Eskom	**Standard**	**Technology**

Title: **AC RETICULATION PHILOSOPHY FOR SUBSTATIONS**

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Date: 03 April 2018

PCM Reference: **240-45541534**

SCOT Study Committee Number/Name: **Part 16/ DC & Auxiliary Supplies**

Content

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1. Introduction

This document sets out the fundamental principles upon which AC Reticulation at substations shall be planned and designed.

2. Supporting clauses

2.1 Scope

2.1.1 Purpose

This standard details the AC Reticulation philosophy for Transmission's double busbar substations, breaker-and-a-half substations and Distribution substations.

2.1.2 Applicability

This standard shall apply throughout Eskom Holding Limited, its divisions, subsidiaries and entities wherein Eskom has a controlling interest.

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] 240-75658628, Distributions Group's Specific Requirements for AC/DC Distribution Units.

[3] DST_41-055, Specification for three-phase intermediate voltage (1.9/3.3kV) transformers.

2.2.2 Informative

[4] 32-9, Definition of Eskom documents

[5] 32-644, Eskom documentation management standard

[6] 474-65, Operating manual of the Steering Committee of Technologies (SCOT)

2.3 Definitions

2.3.1 General

Definition	Description
Distribution Board (DB)	An enclosure that contains electrical equipment for the distribution or control of electrical power, from one or more incoming circuits, to one or more outgoing circuits.

2.3.2 Disclosure classification

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

2.4 Abbreviations

Abbreviation	Description
AC	Alternating Current
CAP	Committee for Accepted Products
CVT	Capacitive Voltage Transformer
DB	Distribution Board
DC	Direct Current
DMK	Diameter Marshalling Kiosk
HV	High Voltage
IV	Intermediate Voltage
JB	Junction Box
LAP	List of Accepted Products
LV	Low Voltage
MCB	Miniature Circuit-breaker
MCCB	Moulded Case Circuit-breaker
n/a	not applicable
NEC	Neutral Electromagnetic Coupler
NER	Neutral Earthing Resistor
PB	Plug Box
PTM&C	Protection, Telecoms, Metering and Control
SDB	Station Distribution Board
TDB	Transformer Distribution Board
VT	Voltage Transformer

2.5 Roles and responsibilities

Stakeholders involved with the design of AC Reticulation at substations shall ensure that the fundamental principles of this document are adhered to.

2.6 Process for monitoring

Compliance with the requirements of this document will be ensured by conducting audits within the different Divisional Design departments.

2.7 Related/supporting documents

Not applicable

3. Transmission – alternating current reticulation network

3.1 Double busbar substations

1 shows all the Distribution Boards (DBs) of an Alternating Current (AC) reticulation network used in transmission double busbar substations.

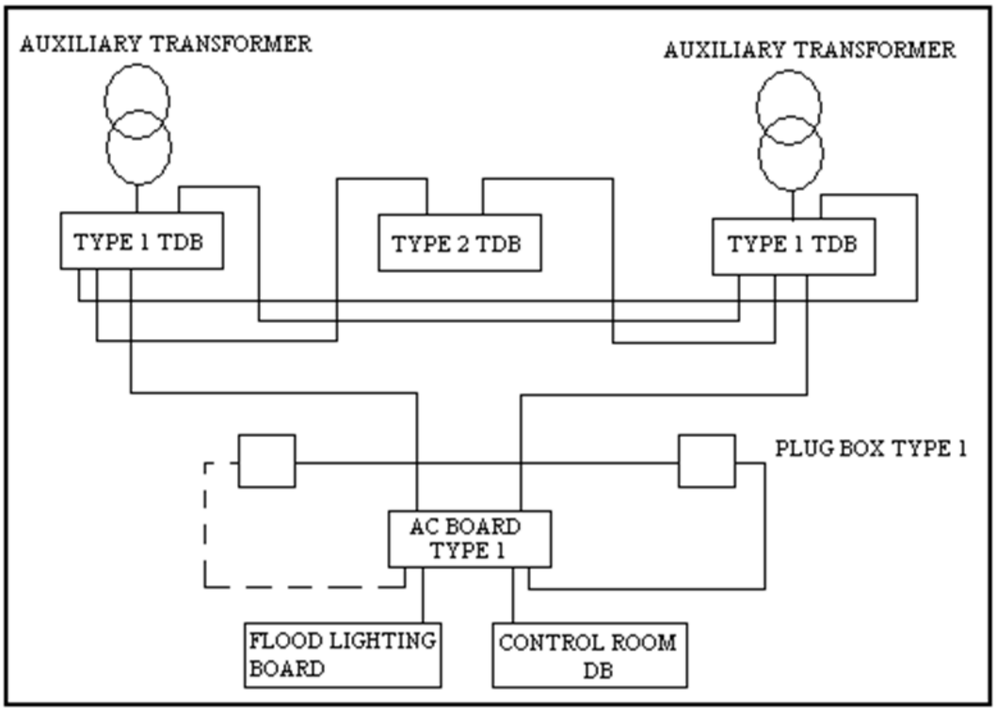

Figure 1: Transmission double busbar substation – AC reticulation network

3.1.1 Auxiliary transformer

The kilovolt-ampere rating of the Auxiliary Transformer is 315 kVA, equipped with a 500 A Moulded Case Circuit-breaker (MCCB).

3.1.2 Transformer distribution board type 1

The Type 1 Transformer Distribution Board (TDB) is a DB that is situated at auxiliary transformers. The Low Voltage (LV) supply from the auxiliary transformer is terminated at the Type 1 TDB. This TDB has a manual changeover switch where two supplies can be connected. The Type 1 TDB has a 500 A rating. All MCCBs and Miniature Circuit-breakers (MCBs) will have a minimum fault current breaking capacity of 10 kA at U_{AC} 400 V.

3.1.3 Transformer distribution board type 2

The Type 2 TDB, which is sometimes called a reactor TDB, is located at reactor bays or at transformer bays that are not equipped with auxiliary transformers. This TDB has an automatic chop-over and is rated for 150 A. It is supplied from a Type 1 TDB. All MCCBs and MCBs will have a minimum fault current breaking capacity of 10 kA at U_{AC} 400V.

3.1.4 AC board type 1

The AC Board Type 1 is located in the control room of the substation. This DB has an automatic chop-over and is rated for 300 A. The AC Board Type 1 is supplied from the Type 1 TDBs. This AC Board supplies the

Flood lighting board and the Control Room DB etc. All MCBs will have a minimum fault current breaking capacity of 5 kA. The reinforced breaking capacities of the MCBs will be greater due to the application of the cascading principle.

3.1.5 Plug box 0100

The Plug Box (PB) 0100 is supplied from the AC board Type 1. PBs are looped as shown in 1. However, the cable from the PB box back to the AC Board is not connected at both ends. This cable remains in the trench until the need arises to back-feed the PBs. A single PB can provide U_{AC} 230 V to eight Junction Box (JB) 0333s. The JB 0333 is a foundation-mounted JB located in every bay. It is an interface JB between the primary plant equipment (located in the High Voltage (HV) yard) and the protection panel (located in the control room).

3.2 Breaker-and-a-half substations

2 shows all the electrical components of an AC reticulation network used in transmission breaker-and-a-half-substations.

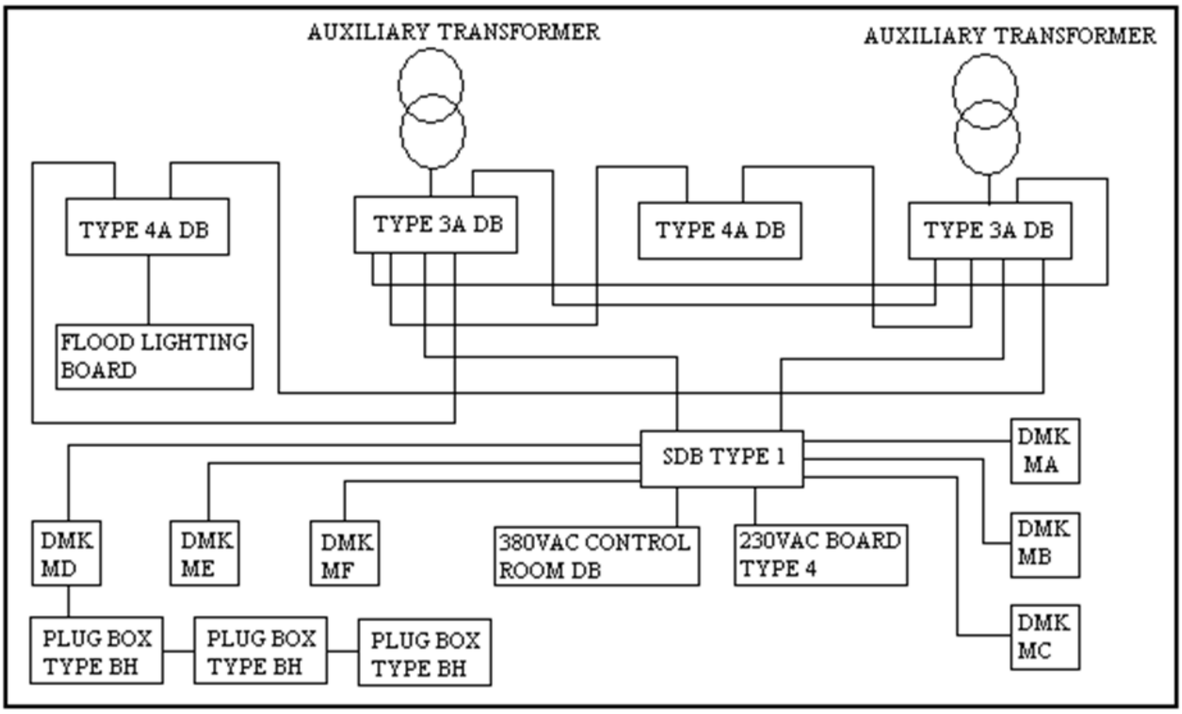

Figure 2: Transmission breaker-and-a-half substation – AC reticulation

3.2.1 Auxiliary transformer

The kilovolt-ampere rating of the Auxiliary Transformer is 500 kVA, equipped with an 800 A MCCB.

3.2.2 Type 3A distribution board

This type-tested DB is situated at the Auxiliary Transformers. The LV supplies from the Auxiliary Transformers are terminated at the Type 3A DB. This DB has a manual chop-over where two supplies can be connected. The busbars of this DB have been type-tested to handle a fault current of 15 kA. The Type 3A DB has an 800 A rating and includes a 350 A MCCB for oil purification and a 63 A MCB welding plug socket. All MCCBs and MCBs will have a minimum fault current breaking capacity of 15 kA at U_{AC} 400 V.

3.2.3 Type 4A distribution board

The Type 2 DB, which is sometimes called a reactor DB, is located only at reactor bays. This DB has an automatic chop-over and is rated for 500 A. This DB is supplied from a Type 3A DB. The busbars of this board have been type-tested to handle a fault current of 15 kA. The Type 4A DB has a 500 A rating and includes a 350 A MCCB for oil purification and a 63 A MCB welding plug socket. The Flood lighting board is fed from the Type 4A DB or the SDB. All MCCBs and MCBs will have a minimum fault current breaking capacity of 15 kA at U_{AC} 400 V.

3.2.4 Station distribution board type 1

The Station Distribution Board (SDB) Type 1 is located as close to the control room as possible. This DB has an automatic chop-over and is rated for 500 A. This DB is supplied from a Type 3A DB. The busbars of this board have been type-tested to handle a fault current of 15 kA. This board supplies the Battery chargers, 230 V AC Board, 380 V AC Control Room DB, and up to six Diameter Marshalling Kiosk (DMK) AC boards. In a substation where both the 765 kV and 400 kV yards are of the breaker-and-a-half layout, two SDBs are required, namely the 765 kV yard SDB and the 400 kV yard SDB.

If at any substation and at a specific voltage level there are more than six diameters, then the SBD can manufactured with additional 63 A breakers per extra diameter to feed the DMK AC Boards. All MCCBs and MCBs will have a minimum fault current breaking capacity of 15 kA at U_{AC} 400 V.

3.2.5 230 V AC board type 4

The 230 V AC Board Type 4 is located in the substation control room. This board has been designed to cater only for single-phase supplies required by protection and control panels within the control room. It caters for a maximum of six diameters. In substations where both the 765 kV and 400 kV yards are of the breaker-and-a-half layout, two 230 V AC boards are required. One board will supply the 765 kV protection schemes and the other board will supply the 400 kV protection schemes. All MCBs will have a minimum fault current breaking capacity of 5 kA. The reinforced breaking capacities of the MCBs will be greater due to the application of the cascading principle.

3.2.6 Diameter marshalling kiosk AC board

The DMK AC Board is located in the DMK. Its supplies the wall-mounted DB within the DMK, heater supplies within the diameter and PBs. All MCBs will have a minimum fault current breaking capacity of 5 kA. The reinforced breaking capacities of the MCBs will be greater due to the application of the cascading principle.

3.2.7 Plug box type BH

This structure-mounted PB is supplied from the DMK AC Board. The PBs are looped as shown in 2. This PB consists only of a single three-pin plug socket. The purpose of this plug socket is to provide power for test equipment. PBs are situated at all circuit-breakers including the 33 kV circuit-breaker, Line Capacitive Voltage Transformers (CVTs), Busbar CVTs and Reactor Transfer CVT.

4. Distribution substations

4.1 General

The distribution of auxiliary power within the substation is achieved by using outdoor and indoor DBs. The AC power is supplied from an auxiliary transformer (typically 150 kVA) or a suitable Voltage Transformer (VT). The auxiliary transformer is fitted with three-phase 50 A and 100 A MCBs, which respectively supply AC power to the main transformer cooling fans and the balance of the AC loads within the substation. The AC power supply from the auxiliary transformer or VT can be fed either via a Yard AC DB or directly to the DB in the relay house. The Yard AC DB is an intermediate board that splits the power distribution between the yard loads (outdoors) and the relay house loads (indoors).

The inside AC DBs can be either wall mounted or floor mounted (standard 19" swing-frame cabinet).

4.2 Auxiliary transformer

The rating of the standard auxiliary transformer used by Distribution with the Neutral Electromagnetic Coupler (NEC)/Neutral Earthing Resistor (NER) is 100 kVA. This transformer can supply a maximum current of 145 A per phase. Two supply MCBs rated at 100 A and 50 A, 10 kA are available as outputs.

The auxiliary supply design allows for the AC supply to the HV transformer cooling fans and Yard AC distribution cubicles to be fed directly from the two output MCBs, mounted on the auxiliary transformer, as shown in Annex B, B.1 and B.2.

The advantages of this are that each auxiliary transformer will be feeding the cooling fans of its own HV transformer, which minimizes voltage drop to the fan motors and reduces costs in terms of cable size and length.

4.3 Oil filtering plants

This plant is used on site when transformer oil has to be filtered to extract the excess water in the oil. 1 gives the standard ratings of the oil filtering plants that are available.

Table 1: Typical ratings of standard oil filtering plants

Oil filtering capacity (L/h)	Maximum current rating (A)
7 500	170
3 000	125
1 800	45
1 500	40
600	25

Because of the high power requirements of the larger oil filtering plant plants, which are the ones most often installed, it is not cost-effective to provide facilities to power equipment that is very seldom used.

If an oil filtering plant is installed on site, a portable generator or a transportable auxiliary transformer will have to be used to operate the plant.

4.4 Yard AC distribution board

The main purpose of the Yard AC DB is to provide an AC supply change-over facility where more than one AC supply source is available, and to provide for the distribution of AC power to load equipment in the substation HV Yard.

The Yard AC DB is modular and consists of the enclosure that houses the control modules which control the flow of AC power to the load equipment; a distribution module which consists of the MCBs; the termination module with the various input and output power circuit terminals; and the PB which houses the one-phase and three-phase plug socket outlets.

4.5 Wall-mounted AC/DC distribution board

The wall-mounted DBs are located inside the relay house. Their main purpose is the distribution of AC and Direct Current (DC) power to all loads within the relay house and sometimes even some outdoor loads.

Two types of wall-mounted AC/DC DBs are available, namely a 24/24 way and a 36/36 way DB. These numbers refer to the number of AC and DC MCBs available on each board. The boards are mechanically split into an AC DB on the left-hand side and a DC DB on the right-hand side. The AC DB has one-pole and three-pole AC MCBs and a four-pole incoming isolator. The DC DB has two-pole DC MCBs and two-pole incoming isolators.

4.6 19" AC/DC distribution board

The 19" DB is a free-standing DB that is located inside the relay house. Its main purpose is the distribution of AC and DC power to all loads within the relay house and sometimes even some outdoor loads. This DB (19″ panel) is also used to house the switched mode rectifiers.

Three types of 19″ AC/DC configurations are available, depending on the number of load circuits, i.e. 14/10 way, 14/20 way and 28/20 way. A 14/10 way configuration is also available for Brickbuild substations typically used in the Western Region. Refer to**Error! Reference source not found.** 240-75658628 for a ore detailed description.

In some cases, the fully populated panel as in these configurations will not be necessary. For instance, if a yard AC DB is used at a site, the AC incoming module will not be required. The reason for this is that the incoming module has the same functionality as the yard AC DB and the addition of it would be a duplication and wasteful expenditure. Also, in some cases, the auxiliary supply is a single-phase supply. Then the AC incoming module will not be needed.

Another module that may not be required is the three-phase AC distribution module. Some typical three-phase loads are the control room's domestic DB, the fan in the battery room and a secondary AC/DC panel. If these are single phase and no other three-phase loads are needed, then the module should not be installed. If it were installed, it would have no purpose and again would be a waste of money. The three-phase loads in the yard are usually supplied from the yard AC DB. Should the design not have a yard AC DB and should there be three-phase loads in the yard, then the three-phase module in the panel would be required for those loads. Again, with single-phase auxiliary supply, the three-phase module would not be needed.

Care must be given to the number of modules added in one panel. The modules may all fit, but the number of cables that need to come through the gland-plate may not be accommodated.

5. Cascading

Cascading is the use of the current limiting capacity of circuit-breakers at a given point to permit circuit-breakers with lower fault rating to be installed downstream. This saves costs. Manufacturers have published cascading tables, which they have verified by laboratory tests. These tables indicate cascading possibilities between upstream and downstream circuit-breakers. Cascading permits a circuit-breaker to be used at an installation where the prospective fault current at that installation is higher than its breaking capacity. In order for the cascading principle to be applied, the MCCBs or MCBs in all switchboards must be the same type, and from the same manufacturer.

6. Intermediate voltage transformers

In cases where the auxiliary transformer (315 kVA or 500 kVA) is located several hundred metres from the TDB or substation, intermediate VTs that step up the voltage to 3,3 kV can be utilized. The design and installation of a sealed Intermediate Voltage (IV) underground system to feed remote loads from the sending end that has an existing three-phase LV connection are covered in **Error! Reference source not ound. Error! Reference source not found.**.

7. Authorization

This document has been seen and accepted by:

Name and surname	Designation
R McCurrach	PTM&C Senior Manager
D Van Rooi	Metering, DC and Security Technologies Manager (Acting)
G Topham	Corporate Specialist (Engineering Protection)
L Kotze	Senior Consultant (Protection)

Name and surname	Designation
K Jagdaw	DC and Auxiliary Supplies Chairperson
C van Schalkwyk	DC Technology Engineer

8. Revisions

Date	Rev	Compiler	Remarks
April 2018	2	AN Majozi	Format changed to SCOT Template
March 2013	1	K Naicker	First issue

9. Development team

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

- Alpheus Majozi

10. Acknowledgements

Christine Van Schalkwyk and Kuben Naicker for compiling the original document that this Standard is based on.

Annex A – Impact assessment

(Normative – for Eskom internal use only)

1) Guidelines

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

2) Critical points

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

Comment: Standard required across wires business.

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

Comment: No impact.

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

Comment: No impact.

2.4 When will new stock be available?

Comment: n/a

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

Comment: Yes.

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

Comment: None.

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

Comment: (n/a during commenting phase).

3) Implementation time frame

3.1 Time period for implementation of requirements.

Comment: ASAP

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

Comment: None.

4) Buyer's guide and power office

4.1 Does the Buyer's Guide or Buyer's List need updating?

Comment: No.

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

Comment: None.

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

Comment: None.

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

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

Comment: n/a

5) CAP/LAP pre-qualification process-related impacts

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

Comment: n/a

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

Comment: n/a

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

Comment:

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

Comment: n/a

5.5 If Yes to 0, what date has been set for all currently accepted suppliers to comply fully?

Comment:

5.6 If Yes to 0, have all currently accepted suppliers been sent a prior formal notification informing them of Eskom's expectations, including the implementation date deadline?

Comment: n/a

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

Comment: n/a

5.8 Material group(s) affected by specification (refer to Pre-qualification invitation schedule for list of material groups).

Comment: n/a

6) Training or communication

6.1 Is training required?

Comment: n/a

6.2 State the level of training required to implement this document (e.g. awareness training, practical/on job, module).

Comment: n/a

6.3 State designations of personnel that will require training.

Comment: n/a

6.4 Is the training material available? Identify person responsible for the development of training material.

Comment: n/a

6.5 If applicable, provide details of training that will take place (e.g. sponsor, costs, trainer, schedule of training, course material availability, training in erection/use of new equipment, maintenance training).

Comment: n/a

6.6 Was Technical Training Section consulted regarding module development process?

Comment: No.

6.7 State communications channels to be used to inform target audience.

Comment: email

7) Special tools, equipment, software

7.1 What special tools, equipment, software, etc. will need to be purchased by the Region to effectively implement?

Comment: None.

7.2 Are stock numbers available for the new equipment?

Comment: No new equipment will be needed to implement this document

7.3 What will be the cost of these special tools, equipment, software?

Comment: n/a

8) Finances

8.1 What total costs would the Regions be required to incur in implementing this document? Identify all cost activities associated with implementation, e.g. labour, training, tooling, stock, obsolescence.

Comment: n/a

Impact assessment completed by:

Name: Alpheus Majozi

Designation: Senior Advisor

Annex B – Single line drawings

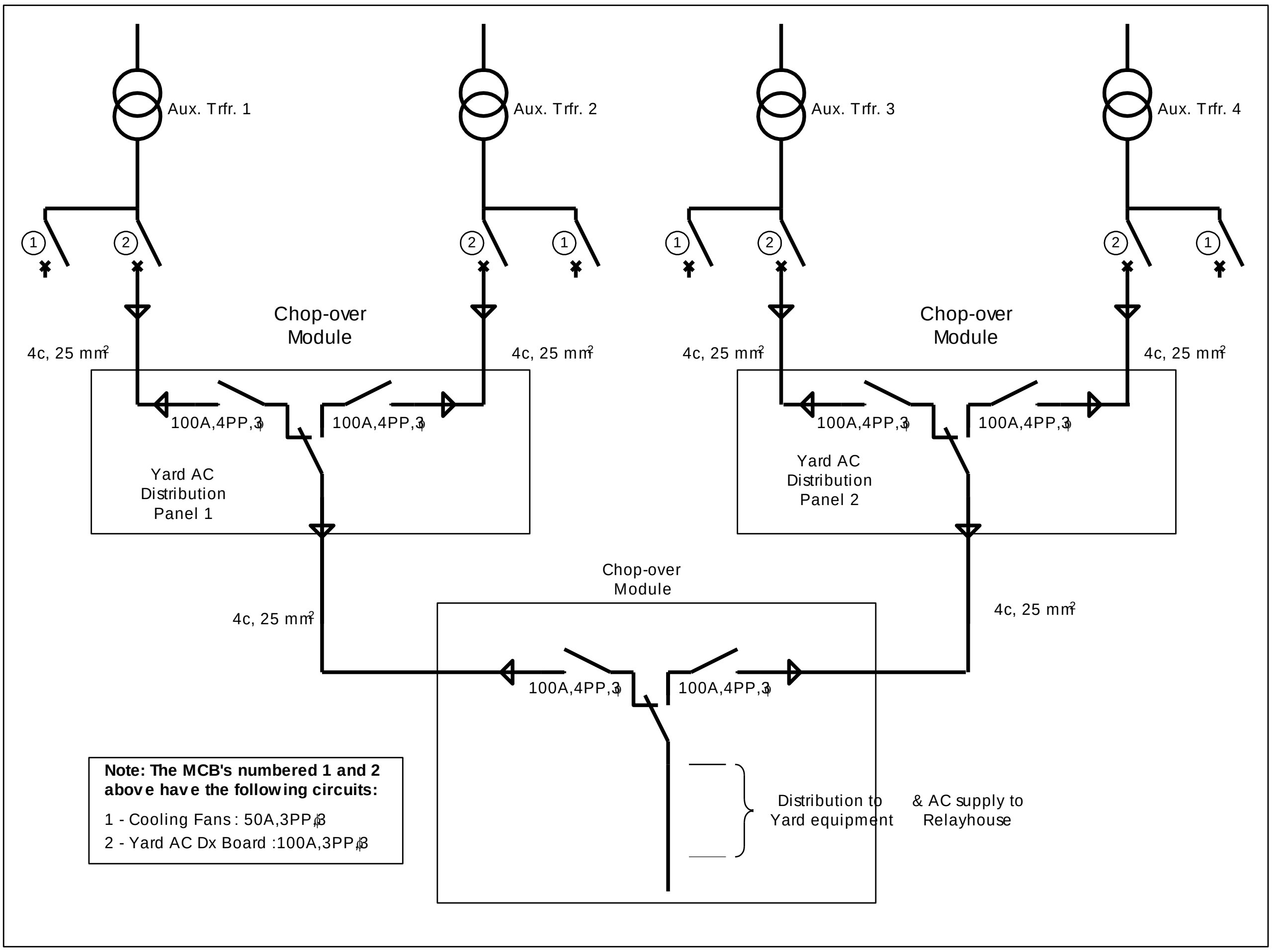

Figure B.1: Single line diagram for four main transformers

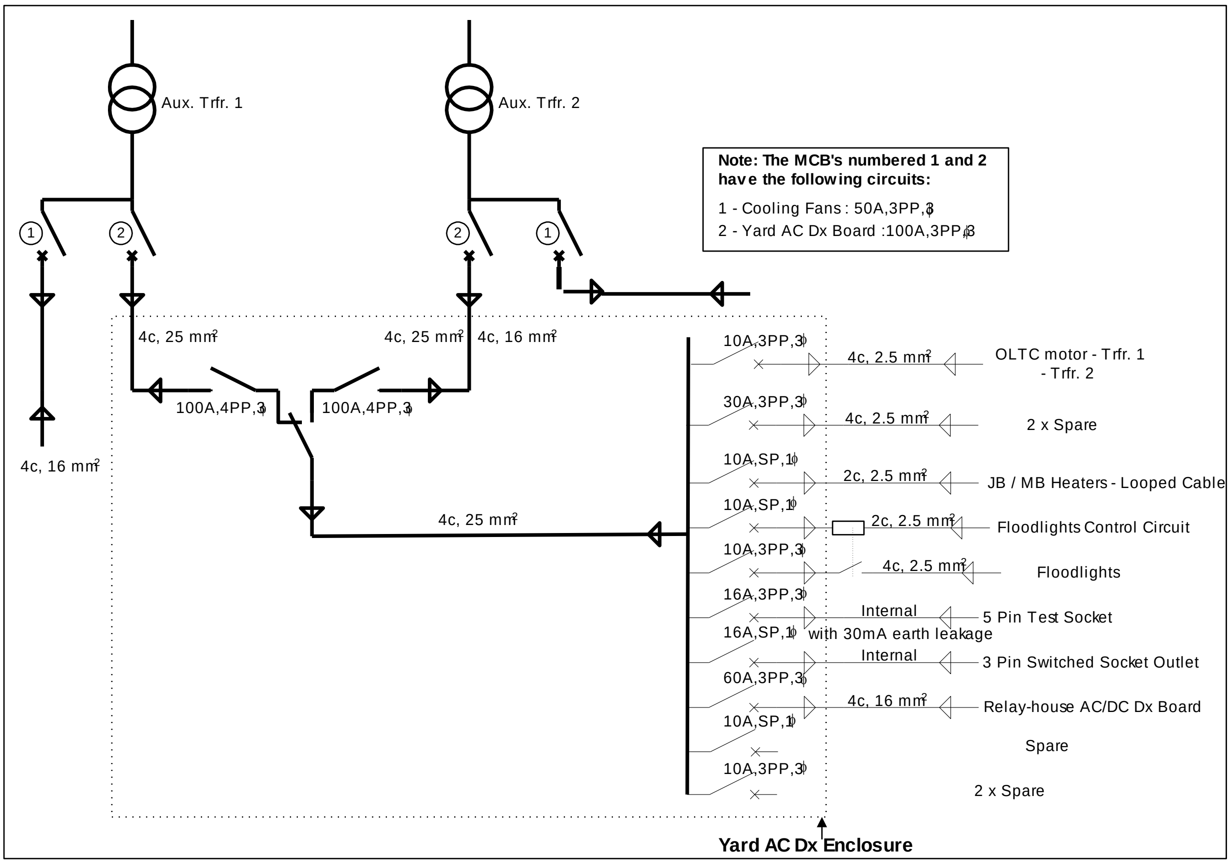

Figure B.2: Single line diagram for yard AC distribution board