Eskom	Report	Technology

Title: **SERE 19.5MW PV PROPOSED CONTROL PLANT FUNCTIONAL SPECIFICATION**

Unique Identifier:	**562/22**
Alternative Reference Number:	**<n/a>**
Area of Applicability:	**Engineering**
Documentation Type:	**Report**
Revision:	**0**
Total Pages:	**16**
Next Review Date:	**n/a**
Disclosure Classification:	**Controlled Disclosure**

Compiled by	Functional Responsibility	Authorized by
Prashil Magan	**Tertius Hyman**	**Erlind Segers**
Control Plant Design Engineer	**Senior Design Engineer**	**NED Manager**
Date: 30 April 2024	Date: 10/05/2024	Date: 10/05/2024

Content

1. Introduction

Not applicable

2. Supporting clauses

2.1 Scope

This document contains the Control Plant Concept Design requirements for the SERE PV Plant project at Skaapvlei substation.

Purpose

The purpose of this Concept Design Report is to specify the minimum Engineering requirements for the Control Plant for the Sere PV Plant Project.

2.1.1 Applicability

This document shall apply to the Sere PV Project.

2.2 Normative/informative references

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

2.2.1 Normative

[1] ISO 9001, Quality Management Systems

[2] ISO 14001 Environmental Management Systems.

[3] Grid Connection Code for Renewable Power Plants (RPPs) Connected to The Electricity

[4] Transmission System (TS) Or the Distribution System (DS) In South Africa, Version 2.9 (July 2016)

[5] The South African Grid Code, The Network Code, V10.0

[6] South African Distribution Code, Network Code, V6.1

[7] 240-84698759, Specification for Distribution Protection Schemes, High Impedance Busbar protection up to 132kV.

[8] 240-56364444, Standard minimum requirements for the metering of electrical energy and demand

[9] 240-65292589, Standard for Substation Meter Panels: HV/MV Indoor

[10] 240-72274830, Multimode Fibre Optic Duct Cable Specification

[11] 240-75658628, Distribution Group's specific requirements for AC/DC Distribution Units

[12] 240-132513474, Telecommunications Network Interface Converters Design Guide

[13] NRS 088-1:2019 – Duct and direct-buried underground fibre-optic cable. Part 1: Product specification

[14] NRS 088-2:2019 – Duct and direct-buried underground fibre-optic cable. Part 2: Installation guidelines

[15] 240-56062704 – Specification for 11 kV to 33kV Fixed Pattern Metal-Enclosed Indoor Primary Switchgear Standard

[16] 240-61266445 – Specification for Distribution Protection Schemes: Medium Voltage Cable Feeder and Busbar Arc Flash standard.

[17] D-DT-15202, Transformer protection scheme

[18] DISSCAAD3, Specification for large power transformers up to 132kV in the rating range of 2.5MVA to 80MVA

[19] DISSCABD1, Specification for a distribution bus zone protection scheme

[20] DSP_34-467, Specification for a distribution transformer protection scheme

[21] DSP_34-543, Specification for a distribution transformer On Load Tap Change protection and control scheme

[22] 240-67712901 (Specification for Transmission and Distribution Protection Schemes: Transformer OLTC Protection and Control)

2.2.2 Informative

Not applicable

2.2.3 General

None

2.2.4 Disclosure classification

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

2.3 Abbreviations

CT	Current Transformer
DC	Direct Current
D-DT	Drawing - Distribution Technology
DNP3	Distributed Network Protocol
DX	Distribution Division
EADS	Engineering and Data Server/Concentrator
AC	Alternating Current
BESS	Battery Energy Storage System
E/F	Earth fault
MV	Medium Voltage: The set of nominal voltage levels >1kV and ≤33kV as defined in the RPP GC
PV	Photovoltaic
HV	High Voltage: The set of nominal voltage levels >33kV and ≤220kV as defined in the RPP GC
IED	Intelligent Electronic Device
I/O	Input/output
kV	Kilovolts
LED	Light Emitting Diode
LV	Low Voltage: The set of nominal voltage levels ≤1kV
ms	Millisecond

MV	Medium Voltage: The set of nominal voltage levels >1kV and ≤33kV as defined in the RPP GC
MVA	Mega Volt Ampere
NEC	Neutral Earthing Compensator
NER	Neutral Earthing Resistor
OEM	Original Equipment Manufacturer
O/C	Overcurrent
OHS Act	Occupational Health and Safety Act
ORHVS	Operating Regulations for High Voltage Systems
PV	Photovoltaic
QOS	Quality of Supply
RMS	Root Mean Square
s	Second
SAGC	South African Grid Code
SAT	Site Acceptance Test
SCADA	Supervisory, Control and Data Acquisition
SHEQ	Safety, Health, Environmental and Quality
VT	Voltage Transformer

2.4 Roles and responsibilities

Not applicable

2.5 Process for monitoring

Not applicable

2.6 Related/supporting documents

Not applicable

3. Control Plant Concept Design

3.1 Protection

3.1.1 Design Background

Skaapvlei Substation is an existing 132kV/33kV substation supplied from Juno main transmission station via a 42km single Kingbird 132kV line rated at 176MVA. Eskom Renewables Business Unit has applied to connect the Sere PV 19.5 MW Solar PV Facility to the Eskom grid. There is also an 80MVA BESS facility planned to connect at Skaapvlei.

The following main equipment will be installed for the Sere PV Plant:

1) 1x 132/22kV 40 MVA transformer bay and 22kV NECRT
2) 1x 22kV fixed pattern switchgear consist of 1x incomer feeder with 22kV/110V Busbar VT, 2x 22kV PV plant feeders.

Please note that the design specifications are subject to change due to technological advancements and philosophy changes, and Eskom reserves the right to require such modifications accordingly.

All the above-mentioned equipment will be protected by the latest protection schemes as detailed below.

3.1.2 Protection Schemes

3.1.2.1 132kV Bus Zone

1) Connect the new 132/22kV Trfr 3 into the 4BZ5800 high impedance Buszone panel installed in the new BESS control room established by the BESS Project. The transformer bay must not be connected to the existing 4BZ5900 scheme positioned in the relay room- this will eventually be decommissioned as the panel cannot accommodate all the required circuits. The 4BZ4800 high impedance bus zone scheme is a two-zone scheme using the GE Multilin F35 feeder management relay.
2) The above schemes conform to 240-84698759 “Specification for Distribution Protection Schemes, High Impedance Busbar protection up to 132kV”.

3.1.2.2 132/22kV 40MVA Transformer Protection

1) The 132/22kV transformer~~s~~ will be a standard DX transformer~~s~~ - refer to the power plant conceptual design for the power plant arrangement of the new 132/22kV Transformer bay~~s~~.
2) Make use of the new post type current transformers provided in the applicable transformer bay.
3) A new CT JB with 6 core terminal inserts will be used to interconnect the current transformer core to the protection and measurement scheme.
4) The 5TM-3200 transformer protection scheme will be used to protect this 40MVA 132/22kV Transformer.
5) The protection scheme has the following functionality:
    i. Two terminal differential protection (RET670)
    ii. HV and MV O/C, E/F and breaker fail (RET670)
    iii. High impedance HV and MV REF (RMS 2V73K1 high impedance relays to be added to scheme)
    iv. Transformer protection (Buccholtz relay, winding temperature and oil temperature) must be wired into the above protection scheme

6) The transformer indications and controls will be transmitted via serial communication using DNP3 protocol to the existing RTU.

7) The 5TM-3200 transformer protection scheme complies with 250-84854878 & 240-84854886 (Specification for a Distribution Protection Schemes: Transformers & Protection Philosophy: Transformers and Shunt Reactors for Wires Business on the Eskom Network respectively)

8) The OLTC of this 132/22kV transformer will be protected and controlled by the 5TC-5200 tap changer protection scheme. This circulating current scheme uses the Eberele REG-DA voltage regulating relay for on load tap changing applications. This scheme complies with 240-67712901 (Specification for Transmission and Distribution Protection Schemes: Transformer OLTC Protection and Control).

9) The transformer protection schemes including the OLTC scheme must be fitted into a standard 800mm wide swing frame panel. Refer to Figure 3 for proposed relay room layout.

10) A 5CF3100 on-board MV Incomer protection scheme shall be installed for the control of the MV indoor incomer breaker. The scheme must be integrated into the transformer protection scheme and will have the following functionality:

    i. ABB RED615 main protection relay used for Directional Overcurrent and Earth Fault
    ii. ABB REF620 to have synchronisation check functionality.
    iii. Scheme voltage 110V DC
    iv. Each panel to have its own Ethernet switch.

11) Refer to Figure 1: 132/22kV Transformer 3 protection and metering schematic.

3.1.2.3 Renewable Power Plant (RPP Panel)

1) A PV RPP Controller is required to be installed in the existing relay room. Dedicated CT and VT circuits are required from the HV side of the 132KV Transformer. Additionally, the PV RPP Controller will require CT circuits or power measurement readings from the HV side of both existing Wind plant Transformers in order to curtail the PV not to exceed 105.8MW when blended with the Wind power generation.

2) See Figure 3 for proposed panel position.

3.1.2.4 22kV Indoor Switchboard

The new 22kV indoor switchboard shall adhere to the Specification for 11 kV to 33kV Fixed Pattern Metal-Enclosed Indoor Primary Switchgear Standard (240-56062704).

3.1.2.5 22kV SERE PV Plant Feeders

1) All proposed 22kV Feeders for SERE PV Plant are cable feeders and will require differential protection.

2) Install a 5CF3100 scheme on-board in the LV Compartment of the fixed pattern switchgear. Scheme will cater for differential protection, backup overcurrent and earth fault protection. The ABB RED615 IED shall perform the differential protection across the cable. The SERE PV Plant Contractor will need to install the same relay to implement differential protection across the feeder cable. The backup O/C & E/F protection function, arc detection on the MV busbar, as well as synchronisation check shall be performed by the ABB REF620 IED.

3) A Line VT for each SERE PV Plant feeder will be required for the synch check functionality.
4) Scheme Voltage: 110V DC
5) DNP Protocol via RS485 for SCADA.
6) Refer to Figure 2 for protection schematic of PV feeder.

3.1.2.6 22kV Bus protection

a) The 22kV busbar protection shall be achieved by making use of the REF620 relays installed on the 5CF3100 protection scheme installed onboard the 22kV switchgear. The REF620 relays will be connected via the ethernet switch and will also take fibre optic arc sensors from both Busbar and Cable chambers to facilitate bus protection via GOOSE.

3.2 Measurements

3.2.1 Tariff & Statistical Metering

a) Four quadrant tariff metering will be installed for the feeders.

b) The 3MM01C schemes will be used with Eskom approved meters.

c) Where applicable due the possibility of supplying the metering from more than one VT, a Voltage selection module will be installed.

d) The Tariff and statistical metering installation shall be in accordance with 240-56364444, Standard minimum requirements for the metering of electrical energy and demand. This includes but is not limited to the requirements around the accuracy class of the meters, CTs and VTs.

e) The planned Substation WAN communication infrastructure will be utilised for remote communications to the meters.

f) The metering equipment shall be installed in a standard metering panel according to 240-65292589, Standard for Substation Meter Panels: HV/MV Indoor. The panels shall include meter modules, modem modules or VT selection modules, where applicable.

g) Refer to the protection and metering schematics for more details on the application of the metering for the above equipment.

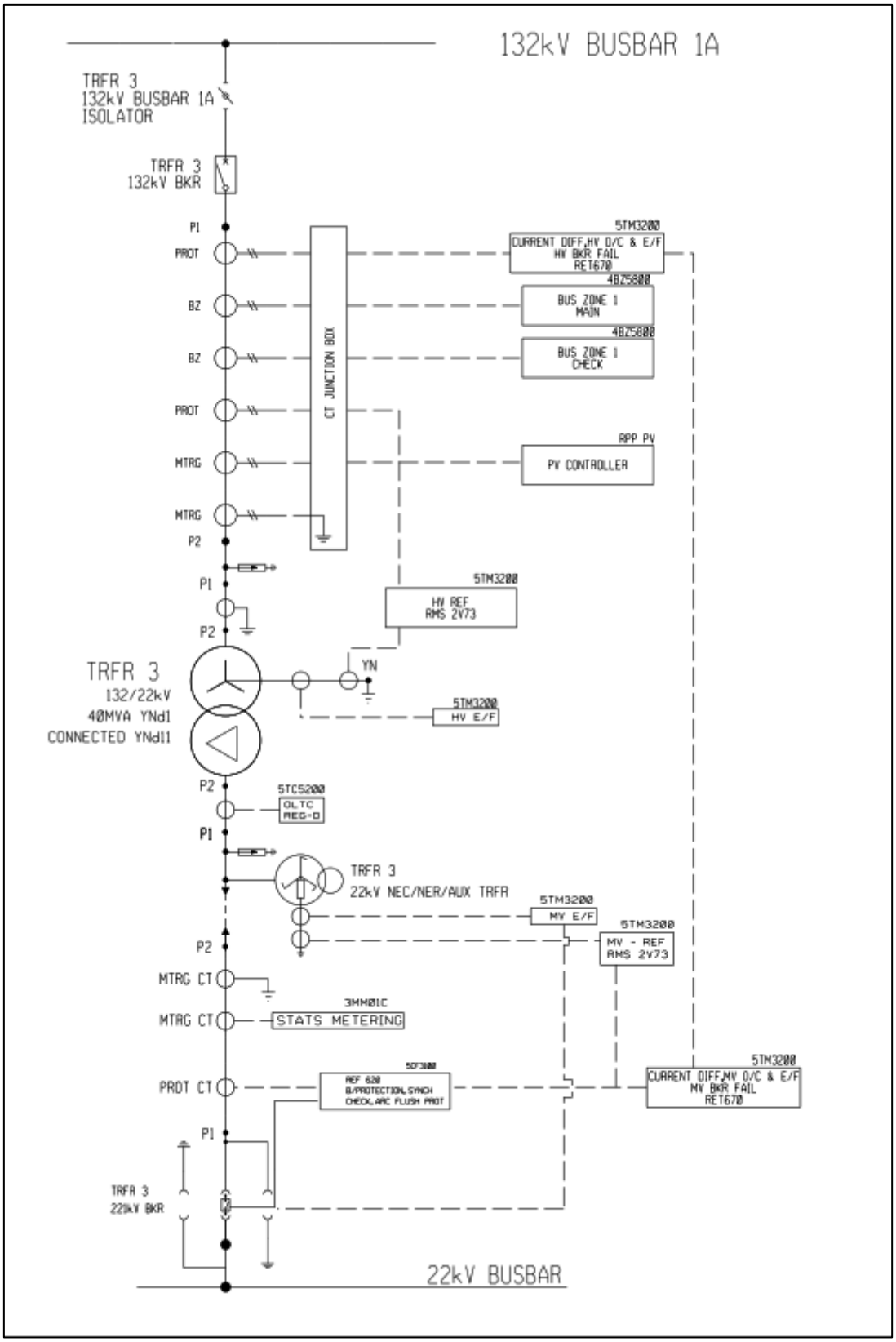

Figure 1: 132/22kV 40MVA Transformer protection and metering schematic

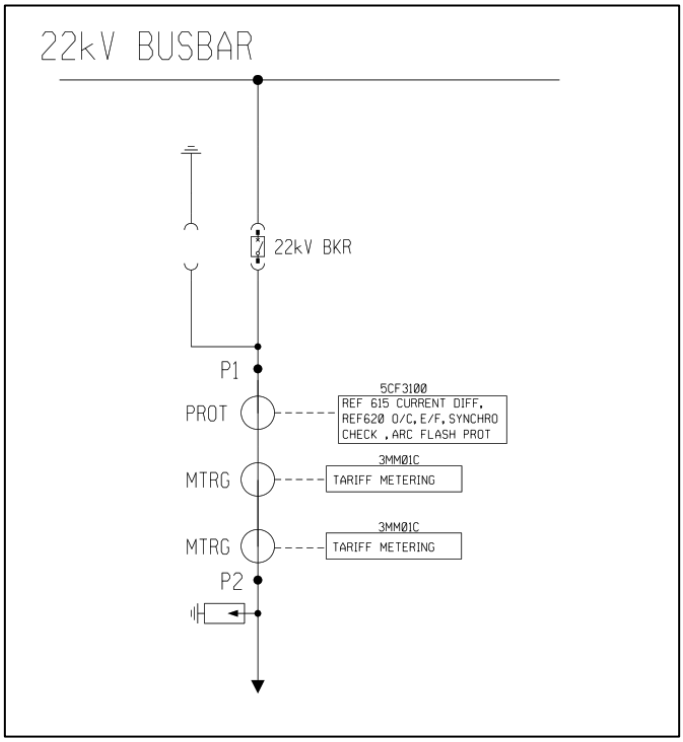

Figure 2: 22kV SERE PV Plant Feeder's protection and metering schematic

Quality of Supply

h) The contractor shall provide information regarding the plant electrical design as necessary to support the Employer to ensure that there is no need of reactive power compensation and/or harmonics equipment.

i) The contractor shall take a baseline reading of the Quality of Supply before and after commissioning the plant. This should be done with the plant completely isolated from the grid.

j) An Eskom Distribution standard Power Quality meter shall be installed to monitor the 22kV circuits. Currently this is the Vecto III by CT LABS.

k) The meter is to be fed from the MV voltage selection module.

l) All transformer MV currents shall be summated, through summation CTs and fed into the Power Quality meter.

m) Quality of supply shall comply with Grid Connection Code for Renewable Power Plants (RPPs) Connected to The Electricity Transmission System (TS) Or the Distribution System (DS) In South Africa, Version 3.

3.3 Auxiliary Supply

3.3.1 Introduction

- Existing installed equipment adding to a standing DC drain of 7.8A is:
- 2 x Transformer
- 2 x Tap Change
- 1 x 132kV Feeder
- 1 x 132kV Bus-zone
- 1 x Conco Interface Panel
- 1 x 33kV Bus-Protection
- 1 x 33kV Bus-Section
- 2 x 33kV Feeders (Trfr MV)
- 8 x 33kV Feeders
- 2 x 33kV VT Panel
- 1 x RTU
- 1 x Substation Automation
- 1 x Fibre Panel
- 10 x DC lights

3.3.2 Scope of Work

a) Current installed equipment in the AC/DC Panel 1:

- 1 x 110V 20A Cordex Switch-mode charger (2 x SMRs),
- 2 x DC Distribution Module,
- 1 x DC Interface Module,
- 1 x 3 Phase AC module
- 1 x 1 Phase AC module
- 1 x AC supply module

There should be sufficient MCB capacity on the AC/DC panel 1 to supply the new equipment, however this needs to be confirmed during detailed design. Use 240-75658628: 'Distribution Group's specific requirements for AC/DC Distribution Units' to design/update the panel to an AC/DC Panel.

b) Current installed battery is:

- 52 cells of FCP13 – 192Ah.

This will likely not be sufficient to supply the installed equipment as well as the new equipment. Use 240-91190310: 'Sizing of DC Systems for Substation Applications' to calculate the new battery size.

The current battery room size should be sufficient even if larger batteries is needed. This however needs to be confirmed during detailed design and using the following standards to design and build the battery room:

- 240-56177186: ‘Battery Room Standard’
- 240-56176113: ‘Classification of Battery Rooms Work Instruction’

c) Current yard distribution box:

There are is a Yard Box currently installed in the substation yard. With the new transformer it may be beneficial to add another Yard Box to ensure Auxiliary supply redundancy. During detailed design confirm that the current NECRTs will not be over loaded with the additional loads.

d) Current 48V equipment:

There currently is a dual 110V-to-48V converter for 48V loads in the relay room. If there are any new 48V loads this shall be supplied by the existing 110V to 48V converter.. This however needs to be confirmed during detail design stage. Any new Power Electronic equipment shall comply with 240-53114248: ‘Thyristor and Switch Mode Chargers, AC/DC to DC/AC Converters and Inverter / Uninterruptible Power Supplies Standard’

3.3.3 Control room layout

Refer to proposed control room layout in Figure 3.

3.3.4 Installation Notes

a. Chargers’ installation

CPM DC section will be responsible for the installation and commissioning of the charger's SMRs in accordance with the relevant Eskom Distribution national standards and procedures.

b. b) Lead acid battery installation

The CPM DC section will be responsible for the commissioning of the Lead Acid battery bank in accordance with the relevant Eskom Distribution national standards and procedures. All storage records of the batteries must be provided before commissioning in accordance with 240-137465740: Standby Battery Storage and Commissioning in Eskom.

3.3.5 DC Standby Philosophy

a. Substation standby times.

Refer to 240-118870219: ‘Standby Power Systems Topology and Autonomy for Eskom Sites’. This substation is further than 200 km from the local DC section. The battery and charger system must be rated to carry the full protection, telecommunications and tele-control load for eighteen (18) hours with remote supervisory.

b. Substation charger sizing

The charger system must be rated to recharge the batteries to 80% capacity within 10 hours at the 10-hour rate.

3.4 Telecommunications

3.4.1 Telecoms

a) Install a 48U Telecommunications Panel with Telecommunications equipment.

b) Install Telecommunications equipment as per design and User Requirements Specification (URS) submitted to Eskom Telecomms. Concept URS to be submitted one month prior to DRT upon request by the design consultant. Detailed Design URS to be submitted upon request after Budget Quote is effective.

c) The URS will aim to cater for dedicated National, Standby National and Regional circuits for the Gateway of the New PV Plant. Additionally, it will seek to normalize any telecommunications at Skaapvlei SS to reduce drain on DC Systems and optimize the network. Further requirements such a Telephony, Internet access, Substation Automation, etc. may be added at concept and/or detailed design stage as required.

d) Install 48-core single-mode DUCT fibre between the 33kV Relay Room and the New PV Plant, as per specifications (240-46264031, NRS088 and all related).

3.4.2 Supervisory

a) 2 x RS232/RS485 Moxa TCC-100i converters shall be installed in the RTU panel to cater for the serial SCADA communications between the D20 RTU and the planned 132kV and 22kV feeder bay IEDs.

3.5 Remote engineering access

a) Substation Automation (incl. Remote Access and Data Retrieval) shall be implemented.

b) All protection & control schemes shall be ordered with the required networking equipment to comply with 240-81321219.

c) All schemes shall be ordered with IEC-61850.

d) The existing network within the 33kV relay room will be extended to include all newly installed equipment.

e) The new protection scheme’s bay switch will interface directly to the 33kV room’s station switch.

f) A new Siemen Ruggedcom RX1400 router will be installed within the existing Substation Automation panel to facilitate inter-VLAN routing. The router shall include/support:

   a. 110VDC/220VDC input supply

   b. 4 x 10/100MB RJ45 copper ports

   c. 1x 1000BaseSx LC (SFP module)

   d. 1x 100BaseFx LC (SFP module)

   e. 2x Serial ports for connecting legacy devices.

3.6 General

1) All control cables, outside of the control building, shall be installed in a dedicated concrete cable trench.
2) Cable trenches shall include covers designed to withstand the load of maintenance vehicles when located in trafficable areas.
3) The document assumes all new Control plant equipment and 22kV switchgear shall be installed in the existing switchgear and relay room. At a detailed design stage if it's found that the current space in the relay or switchgear room is insufficient then this document and design will need to be updated to cater for the new proposed solution.

3.7 Relay room floor plan layout

Proposed layout of relay room shown in Figure 3.

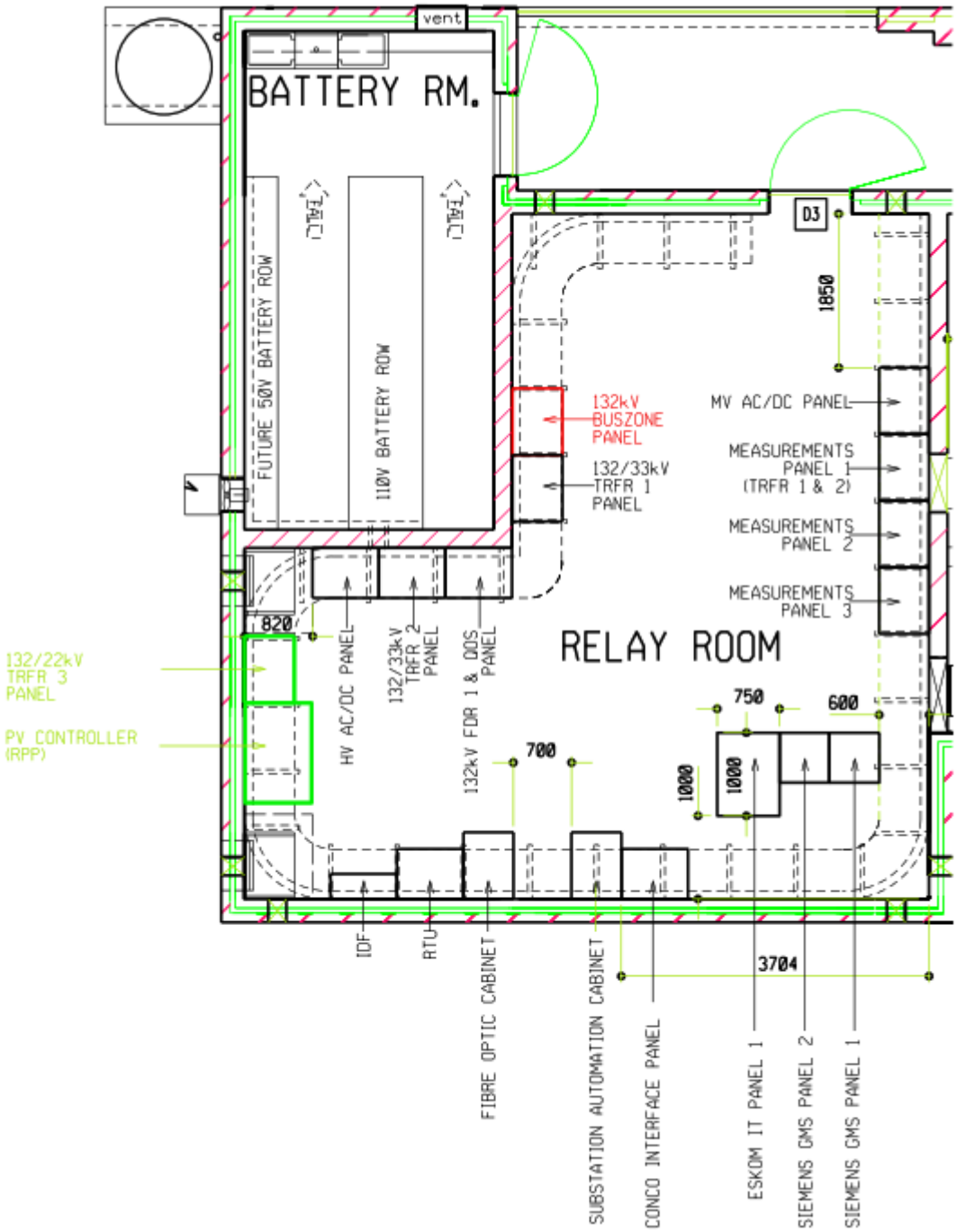

Figure 3: Proposed relay room layout

4. Authorization

Name and surname	Designation

5. Revisions

Date	Rev	Compiler	Remarks
April 2024	0	Prashil Magan	First issue

6. Development team

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

Wendy Nodada

Tertius Hyman

Zeyaad Panday

Christine Van Schalkwyk

Gregory Pieterse

Raees Dalvie

7. Acknowledgements

Western Cape Operating Unit Engineering team.