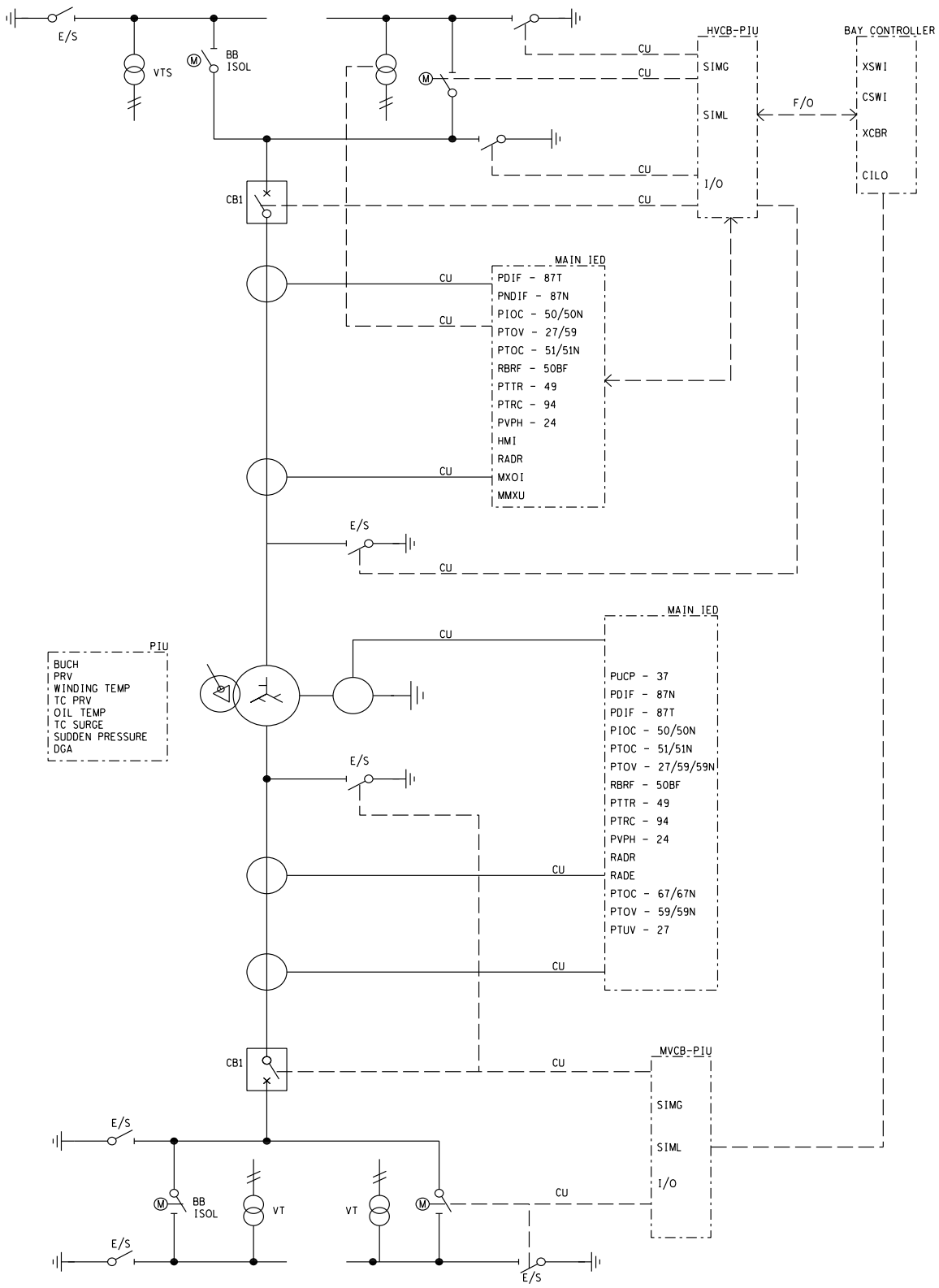

FIGURE 4 - 6TT-#100 PROTECTION BLOCK DIAGRAM

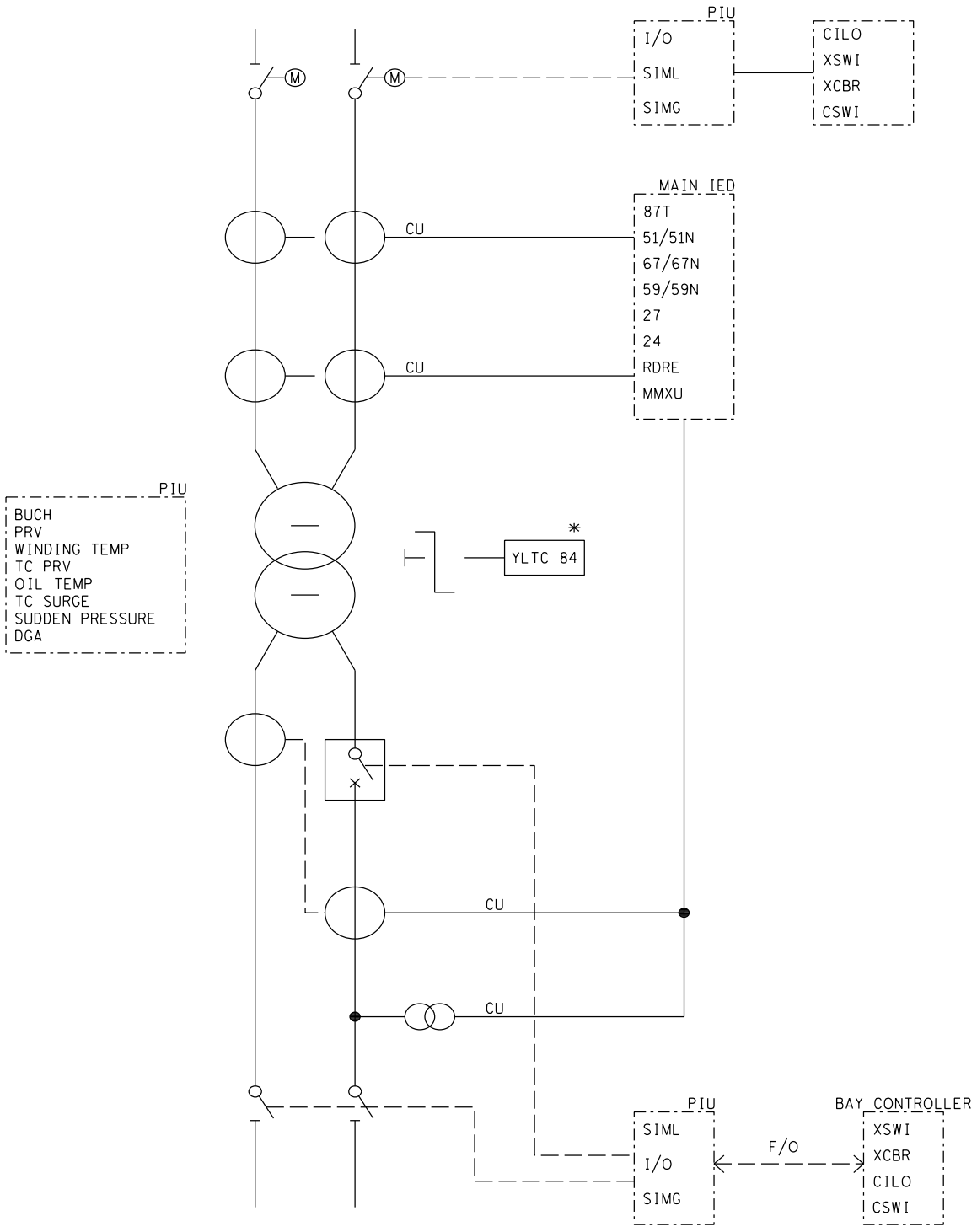

FIGURE 5 - 6SR-#100 PROTECTION BLOCK DIAGRAM

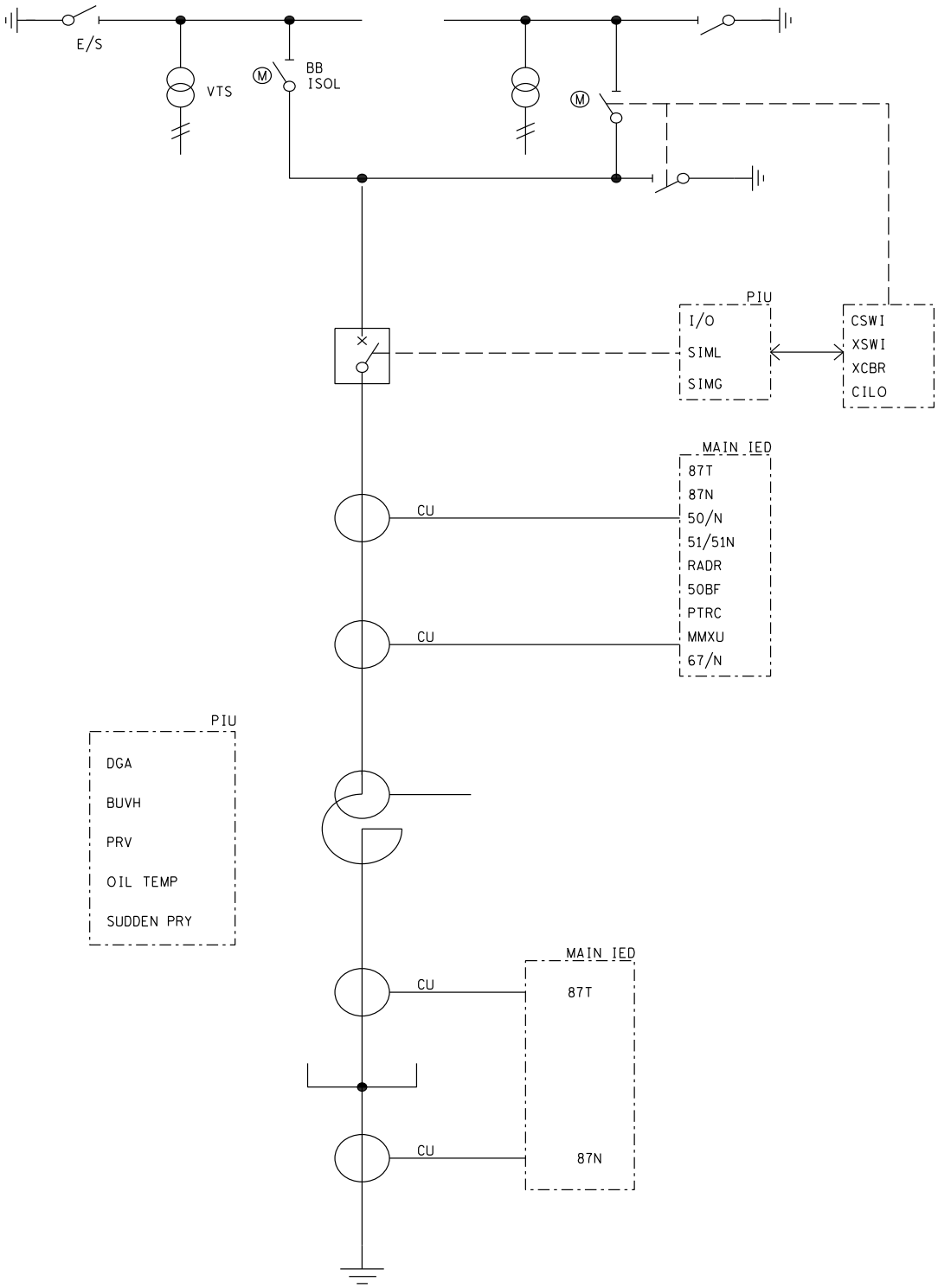

FIGURE 6 - 6SR-#200 ROTECTION BLOCK DIAGRAM

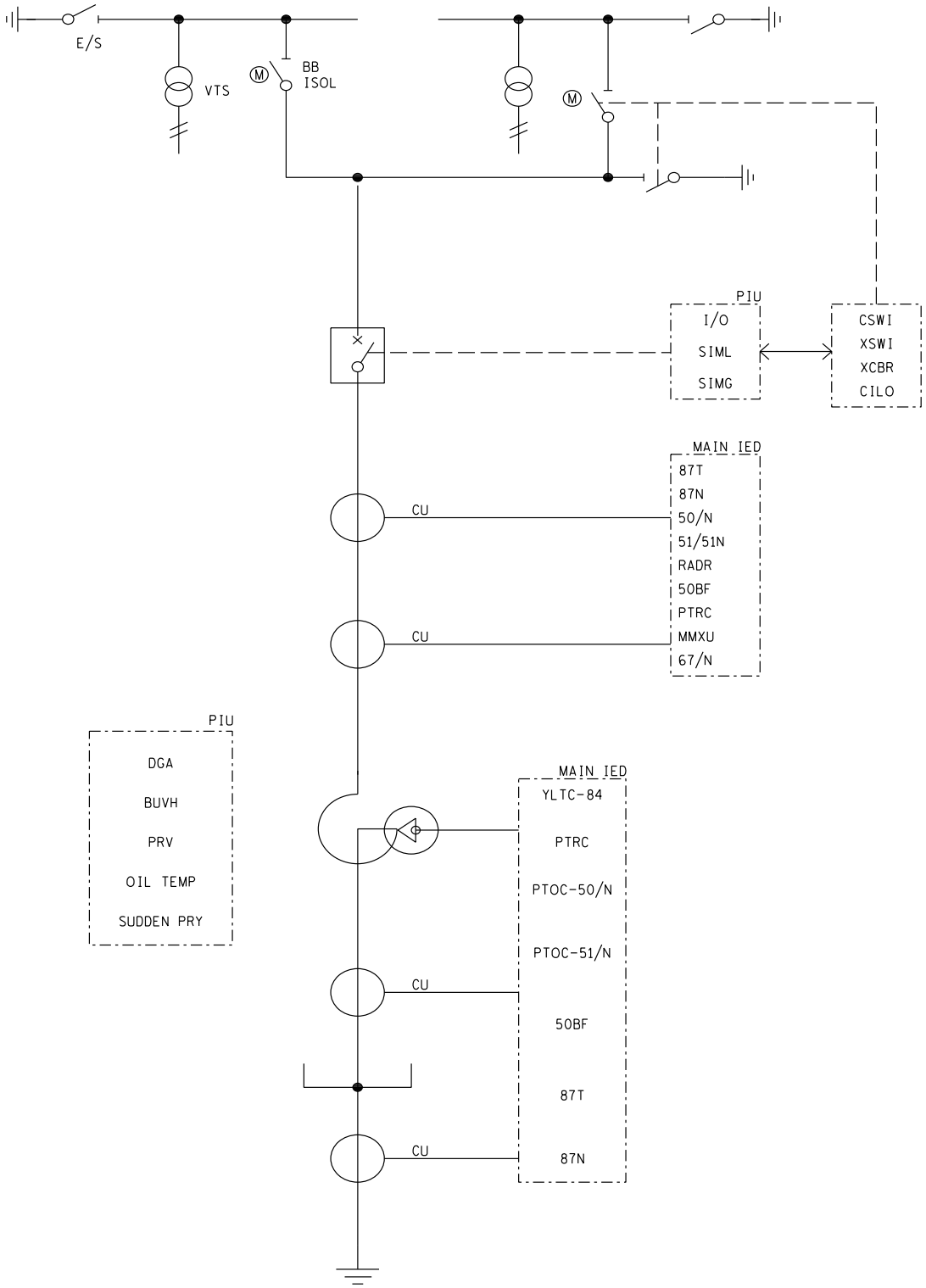

FIGURE 7 - 6SR-#300 PROTECTION BLOCK DIAGRAM

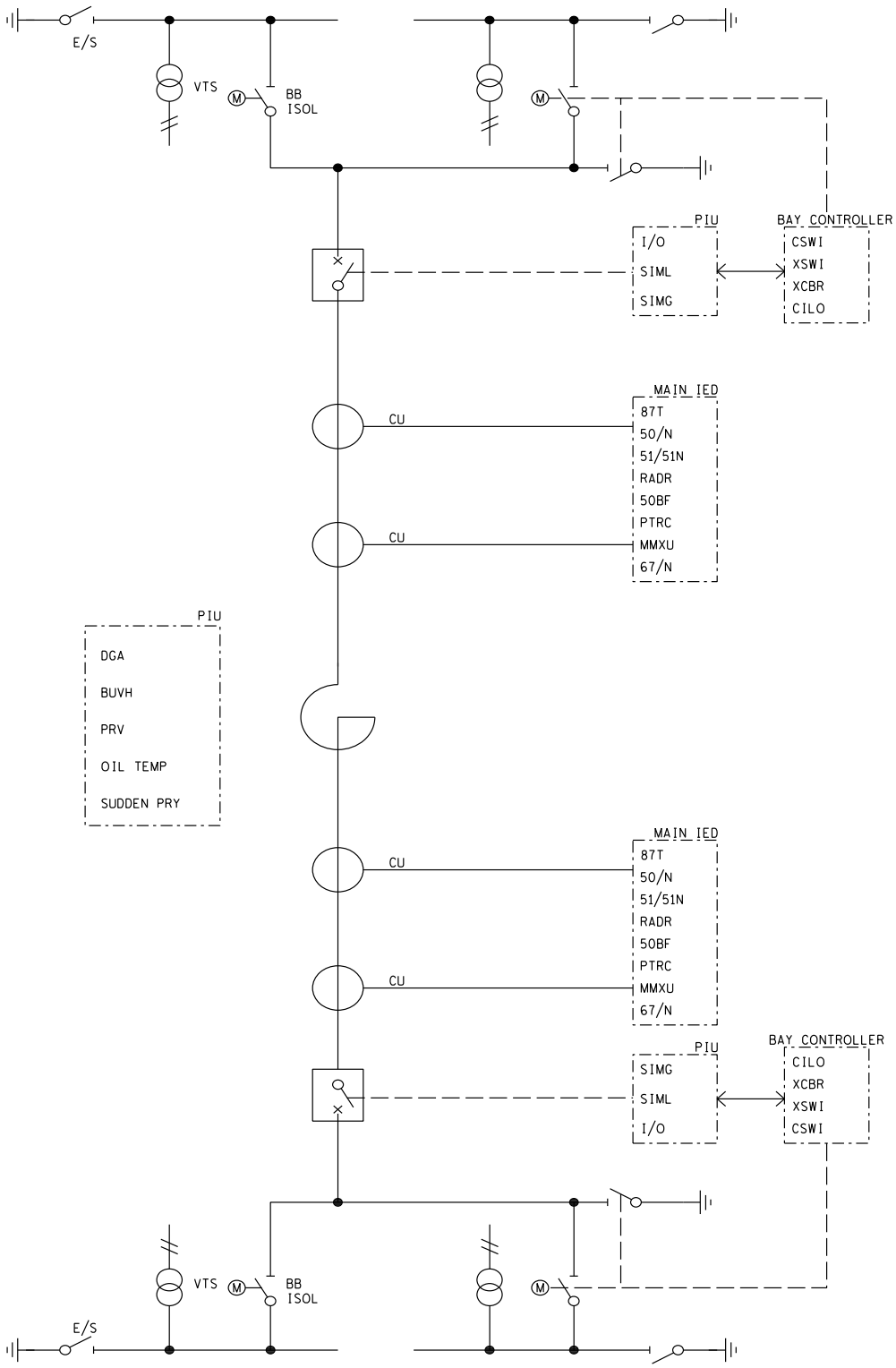

Figure 8

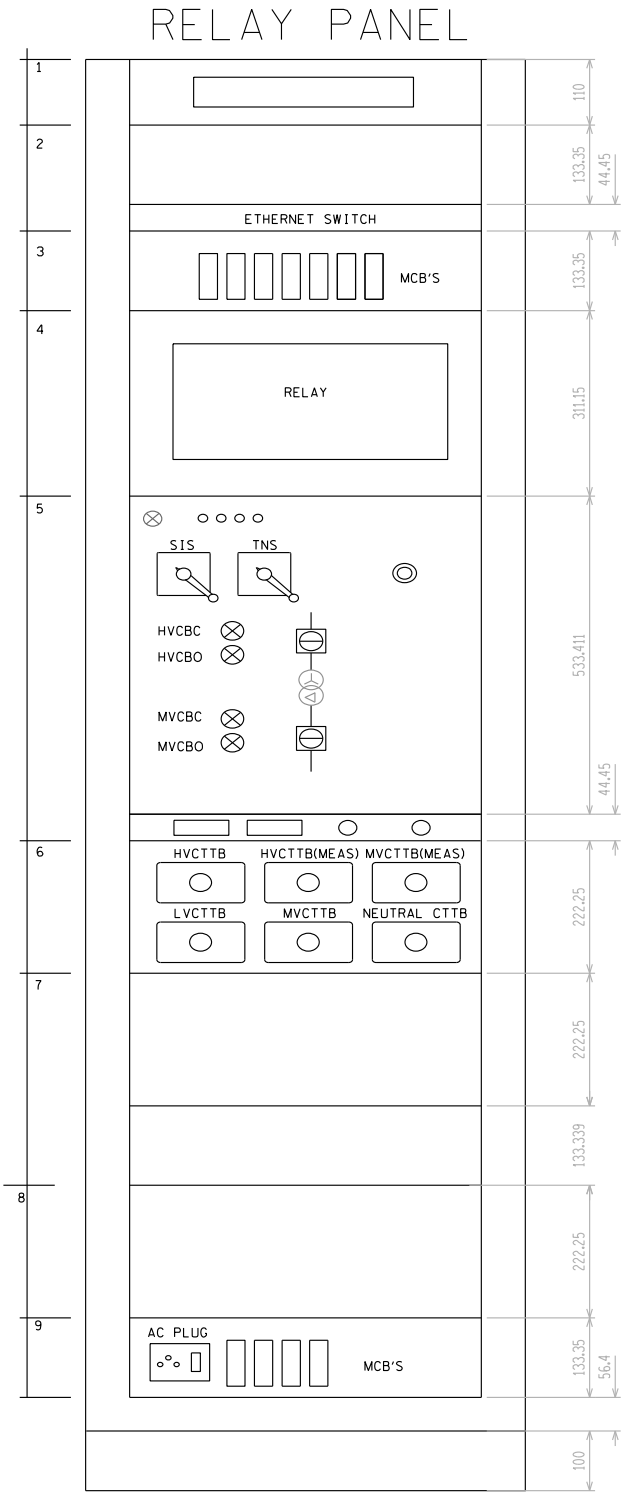

Figure 9 - 6TM-#150 Single line diagram Mobile Transformer scheme