

	Standard	Technology
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Title: **STANDARD FOR AUXILIARY TRANSFORMERS FOR MAIN TRANSMISSION SUBSTATIONS**

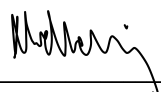
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Subhas Maharaj

Senior Manager: Substation Engineering

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DBOUS Acceptance



Amelia Mtshali

Senior Manager: Design Base & Operating Unit Support

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1	A specific plant, project or solution	
2	A mature and stable technical area/technology	x
3	Established and accepted practices.	x

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 Eskom	Standard	Technology
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		Supported by SCOT/SC  Phineas Tlhatlhetji SCOT/SC Chairperson Date: 04/12/2014

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Executive Summary

Auxiliary power requirements at Main Transmission Substations have changed over the years, initially seeing an increase in the number of auxiliary transformer units and then a reduction. These changes were never properly documented and relied on in-house training and word of mouth to convey this information to new design engineers. This document is therefore a means of ensuring this information is kept up to date and is properly recorded to ensure designers get the latest information pertaining to how auxiliary transformers are to be allocated in a substation design.

In earlier times, the security of the substation was a priority. Lethal electric fencing was the order of the day to deter unwanted elements gaining access to substations. For this reason, a second auxiliary transformer was installed to separate this load from normal station supplies in order to minimise the impact operational impact.

The current practice is to install non-lethal electric fencing which draws minimal current. A single wall plug can power up to 5 energisers, 12 energisers being typical for a station. Due to the much lower power requirement, only one auxiliary transformer per power transformer is required.

In order to arrive at the correct size of transformer, a detailed auxiliary load analysis has been carried out. The difference in load requirements of MTS substations up to and including 400kV as compared to 765/400kV transformer stations leads to two standard sized transformers, viz. 315kVA and 500kVA.

1. Introduction

The manner in which auxiliary transformers are allocated and connected to the main coupling transformers varies with the application. The document is necessary to give clear guidance on the number and capacity of auxiliary transformers to be installed.

2. Supporting clauses

2.1 Scope

This document is a standard for the application of auxiliary transformers in Transmission substations.

2.1.1 Purpose

The purpose of the document is to assist design engineers in allocating the correct number of auxiliary transformers to an MTS substation

2.1.2 Applicability

This document shall apply throughout Eskom Holdings Limited Divisions.

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.

2.2.2 Informative

[2] 240-55151908 AC Reticulation Application Design for Substations

2.3 Definitions

2.3.1 General

Definition	Description
Auxiliary Transformer	A transformer intended to provide supply to the auxiliary equipment such as main transformer fans, protection and control equipment, building lighting, floodlighting, etc.
Circuit Breaker	Mechanical switching device that is capable of making, carrying and breaking currents under normal circuit conditions and of making, carrying for a specified time, and automatically breaking currents under specified abnormal circuit conditions such as those of overcurrent.
Distribution Board	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).

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2.4 Abbreviations

Abbreviation	Description
A	Ampere
AC	Alternating Current
DB	Distribution Board
DC	Direct Current
MCB	Miniature Circuit Breaker
MVA	Mega Volt Ampere
OLTC	On-load Tap Changer
PB	Plug-box
TDB	Transformer Distribution Board
TRFR	Transformer
VDC	Volts Direct Current

2.5 Roles and responsibilities

None

2.6 Process for monitoring

None

2.7 Related/supporting documents

None

3. Auxiliary Transformer

An auxiliary transformer is used to supply low voltage AC power system inside the substation. The ac load in the substation comprises amongst other, lighting, air conditioners, transformer cooling fans, transformer OLTCs and other AC supply system and DC power system such as protection relays, batteries, SCADA & telecommunication systems and other DC supplies.

It is necessary to have a minimum of two independent supplies to ensure the security of supply.

3.1 History

In earlier times, the security of the substation was a priority. Lethal electric fencing was the order of the day to deter unwanted elements gaining access to substations. For this reason, a second auxiliary transformer was installed to separate this load from normal station supplies in order to minimise the impact operational impact.

The current practice is to install non-lethal electric fencing which draws minimal current. A single wall plug can power up to 5 energisers, 12 energisers being typical for a station.

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3.2 Preamble

The AC Boards used at Transmission substations are rated for 300A, and have an automatic chop-over system. In the event of the current independent power supply being lost, the chop-over system will automatically switch over to the remaining independent system. The AC Boards rating are rated thus due to the battery chargers. The batteries remain charged and will only fully discharge in the rare event of total station power failure.

Power supply for the flood lighting, control room DB and security systems is supplied through a separate 100A or 160A MCB located in the AC Board or Station DB.

Power for the main power transformer cooling fans, are supplied directly from the auxiliary transformers via the transformer distribution boards (TDBs).

Only one auxiliary transformer is required for the station requirements. However, each main power transformer is required to supply its own fans, tap-changer and auxiliaries from its own unit auxiliary transformer. The 400V supplies are interlinked in via the TDBs in such a manner as to supply two independent secure supplies to the station ac board through a chop-over system (Secondary Plant drawings 0.52/20288 and 0.52/20289).

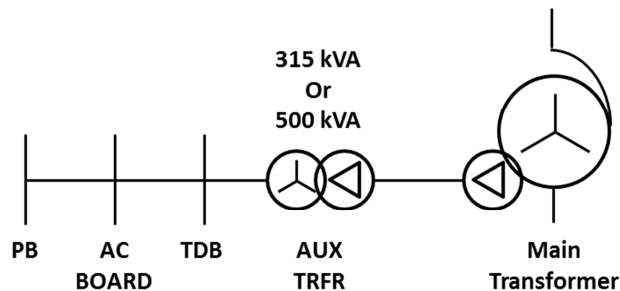


Figure 1: Auxiliary Transformer Connected to Main Transformer

3.3 Transformer Cooling Fans

The cooling fans of the main transformer, if we assume that a total of eight 1,5 kW fan motors, are started in a sequence of pairs (two at a time). When the last two motors (7 & 8) are started the total current at this time will amount to 148,96 A. This value was worked out by using the following information that was obtained from a typical fan motor data sheet.

Power output: 3 kW

Rated voltage : 380 V

Rated Current : 8.96 A

L.R. Amperes : 47.4 A (start-up current)

Figure 2 illustrates the start-up of the fans. At time period 1, fans 1 & 2 starts-up. The current for the two fans motors peaks at 94,8A and then returns to the rated value of 17,92A. We assume that the fan is a 100% load on the motor. At time period 3, fans 3 & 4 starts-up. The peak current is now 94,8 A, plus the rated current of fans 1 & 2. The current then returns to the rated current of 4 fan motors. The current continues to rise in this manner until all the fans are running.

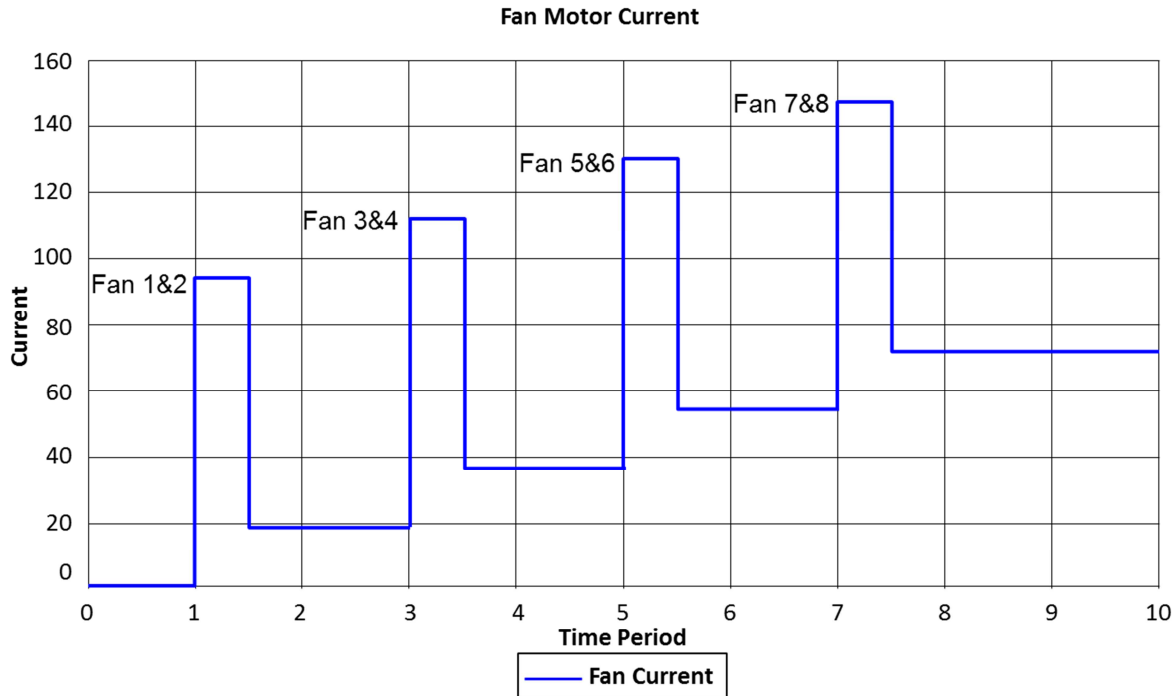


Figure 2: Start-up Currents of Transformer Cooling Fans (per transformer)

3.4 Floodlights

The Floodlights are controlled via switches located on the porch of the control building. The floodlights are energized by these floodlight switches through a contactor in the Floodlighting Distribution Board inside the control room.

Floodlights are only switched on when entering the HV yard at night times.

The floodlights are controlled by two-way switches, which shall be located on the inside of the substation gate and at the relay house entrance. The floodlights are energized by these two floodlight switches through a contactor in the Yard A.C. Distribution Panel. The floodlight supply circuit is a looped supply, which, in the case of large yards, should be balanced from a three-phase looped supply. The supply to the floodlights may be split so that only some lights are switched on from the remote switch while the rest are switched on at the light.

A maximum of 8 x 400W luminaires are allowed for per mast, depending on the substation size the amount of masts can range from 1 to 14 masts for a 400/132kV station.

Floodlight design parameters: A maximum of 8 x 14 x 400 W lights is allowed for in the design.

$$\begin{aligned}\text{Phase current} &= ((8 \times 14 \times 400) / 3) / (400 / \sqrt{3}) \\ &= 65 \text{ A}\end{aligned}$$

3.5 Transformer Auxiliary Power Requirements - Load Analysis

The typical equipment in a substation with typical maximum load currents is shown in Table 1 and Table 2.

NOTE - These tables also show the preferred phase connections to the loads in order to get a good balancing of load currents.

Table 1: Typical yard A.C. Distribution Loads

Yard A.C. Loads	3-Phase Transformers in Single Tank up to 800MVA Phase Currents [A]	3-Phase Transformers made up of Single Phase Units up to 2000MVA Phase Currents [A]
Transformer 1 OLTC – motors	3	5
Transformer 2 OLTC – motors	3	5
Transformer 3 OLTC – motors	3	5
Transformer 4 OLTC – motors	3	5
Transformer 1 Oil Pump	5	5
Transformer 2 Oil Pump	5	5
Transformer 3 Oil Pump	5	5
Transformer 4 Oil Pump	5	5
Transformer 1 Cooling Fans	36	72
Transformer 1 Cooling Fans	36	72
Transformer 1 Cooling Fans	36	72
Transformer 1 Cooling Fans	36	72
Transformer Cooling Fan Sequence Start-up	24	48
Heaters	5	5
Floodlights	65	65
Floodlights Control	2	2
Test socket	16	16
Total Yard Current	288	464

Table 2: Typical Relay-house A.C. Distribution Loads

Relay house Loads	Phase Currents [A]
Transformer/OLTC Panels (4)	1.5
HV Feeder Panels (4)	1.5
Transformer Panels (4)	1.5
HV B/C and B/S Panels (4)	1.5
MV Feeder Panels (14)	5
MV B/C and B/S Panels (4)	1.5
MV Cap Banks (4)	1.5
Buszone Panel (2)	1
UFL Panel	1
Measurements Panel	1
110V Charger (2 x 25A)	50
50V Charger (2 x 25A)	50
Test socket	16
Domestic Distribution AC-DB	30
Total Relay-house Current	163

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3.6 Total 3-Phase Load**3.6.1 3-Phase Transformers in Single Tank up to 800MVA**

The total 3-phase load current with all the loads operating (worst case) is $(288+163) \text{ A} = 393 \text{ A}$:

$$\begin{aligned}\text{Aux Transformer Rating} &= \sqrt{3} \times 400 \times 451 \\ &= 312 \text{ kVA}\end{aligned}$$

$$\begin{aligned}\text{Allowing 5\% for contingency power} \\ &= 328 \text{ kVA}\end{aligned}$$

$$\begin{aligned}\text{Nearest standard size} \\ &= 315 \text{ kVA}\end{aligned}$$

3.6.2 3-Phase Transformers made up of Single Phase Units up to 2000MVA

The total 3-phase load current with all the loads operating (worst case) is $(464+163) \text{ A} = 627 \text{ A}$:

$$\begin{aligned}\text{Aux Transformer Rating} &= \sqrt{3} \times 400 \times 627 \\ &= 434 \text{ kVA}\end{aligned}$$

$$\begin{aligned}\text{Allowing 5\% for contingency power} \\ &= 456 \text{ kVA}\end{aligned}$$

$$\begin{aligned}\text{Nearest standard size} \\ &= 500 \text{ kVA}\end{aligned}$$

4. Authorization

This document has been seen and accepted by:

Name and surname	Designation
Braam Groenewald	Corporate Specialist - Substations
Enderani Naicker	Chief Engineer - Substations
Phineas Tlhatlhetji	Senior Manager - Substations
Asiff Amod	Chief Engineer - Substations
Leon Kotze	Senior Consultant - Protection
Dr Rob Stephen	General Manager – Master Specialist
Thys Bower	Corporate Specialist - Protection
Prince Moyo	General Manager – Power Delivery Engineering

5. Revisions

Date	Rev.	Compiler	Remarks
Dec 2013	1	A J S Groenewald	First issue.

6. Development team

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

- Braam Groenewald
- Enderani Naicker
- Leon Kotze

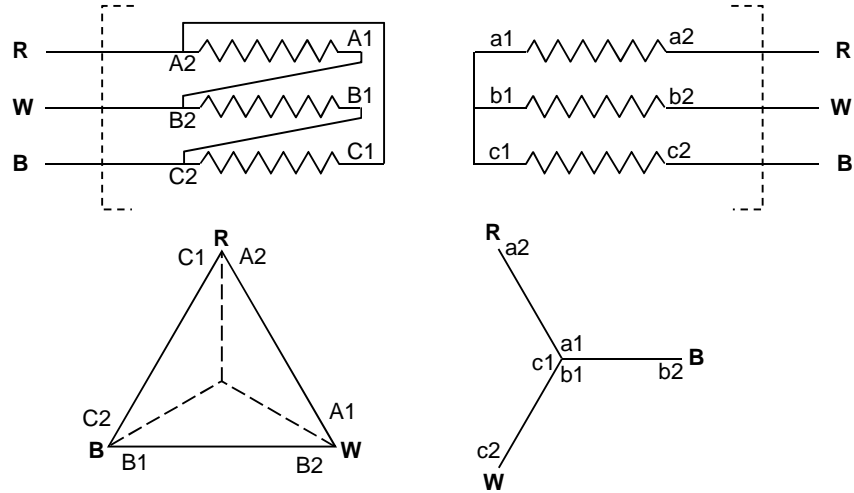
7. Acknowledgements

With thanks to the development team.

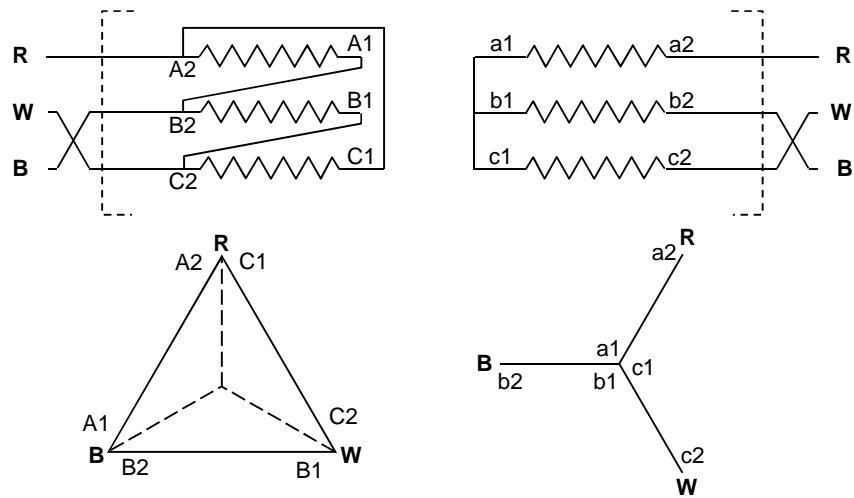
Annex A – Auxiliary Transformer Vector Group and Connections

CONNECTIONS TO PARALLEL AN EXISTING YD11 TRANSFORMER WITH A DY1 STANDARD UNIT

DY11 TRANSFORMER



a) Normal Dy11 Connection



b) Connecting a Dy11 Transformer to Give a Dy1 Vector Relationship

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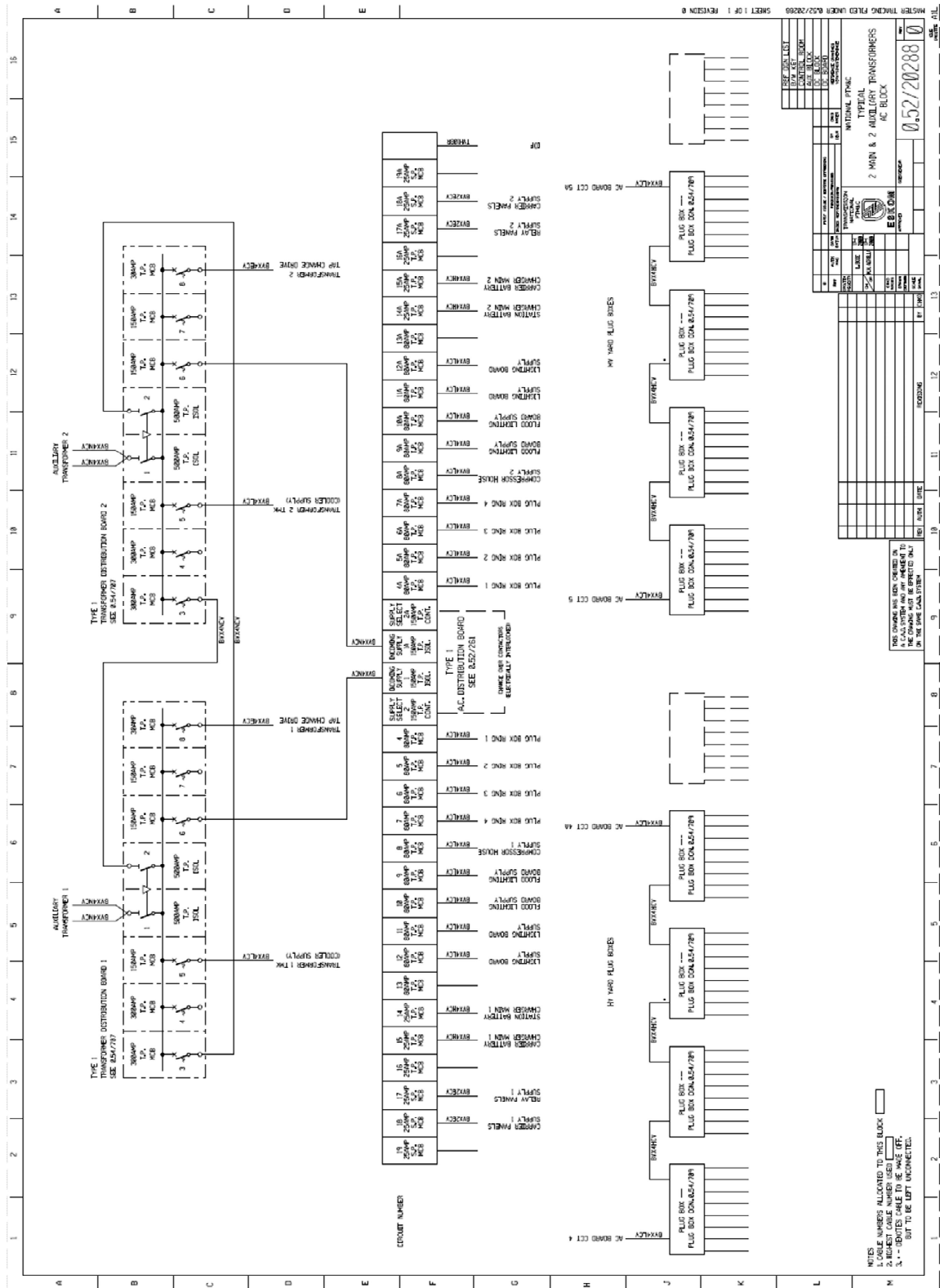
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Annex B – 2 Auxiliary Transformer Schematic



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