Eskom	Standard	Technology

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Area of Applicability: **Engineering**

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Richard McCurrach

Senior Manager: PTMC

Date: 4/10/2019

DBOUS Acceptance

[signature]

Amelia Mtshali

Senior Manager: Power Delivery Engineering (DBOUS)

Date: 7/10/2019

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.	X

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Compiled by	**Approved by**	**Authorized by**
Haggai Sithole	**Philip Groenewald**	**Richard McCurrach**
Senior Engineer Protection	**Acting Protection Technology Manager**	**Senior Manager PTM&C**
Date: 21 July 2014	Date: 4 August 2014	Date: 11/08/2014

Supported by SCOT/SC

Graeme Topham

PASC Chairperson

Date: 23 July 2014

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1. Introduction

This document is intended for use by Secondary/Control Plant Application staff and Project Engineers involved in the design and commissioning of protection schemes for secondary and primary plant. The document can also be used for reference purposes by Eskom hired consultants supervising contractors and can also be used for general training purposes.

It is advisable that this standard is read in conjunction with the latest documentation for protection schemes on national contract as well as any applicable technical instruction, technical bulletin and modification instructions that may be applicable.

2. Supporting clauses

2.1 Scope

This standard serves as a generic document that can be used by the secondary plant staff within the grids and operating units. The standard specifically targets staff that is involved in the design and application of control and secondary plant protection schemes.

2.1.1 Purpose

The purpose of this document is to create a Control Plant design standard/handbook outlining all technical aspects of control plant design for example, current transformer (CT) ratio selection, segregation of signals etc. It seeks to provide the Application Design Engineers, amongst other end users, with the basic tools required to perform a protection application function within the Transmission and Distribution protection applications environment. This standard only addresses the application aspects and not the detailed scheme designs. Detailed aspects outlining e.g. rationale for choice of a particular scheme are described in the respective protection philosophy documents.

2.1.2 Applicability

This standard shall apply throughout Eskom Transmission and Distribution Division.

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] 41-941 Transmission Protection Application Guideline

[3] DST 34_461 Distribution Standard For The Application Of Bus Zone Protection

[4] NRS083-2 Electromagnetic compatibility (EMC) in electricity utility networks Part 2: Substation design and equipment installation practices

[5] NRS031-2008 Alternating Current Disconnectors and Earthing switches (Up to 145kV)

[6] DPC 34 -1034 Distribution Test Procedure for High Voltage Disconnectors

[7] Control Plant Cell Library Drawing No. D-DT-5414

[8] 240 – 61268576 Standard for the interconnection of embedded generation

2.2.2 Informative

None

2.3 Definitions

2.3.1 General

Definition	**Description**
High Voltage	A nominal AC or DC voltage higher than 1 000 volts
Direct transfer trip	A signal that causes a remote end to trip without reclose irrespective of that end sensing the fault or not, for example, local "breaker fail" condition
Permissive signals:	A signal that assists the protection device to make a trip decision, for example, permissive overreach impedance relaying.
Intertrip	A signal that causes a remote end to trip and reclose irrespective of that end sensing the fault or not, for example, remote weak infeed condition
Protection scheme	All switches, relays, controls, indications, wiring, terminals and the cabinets housing these items that provide the required protection functionality for the specific application.

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
APT	Anti-pump timer
ARC	Auto reclose
ARCMS	Autoreclose mode switch
ARCRSR	Auto reclose repeat selector relay
ARCSS	Auto-reclose selector switch
B/U	Back up
BCD	Bay Closing Device
BF	Breaker fail
BP	Bay Processor
CBC	Circuit breaker closed
CBCS	Circuit breaker control switch

Abbreviation	Description
CBO	Circuit breaker open
CT	Current transformer
CTTB	Current transformer test block
DC	Direct current
DCI	Direct current isolator
DRTU	Distribution remote terminal unit
DTF	Distance to fault
DTL	Definite time lag
DTTS	Direct transfer trip send
DTTR	Direct transfer trip received
E/F	Earth fault
FC	Fault counter
HV	High voltage
IDMTL	Inverse definite minimum time lag
IEC	International Electrotechnical commission
IED	Intelligent electronic device
LCS	Lamp control switch
LED	Light emitting diode
LV	Low voltage
MCB	Miniature circuit breaker
MMI	Man machine interface
MSB	Most significant bit
O/C	Overcurrent
PDT	Pole discrepancy timer
PNH	Protection not healthy
SIR	Source impedance ratio

Abbreviation	Description
TNS	Test normal switch
TP	Test point
TPIS	Teleprotection isolating switch
TTPB	Trip test push button
VSR	Voltage selection relay
VT	Voltage transformer
VTTB	Voltage transformer test block

2.5 Roles and responsibilities

Not applicable

2.6 Process for monitoring

Not applicable

2.7 Related/supporting documents

Not applicable

3. Document content

3.1 Protection application check list

The check list below, used mostly in Transmission, gives an overview of the salient points to be considered when doing Application, Design and project engineering work. It is by no means exhaustive.

Activity No.	Description	Checked
	Applications Engineer	
1	Receive Job in a form of a project file /Grids emergency work request handover from Project Engineer /Applications Manager	
2	Obtain bay layout and primary plant information from Project manager from Substation Design. Do not accept incomplete bay layout drawings. Visit site if necessary to confirm equipment to be used.	
3	Make sure you have the correct revision of existing application, or check that you are implementing the correct master tracing revision from standards	
4	Check options on proforma and ensure you use the correct levels	
5	Check with other protection application staff if there are cells available on the system for primary plant if not create a cell and register it.	

Activity No.	Description	Checked
7	Control room layout. Mark up according to information received from Project Engineer and site inspection	
8	Check station DC voltage from station electric or proforma.	
9	Confirm bus zone CT ratio from station electric	
10	Confirm with Measurements department interfacing points.	
11	Check with DC department interfacing points. DC output performed by Application Engineer	
12	Check with Power telecoms department interfacing points. This output is incorporated in the scheme by selecting levels.	
13	Check with Tele-control department interfacing points	
14	Communicate with Project Manager/Project Engineer and Protection field department if further information is needed	
15	Check if you have all the interfacing drawings to be marked up (i.e.: VT, CT, BZ, AC Retic, DC Board etc.)	
16	Mark up VT circuits - Part of detailed design	
17	Mark up Buszone circuits - Part of detailed design	
18	Mark up DC key and loops - Part of detailed design	
19	Mark AC key and loops - Part of detailed design	
20	Mark up other interfacing panels e.g. UFLS, Recorders etc. - Part of detailed design	
21	A3 copies and Red/Yellow originals to appropriate person to check. If old drawings, A2 is fine. (Full set, not only mark-ups) - Part of detailed design	
22	Copy of design checklist in project file	
	Senior Application Designer	
1	Check all above steps are done	
2	Check and authorise drawings	

	PROJECT ENGINEER	
1		
	APPLICATION ENGINEER	
23	Send copies of signed and completed drawings to Project Manager for archiving.	

3.2 General philosophy

3.2.1 Current transformers

3.2.1.1 CT Star Points

3.2.1.2 Standard Eskom practice with regard to the connection and earthing of protection CTs is such that the star point of the CTs faces the item of plant to be protected. For example: CTs connected to a distance relay, protecting the HV line, have the star point of the CTs connected towards the line side and transformer CT star points face each other across the transformer. This convention is however not followed in Distribution where CT circuits used for high impedance bus zone protection, the star points face away from the busbars. Document DST 34-461 details the reasoning behind adoption of this convention.

3.2.1.3 CT Star Points Earth Connection

The CT star points are connected to earth at the protection panel and not at the junction box. This enables field staff to test the earth connection of the CT from within the control room, minimises voltage rise near relaying equipment and reduces the shock hazard for personnel in the control building (NRS083-2). All CT cores shall be connected to earth at one point only, to prevent the possibility of circulatin

Earthing bars used to earth spare cable cores

3.2.1.4 CT Cores – overlapping zones

The utilization of CT cores is such that zones of protection are arranged to over-lap each other. The principle of over-lapping zones of protection is applied wherever possible to maximise the protected zone and avoid 'blind spots'. A 'blind spot' refers to a fault position that does not cause fault current to flow through the CT connected to a protection element.

3.2.1.4. Cable cores

The Eskom standard is to earth all spare cores on cables at one point only. Provision must be made for sufficient slack to reach the furthest point on the terminals.

In the case of cables between panels within the control room with spare cores, the spares must be earthed in one panel only. Similarly, there must be provision made for the cores to reach the furthest termination point.

3.2.1.5 Unused CT cores

Unused CT cores are shorted out and earthed at the CT junction box and are not brought back to the control room or the protection panel. This practice reduces the number of control cable cores required between the primary plant and the control room.

The picture in Fig. 1 below shows properly earthed unused cores in a Transmission junction box.

Figure 1: Properly earthed spare cable cores in yard JB

3.2.1.6 CT P1 – P2 Orientation

The standard order of plant arrangement in Eskom substations is Busbar-Circuit-Breaker-CTs. The P2 terminal of post-type CTs is bonded to the metal outer casing of the CT. With the CT oriented with P1 facing the circuit-breaker, a fault or flashover from the casing to earth will be detected by protection elements as a line fault rather than a busbar fault, resulting in the minimum plant being removed from service for this fault condition. The P1 terminal of post type CTs thus faces the circuit-breaker in standard applications. In the event of post type CTs on both sides of the circuit-breaker, optimal protection selectivity is attained in P1 faces the busbar on both sets of CTs. For bus coupler/section applications with post type CTs on either side of the circuit-breaker, P1 must face the circuit-breaker for both sets of CTs. Transformer internal CTs have terminal P1 facing the outer extremities of the plant.

3.2.2 CT ratio selection

Current transformer ratio selection must be done by settings engineers.

3.2.2.1 Anti-pump timer

The Transmission philosophy is such that the protection scheme shall have this timer fitted, irrespective of a timer being available on or within the circuit-breaker. This enables all protection related timer settings to be applied (and tested) at the protection panels, without any devices being exposed to outdoor conditions. Where a circuit-breaker has a timer and circuitry fitted, this shall be disabled to allow the panel mounted device to operate correctly.

The Distribution specifications for circuit-breakers call for a “one-shot” function by which a close command can only effect a single close operation. This provides a settings-free Anti Pump Timer (APT) function. This function will operate prior to any conventional APT in the panel, and should not therefore be disabled. The philosophy then is that the panel has an APT function built in, which should operate as back-up to the CB’s internal one-shot close function.

3.2.2.2 Cross tripping philosophy

Where protection schemes have been designed for a dual main or main and back up protection tripping philosophy, and applied to circuit-breakers with two trip coils, all tripping signals shall "cross trip" and effectively provide a trip signal to both trip coils.

3.2.2.3 Tripping philosophy

For all schemes that utilize unit trip protection elements, this output shall trip the associated circuit-breaker directly, and possibly operate a latching type relay as well (i.e. restricted earth fault, transformer differential, etc. operating a master trip relay). In other words a trip shall be latched if visual inspection/testing is required prior to energisation following a trip. The scheme design should prevent circuit breaker closing whilst the trip is on.

3.2.2.4 Voltage transformer applications

Voltage transformers include power and control pant transformers. Both types of VTs are used to supply an auxiliary supply. Power VT is outdoor, typically 44kV, 66kV, 88kV or 132kV. Control plant transformers are used indoor with indoor switchgear.

Three single-phase busbar-connected VTs are utilized for standard distance based HV line protection schemes. Where synchronizing or single pole tripping schemes are utilized, an additional single, line connected VT, will be required. For each section of busbar a separate VT is required where either measurement or protection functionality dictates their use. For metal-clad switchgear applications, a five-limb VT will be required. Each transformer shall have a single MV VT available for application with the tap change control scheme measuring the transformer phase to phase tap-change voltage.

Segregation of VT circuits. Protection and measurement VT circuits shall be segregated so as to ensure protection reliability. The two windings from most VTs are actually identically designed and dual rated for protection and measurements (e.g. 3P/0.2) in most applications, so this is not a result of an accuracy limitation of the VT, but purely a reliability decision. The "protection" winding can be used for substation measurements, typically reported locally and to SCADA via a protective IED without problem. Thus segregation shall only apply with dedicated measurement transducers**.**

Note: Many VTs have one winding designated Class 3P/0.2 and 0.2 respectively as a result of the wording of Eskom's specification. In fact, the two windings are of identical construction in almost all cases.

Refer to the Eskom Standard for the interconnection of embedded Generation regarding requirements for synch or system checks in IPP applications.

3.2.2.5 Power plant equipment arrangement

Primary power plant equipment is physically positioned from the busbar in the following order: Busbar link, circuit-breaker, CT, line VT (where used), line link and line surge arrester for HV line bays. Where the use of power line carriers is required for teleprotection communication purposes, the line trap and coupling capacitor are mounted on the line side of the line link. For applications requiring line VTs and power line carriers, the coupling capacitor may be replaced with a capacitive VT combined with a coupling capacitor. The transformer bay power plant equipment is physically positioned from either busbar as follows: Transformer busbar link, circuit-breaker, CT, transformer link and transformer. Transformer surge arresters are physically positioned as close to the transformer bushings as possible to ensure optimal surge protection, preferably mounted on special brackets on the transformer tank itself. MV feeder bays utilize combined CTs and circuit-breaker devices within a single 'dog-box' cubicle, with the physical positions from the MV busbar as follows: Busbar link, circuit-breaker and CT cubicle, line link and line surge arrester.

Some MV feeder bays utilize metalclad switchgear, with the physical position from the MV busbar as follows rackable circuit breaker, CT chamber, cable termination and surge arrester.

3.2.3 Power Transformer protection

3.2.3.1 Interfacing methods

Interfacing a protection scheme with other protection schemes and primary plant is achieved via appropriately selected and numbered cable runs terminated on interface terminal strips. By using a precise and methodical approach unwanted errors may be eliminated and the quality of the application work will be enhanced. This is very important as the time for commissioning equipment is very restricted and the field staff cannot afford to waste time on corrective action due to incorrect application work. A site visit is of utmost importance to verify information on existing applications.

1) Study the protection scheme to be utilised. Make sure you have the correct revision of existing application or check that you are implementing the correct master tracing revision from standards.

   Check options on the proforma and ensure that you use the correct levels. Make sure you understand the functionality and philosophies used in the scheme. Obtain a copy of the scheme specific application guideline from the Designer appointed as custodian for the scheme that you are to use. If unsure of anything ask Supervisor to explain.

2) Study the primary plant information. If cells are available use it to ease the workflow. If cells do not exist, create and discuss with the Standards person for approval. Do comparative checks with the manufacturer drawings.

3) Page through the scheme drawings transferring all primary plant information into the relevant spaces allocated. On the single line diagram add the make, type, etc. of the primary plant used. This information is used by the settings department and will aid the Senior Engineer when doing the final check and approval.

4) For cross reference indicate on the primary plant drawings which circuits and contacts have been transferred to the scheme drawings. This will eliminate omissions of circuits and duplication of contacts used.

5) Study the interfacing points with existing panels and give proper reference to the equipment. Provide drawing and sheet reference numbers.

6) Transfer all information from the scheme drawings onto the cable schedules by doing one page at a time. This is critical as the contractors on site use the cable schedules and block diagrams only. All wiring and cabling are done as specified on the schedules.

7) Create a cable block diagram from the cable schedules. If a master exists use it, if not create a standard and register with CAD office.

3.3 Application designer checks

3.3.1 Draft checks

After completion of the application, it is essential that the entire application and all interfacing drawings be thoroughly checked. This must be done before submitting to the senior for final checking and approval. Confirm with the senior as to whether the original red/yellow mark ups must be submitted with the draft copy.

Use the following steps as a guide for checking the application.

1) Page through the scheme and check every sheet with respect to the functionality of each circuit with which the scheme interfaces.

2) Refer to the primary plant drawing checking that the secondary circuits and interfacing points have been transferred correctly.

3) Check that the circuits from the AC and DC keys that were transferred to the schedules are correct and all information noted. Ensure that the correct suffixes are used. Confirm station DC voltage.

4) Check with Measurements department. Confirm interfacing points.

5) Check with Power telecoms department. Confirm interfacing points.

6) Check with Control department. Confirm interfacing points.

7) Do cross check between the cable block and cable schedules to ensure all the cables have been included.

8) If in doubt of any interfacing or circuitry used confirm with the Planner as to ensure that the correct philosophy is applied before having CAD work done.

9) Ensure that you obtain a new drawing number for new bays or scheme replacements. Ensure that the rev is adjusted and marked on existing drawings. Supersede all replaced drawings referring to the new drawing number.

3.3.2 CAD drawings checks

The first copy of the drawings received from the drawing office needs to be thoroughly checked by the Application designer against the original application drawings submitted. Minor errors can be marked up on the cad plot before submission to the Planner for initial checking. Major errors must be marked clearly on the A3 draft copy and returned to the drawing office before submitting to the Planner. Do not give A1 copies to the Planner for checking. The Application designer must check the copies received from Cad to ensure that all corrections marked by the Designer and Planner were correctly done. If satisfied A1 copies are then requested by the Application designer. After signing the copies as checked, submit to the Planner for approval signature.

No further corrections should be necessary as it was checked by the Designer and the Planner.

3.4 Application notes

On the master copies of the schemes there are often notes included from the design engineers intended to assist the application designer.

Example: On the current transformer circuits of a feeder there might be a note stating "*Connect to disturbance recorder. If no disturbance recorder short."*

The application designer must decide whether the circuit is used and the note removed from the drawing accordingly.

Not used and optional labels:

Master copies of scheme drawings are modified and adopted to suit the specific requirements of each specific bay.

Not used and optional labels must be applied where needed as specified on the proforma.

Example:

On a scheme ordered with an anti-pump timer as part of the scheme and the panel delivered with the circuit fitted the word "optional" on the master copy being used must be removed. If the scheme was ordered with the anti-pump timer and it is not used then replace "optional" with "not used" on the scheme drawing. If the anti-pump timer was neither ordered nor installed and no wiring is provide then the circuit must be removed from the drawing.

3.5 Relay type and manufacturer

The information regarding the type and manufacturer of the relays and scheme should be included on the first couple of sheets of each scheme. If omissions are picked up, discuss it with the design section to have the master drawing revised. When retrofitting a relay on an existing scheme confirm relay points to be used with the design section.

3.6 Manufacturer's drawings

Different manufacturers are used to supply primary equipment and there are differences in the way their standards are applied to drawings. An example of this would be the different ways in which suppliers name an identical function.

SF6 urgent and lock out might be labelled as SF 6 monitoring by one supplier. The manufacturers drawing must therefore be studied when doing the application to avoid confusion. The manufacturers drawing details must be reflected on our drawings for future reference.

3.7 Circuit breakers

Circuit breaker manufacturers differ in the way the breaker position and status of secondary equipment and contacts are drawn. Irrespective of the supplier standard, Eskom drawings are done with the breaker information as listed.

1) Circuit breaker in open position
2) Spring discharged
3) Gas unhealthy
4) Control circuit DC supply switched off

Manufacturers drawings often refer to the phases as a, b, c. As a standard always designate the three phases as Red, White and Blue.

The preferred option when doing interfacing with circuit breakers is to include the different circuits on the appropriate sheet rather than adding an extra sheet to the scheme drawings. The reason for this is to enable field personnel to follow the circuits without having to cross reference. If not possible to add circuitry to the scheme due to space constraints then an extra sheet may be added. Ensure that all cross reference points are clearly indicated.

A legend explaining all equipment, relays and contact functions must be added.

SF6 secure DC key sheets must be added where schemes do not make provision for SF6 monitoring. Alarms from the secure supply module must be added to the appropriate alarm sheet. Secure supplies are not used in Distribution. The philosophy is that the SF6 monitoring supply is provided from the alternative protection DC supply (main or back-up) to that which powers the breaker fail relay.

3.7.1 Separation of AC and DC signals

To the extent possible, some provisions NRS 083-2:2009 Electromagnetic Compatibility (EMC) In Electricity

Utility Networks Part 2 must be adopted.

Part 2: Substation design and equipment installation practices, gives guidance on the installation of secondary equipment, specifically control cable connections from field equipment and the switchyard. The standard recommends separation of switchyard cables based on the principle of keeping cables of significantly different voltage or current levels separate in order to reduce common mode magnetic coupling between them. The segregation methods recommended for control plant equipment is that low-voltage power cables and control cables may be run in the same trench or tray, but grouped separately. Separation of AC and DC signals must be given due consideration where electrical interference under certain conditions may lead to equipment failure or maloperation.

The following is recommended without being prescriptive:

- 1 x DC supply cable for main protection - looped to back-up protection.
- 1 x DC supply cable for Spring Rewind.
- 1 x AC cable for 230VAC supply to breaker heater.

3.8 AC & DC supplies are to be supplied on separate cables. Primary Plant contacts

Manufacturer drawings indicate breaker and isolator contacts in various ways. To standardise the contacts in the manner shown, the following are guidelines is to be used irrespective of the symbol used by the supplier.

1) All contacts must be drawn hinged on the right hand side with the swivel contact moving in a clockwise direction.

2) The contact must be shown with the lowest number on the left and highest number on the right hand side.

3) Clearly indicate the type of contact used, M, N, G, sls, in the middle of the contact.

4) All contacts must be drawn in accordance with the Eskom Standard drawing practice document.

5) The application designer must confirm and ensure that the contacts that are used are suitable for the application (see Annex C). Annex C explains why certain contact types are used in specific applications.

N.B: It is good practice to apply two G-type contacts in parallel for Bus Zone CT selection.

6) Confirm that the rated primary current is sufficient for the application (e.g. based on conductor/transformer ratings. Confirm that the rated short time withstand current is suitable for the maximum fault level at the point of application.

Check also that the insulation level of the isolator is sufficient.

<u>Pantograph contacts</u>

1) Change-over relays used for bus zone CT switching.

The normally open contacts used to operate the change –over relay when the pantograph is closed must be connected in parallel.

The normally closed contacts used to reset the change –over relay when the pantograph is opened must be connected in series.

2) Indication change-over relays.

The sets of pantograph auxiliary contacts that are used to drive the operate and reset coils of change-over relays used for indication purposes, must both be connected in series. This arrangement will alarm the operator or remote controller that all the poles of the pantograph did not operate correctly.

3) VT selection change-over relays.

The normally open contacts used to operate the change –over relay must be connected in series.

The normally closed contacts used to rest the change –over relay must be connected in parallel.

3.9 Local/Off/Remote switch

The LOR switch in the junction box is used as an interface point between the primary plant circuit breaker, and the secondary equipment on the panel in the control room. This enables local control from the junction box for field personnel when doing testing and maintenance. The LOR will prevent unauthorised operating of the plant while maintenance, repair work etc. are in progress.

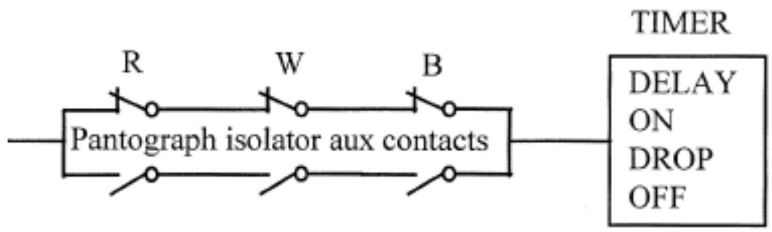
The LOR switch must be drawn in the Off position as it is standard practice in a Transmission substation.

Protection schemes make provision for the LOR switch position to be alarmed. This is necessary as the protection functions are isolated when the switch are in the local or remote position.

When using a distribution scheme at a Transmission station, the scheme must be modified to include the LOR alarm.

3.10 Pantograph pole discrepancy

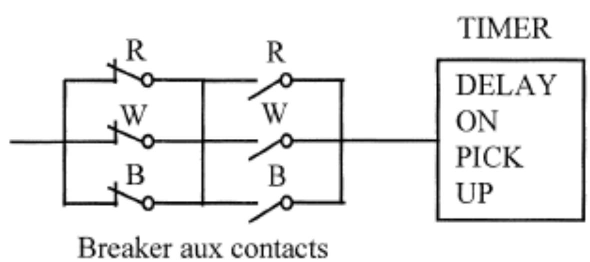
A pantograph is a three pole device meaning that it has three separate operating mechanisms. It is possible to operate each pole separately as each pole is equipped with a control mechanism box. It is not standard operating procedure to open or close the poles separately and therefore protection schemes employ a pole discrepancy circuit to alarm personnel should this occur.



Shown above is a simplified pole discrepancy circuit. The timer must be set at a value higher that the longest time of the slowest pole to enable the pantograph to operate and ensure that no false alarms occur.

3.11 Circuit breaker pole discrepancy

Circuit breakers with three separate operating mechanisms that are able to operate each pole individually are installed on EHV and HV feeders on the transmission network. The reason for using these breakers is to enable single pole tripping as supported by the protection schemes. As an example when a feeder protection scheme detects a fault on the Red phase, the Red phase pole of the circuit breaker is tripped. The remaining poles are still closed. The condition of having the poles in different states is acceptable for a short duration. To avoid this to be a prolonged condition a circuit breaker pole discrepancy circuit is used. A trip signal is issued after a set time by the pole discrepancy circuit to open the remaining poles.



Circuit breaker pole discrepancy circuit

3.12 Anti-pump timer

The primary function of an APT is to prevent "pumping "of the circuit-breaker. That is, successive trip and close operations that may be caused in the event that both the trip and close coils are energised simultaneously. In modern circuit-breakers, this risk is addressed via a one-shot closing function that is built into the CB's closing circuitry.

The secondary function is as described. In many Distribution schemes, closing is controlled by a suitably rated contact from one IED. This contact controls the pulse length which is controlled by the IED. A traditional APT is not needed in this case (provided the CB one shot close is available).

3.13 Busbar voltage selection

Busbar voltage selection is done by using latching relays installed in the protection scheme (VSR Relay).By using the latching relays an electrical interlock is possible but currently it is not used.

When doing an application on new and existing schemes ensure that the correct contact configuration is used. The input contacts from the isolators must be "late make" to enable the energizing of the busbar before VT supply is fed to the relays.

When using line voltage transformers on feeder bays and the option of multiple busbar selection was taken, note that the required looping in the protection panel is to be done on site. Indicate this on the appropriate sheet.

3.14 Cables

A 10% spare capacity factor must be used for all long run cables when selecting the cables during an application. Long run cables refer to all cables between the control room and the various bay junction boxes.

The reason for the spare capacity is to make provision for damaged cores and availability of extra cores should modifications be necessary at a later stage. As an example a 37 core cable should have 4 spare cores.

Calculate the nominal current from the connected load. The standard cable sizes used are 2, 5 sq.mm, 4 sq. mm and 16 sq. mm. Measure the required length of cable and the insulation type of cable (PVC etc.). Define the number of cores required for the application.

Always calculate volt drop under normal conditions and if the volt drop is > 5%, increase the size of cable. See Annexure A for example of volt drop calculation.

As a guide the following can be used on all applications:

Main 1 and Main 2 DC supply cables: 2 ECV

AC supply cable 2 ECV

Spring rewind 4 ECV

All other cabling # DCV

Plug box 2 ECV

ITM panel 4 ECV

VT's 4 ECV

Number of cores required by the application.

Cable size reference numbers are as follows:

Ref number	Core Size (sq. mm)	Current Rating (A)
D	2.5	25
E	4	33
H	16	77
L	35	126
Q	120	270

3.15 Cable block diagram

The cable block diagram must clearly indicate the cable size, number and destination of each cable. This is of utmost importance as the cable contractor will use this information for all cables installed. Include as many details as possible to ensure that there is no confusion as to what needs to be done. If the same cable appears in more than one drawing add note to the cable to indicate that it is also indicated on other drawings.

3.16 Cable schedules

It is of utmost importance that the cable schedules are correct as it is used by the contractor doing the cable installations. It must contain all the necessary information regarding the termination points of all cores used on the cables. This includes the correct ferruling to be used. Cross check with the scheme drawings to ensure that all interfacing points were transferred correctly.

All additional looping to be done by the cable contractor must be listed under the appropriate primary plant headings. The description given to the destination of the cable on the cable schedule must match the description of the destination indicated on the cable block diagram.

3.17 Standard numbering of wires

Rules for application:

1) Each wire shall have a letter to denote its function.
2) Each wire shall have a prefix number identifying the individual wire and function thereof.
3) Where a number of similar leads from separate units are taken to a common point suffixes A, B, C etc. shall be used to distinguish them.
4) Current and voltage transformer function letters shall follow through any interposing and auxiliary current and voltage transformers.

Circuit identification in Schemes

Letter	Description
A	Current transformers for primary protection
B	Current transformers for bus zone protection
C	Current transformers for secondary or back-up protection
D	Current transformers for metering and measurements
E	Reference voltage for instruments, metering and protection
F	Reference voltage for voltage control
G	Reference voltage for synchronizing
H	A.C. supplies and AC/DC supplies for motorized isolators and circuit-breakers
J	Primary DC supplies
K	Protection, closing and tripping circuits

Letter	Description
L	Indication initiated by auxiliary switches and relay contacts excluding those for remote selective control and for general indication equipment
M	Auxiliary and control motor devices, governor motor, rheostat motor, generator AVR control, spring charging motors, transformer cooler motor control, motors for isolator operation
N	Tap-change control including AVC, tap position and progress indication
P	D.C. tripping circuits used solely for busbar protection
R	Interlock circuits and Transfer circuits
S	D.C. Instruments and relays, exciter and field circuits for generators
T	Pilot conductors between panels, independent of the distance between them, for pilot wire protection, for inter tripping or for both
U	Spare cores and connections to spare contacts
W	Supervisory Controls and Analogues, Energy pulsing
X	Supervisory Alarms and indications
Y	Telephones

NB Combined letters KL are used in breaker and a half schemes where Secure Supply Circuits apply.***19 Cable block diagrams-Standard numbering***

The following standard numbering must be used when selecting the appropriate cable numbers:

Voltage level (kV)	Cable number series	Cable number prefix
765	8000-8065	#
400	100-165	#
275 and 220	200-265	#
132	300-365	#
88, 66 and 44	400-465	#
33, 22 and 11	500-565	#

Looped supplies	**Cable number series**	**Cable number prefix**
230 VAC E/L supply	93	*$
Trans Mast/Follower	94	*$
Spring rewind supply	95	*$
230 VAC supply	96	*$
VT Phasing & Sync	97 and 98	*$
Transfer buswires	99	*$

Other cables	**Cable number series**	**Cable number prefix**
Teleprotection Main 1	800M1	#
Teleprotection Main 2	800M2	#

Voltage level (kV)	**Prefix**
765	80
400	1
275 and 220	2
132	3
88, 66 and 44	4
33, 22 and 11	5

N.B. # The buszone suffix allocated to a bay is used as the cable prefix.

Example: Cable number A.100 would refer to a cable used in a 400kV feeder bay with the allocated buszone suffix of A. The suffix can be obtained from the station electric diagram

N.B *$ The buszone suffix of the source panel followed by the buszone suffix of the destination panel. Add the voltage level prefix and then the appropriate looped supply cable number.

Example: Cable number A.B.195

A Bay with allocated suffix A

B Bay with allocated suffix B

1 400 kV Bay

95 spring rewind supply.

3.18 CABLE BLOCK DIAGRAM – Cable identification number alignment

Shown below is a typical Distribution application cable block diagram. Block diagrams and cable schedules for construction cables shall be prepared and maintained by the Eskom Project Engineer or appointed consultant.

This drawing must be part of each control plant drawing package. It must show all cable numbering, types and destination in a block diagram format.

Cable Designation →		B/Zone	TRFR1	TRFR3	FDR1	FDR3	B/SECT
Cable Prefix>>		W	A	C	E	G	X
Cable No	Cable type						
315	BVX12DCV		√	√	√	√	√
316	BVX4ECV		√	√	√	√	√
700	BVX4ECV	√					
701	BVX4ECV	√					
800	TPH10VX	√					

3.19 Control Plant drawings processes

What follows hereunder is basically captured in two documents, viz; DST 34_195 *Standard drawing practice for CAD users in the Power Plant and Control Plant technologies environments and for Electrification Network, and* TST 41_634 *Drawing Office Standard.* The former document describes mostly the physical aspects whilst the latter details the physical aspects relating to drawings as well as the mark up procedure in detail. The two documents will in future be merged into one national standard.

Updating or revision of drawings is occasionally required in order to cater for changes in drawings that arise from one of the following scenarios:

- Drawings received from Grids or Operating Units subsequent to commissioning of a green field project.
- Drawings received from Grids or Operating Units subsequent to mark ups on drawings due to routine maintenance work done, and
- Drawings received with equipment related changes after a project is commissioned.

The general process to be followed shall be as follows:

- All marked-up drawings must be submitted to Project Engineering on a project by project basis, i.e. Protection, Metering, Telecontrol, AC and DC mark-ups must be submitted simultaneously.
- Each discipline must ensure that all drawings are marked-up. This includes panel layouts, key, cabling and cable block diagrams.
- Any modification to a drawing must be reflected on all the above mentioned drawings.
- All mark-ups must be submitted as soon as the project is finished so as to ensure that mark-up queries can be dealt with speedily.
- When a panel or equipment is decommissioned and its respective drawings are no longer applicable, those drawings must be submitted to Project Engineering for cancellation.

- A backup marked-up drawing set must always be kept in the Field Services environment.
- Marked-up drawings must always be checked by a second person and respective individuals' names must be reflected on the mark-up in case queries arise.
- Only marked-up drawings having signatures shall be submitted.

Marked-up drawings specifics shall comply with the following:

- All marked-up drawings from site to be transferred to a clean drawing so as to ensure clarity of changes done on site.
- A **red** pen must be used to indicate additions and a **yellow** pencil must be used to indicate drawing content/s to be removed.
- All symbols of equipment must be in accordance to SABS NRS: 002 latest edition.
- All added MCBs and their ratings must be shown in the marked-up drawings.
- Any added relay or switch etc. must have its name, manufacturer's name and label indicated on the panel equipment layout of the affected scheme.

The following extract from DST 34_1692 Specification for the Wiring of Outdoor Circuit Breakers is worthy of note.

Contact reference positions.

The convention applied to schematic wiring diagrams and the requirements of this standard shall be that limit switches, pressure switches, relay contacts etc. are shown assuming the following reference conditions:

a) Circuit breaker main contacts are open

b) Springs are discharged

c) Gas compartments are without pressure (where applicable)

d) Relay coils are de-energised

e) No AC or DC supplies are connected

f) Earthing switches not applied (where applicable)

g) Disconnectors in the closed position (where applicable)

It is important to note that schematic wiring diagrams submitted to Eskom for approval shall comply with the above convention.

Standardised power plant equipment interfaces

The control wiring interface to power plant equipment indicated below has been adopted within the Distribution division.

a) D-DT-5403 Isolator Junction Box

b) D-DT- 5404 CT Junction Box

c) D-DT-5405 VT Junction Box

d) D-DT- 5407 Outdoor Circuit Breakers

e) D-DT- 5408 Indoor Circuit Breakers

f) D-DT-5409 Specification for Large Transformers, includes On Load Tap Changers

    1) Section 4.12.7 CTs

    2) Table 14 Standard Marshalling Interface Box Layout

g) DSP 34-1690 Specification for Neutral Electromagnetic Couplers

    1) Section 4.3 CTs

2) Standard Interface D-DT-5411

The control and power plant equipment interface wiring options

Protection and control schemes have, of necessity, to interface with power plant equipment, which they control. Outlined below are the two schools of thought regarding the representation of power plant equipment wiring in scheme application drawings.

a) Representation of power plant equipment on a functional level, indicating the terminal numbers to which cabled wires shall be terminated, and indicating associated wire numbers within the primary equipment. The power plant equipment is thus seen as a "black box" to the scheme application drawings. The power plant equipment manufacturer's wiring diagrams are:

- Referenced by drawing number in the scheme application drawings.
- Issued to all staff.
- Stored electronically, either with the application drawings or as some regions do, on a central "equipment drawing" repository system.

b) The power plant equipment manufacturer drawings are reproduced on the scheme application drawings, including a list of abbreviations and contact timing diagrams (as applicable). The relevant manufacturer's drawing must still be referenced in the application drawings. The manufacturer's drawings should also be managed as in a) above.

Option a) above is preferred for the following reasons:

1) Application drawings can be kept largely independent of the specific make and type of power plant equipment to which they interface. The scheme drawings will require only minor changes (e.g. manufacturer drawing references) in the event that an item of power plant is replaced.

2) The benefits of standardised equipment interfaces can be leveraged in that scheme Master drawings can include application levels reflecting typical applications. It is then simple to generate application drawings for a project in which standard equipment is used.

3) Full replication of primary equipment manufacturer drawings is onerous, and the replication may not be as user-friendly (e.g. grid references to equipment), detailed (e.g. equipment location and types) or accurate (copying errors) as the original. Detailed fault finding will most likely require the field technician to have access to the original manufacturer's drawings.

Legal matters

Detailed below are the legal requirements with respect to approval of drawings and signatures.

The Engineering Profession Act 46 of 2000 established the Engineering Council of South Africa (ECSA), as an accreditation body for the industry, tasked with registration of professional engineers under one of four (4) categories: Professional Engineers (Degree holders), Certificated Engineers (Government Ticket), Professional Engineering Technologists and Engineering Technicians.

The Act (Clause 26) requires the Council to identify engineering work that must be performed by registered persons. A person who is not registered may not perform such work unless such work is done under supervision of a registered person who will assume responsibility for such work. The Act also requires the Council to publish a Code of Conduct for registered persons, thus Clause 4 (C) of Engineering Profession Act 2000 requires that a person may not issue any information in respect of work done by them, or under their direct control, unless it is signed and dated by them, and bears the name of the organisation concerned.

Eskom's primary and control plant drawings are likely to be construed as "engineering work even though this is not clearly defined in law. It follows that drawings should be approved by a registered Engineer, Technologist of Technician. Which level of registration is required to approve drawings is presently a moot point; it is however deemed prudent for a Pr. Eng. or C. Eng. to approve Master drawings. Technologists and Technicians could probably sign application drawings.

Eskom generally requires that a second, suitably qualified person signs drawings as "Checked". This is not a legal requirement and can be done by an unregistered person.

All drawings, inclusive of those from overseas suppliers, must be approved by a registered engineering professional as outlined above. Drawings done by contractors are normally “approved” by an appropriate member of Eskom’s staff.

Signature Format

As stated above, ECSA Code of Conduct requires that all engineering information, including designs, drawings etc. be signed by the registered person. The signature may be a traditional “hand” signature or of an electronic type. The appropriate act regarding electronic signatures states that where signatures are required by law, and such law does not stipulate the type of signature, that electronic signature shall be of an advanced type.

“Advanced electronic signatures” are such that one can be legally guaranteed that the person identified by the signature actually signed the document, and places the onus on that person to prove that they did not sign if this is to be contested.

Storage of drawings

The preferred method for the storage of drawings which is legally acceptable is electronic storage with reasonable back up. This is preferred to paper storage on the grounds of floor space, printing costs and risk of fire.

3.20 Wiring identification

All control/secondary plant wiring shall be done according to the standard 240_64636794, *Standard for Wiring and Cable Marking in Substations.*

3.21 AC Key diagrams

Secondary AC leads are to be prefixed as per their circuit identification letters. Red phase circuits shall be numbered from 10 to 29, White phase from 30 to 49, and Blue phase from 50 to 69 and the residual/star point/neutral from 70 to 89. This applies for both current and voltage circuits.

The scheme wiring is to be numbered so as to permit the following standardised numbering of incoming wires from the substation yard:

a) Current circuits: Red: x11; White x31, Blue: x51, Residual: x71, Neutral x80, x81 etc. where x is A, B, C or D as per Section 3.18 above.

b) Voltage circuits: Red: x11; White x31, Blue: X51, Neutral: x71 where x is E, F or G as per Section 3.18 above.

c) Where a scheme has current- and/or voltage inputs from different voltage levels, the inputs from the highest voltage side will be numbered x11, x31 etc. Add 100 to each wire number for each successive lower voltage level (e.g. x111, x131 for the transformer MV CTs and x211, x231 etc. for tertiary CTs).

d) Where a scheme includes inputs from different busbars/bus sections, these shall be numbered x111, x131 and x211, x231 for busbar 1 and 2 inputs etc.

The incoming wires for 230V AC supply circuits shall be numbered H11 (live) and H71 (neutral). Successive wires shall use consecutive numbers. An additional prefix of 1 shall be used for H111 and H171 to denote Earth Leakage Supply.

3.22 DC Key diagrams

Incoming DC supplies shall be numbered J1 and J2 for the Main supply and J3 and J4 for the Main 2/back-up supply. Ferrule number suffixes shall change to K, L, M, N or P (as appropriate) after the MCB.

Main tripping lead numbers are to be prefixed with "K" and start with 101 and end with 299. Positive-related leads are numbered with odd numbers, while negative-related leads with even numbers.

101 – 299 – Main tripping lead numbers

301 – 499 – Main 2 or Back Up tripping lead numbers

501 – 699 – Closing circuits

Leads for the Main 2 or back-up tripping circuits are prefixed K and are numbered from 301 to 499. They follow the same pattern as for the Main circuits.

Prefixes L, M, N or P shall be used in place of "K" as appropriate.

These numbers change to the next odd or even number after passing through a contact, test block or switch.

The terminal number does not change after passing through a terminal.

A combined alpha numeric numbering system e.g. KLx is used at Transmission/Generation interface applications, on the 765kV Transmission breaker and a half schemes, low impedance bus zone schemes and secure supply schemes, where x is as per the numbering system above.

The ferrules of circuit-breaker fail output wires shall be numbered P7 and P17. For schemes with two circuit-breaker fail outputs (e.g. transformer schemes), these shall use ferrule numbers P7 and P17, and P107 and P117 respectively.

3.23 Scheme to plant interfacing.

Protection and Control schemes have, of necessity, to interface with Power Plant equipment which they control.

Wire numbering principles:

The following standard is proposed for the numbering of lead wires in power plant assets: All wires used in power plant equipment shall be labelled, and all wires terminating at Eskom specified interface terminals shall carry numbers designated by Eskom according the BSS 158 wire numbering system currently used by Eskom.

The following standard shall be used when assigning wire numbers at the interface:

Current transformers (where provided internal to the equipment): "A" or "D". Power transformers will use the CT secondary terminal number as the wire number. For example, 1AS1 will be used as the wire number to the HV red phase bushing CT.

Status contacts:

'U' is used to indicate N/O and N/C aux contacts in a breaker

Indications/Alarms: "L"

Tripping or closing functions "K"

DC power supply (e.g. gas monitoring supply): "J"

AC Supplies "H".

The convention of odd numbers for positive supply and even numbers for negative supply shall be respected. Specifically, the wire number across a contact will advance by two (U1 becomes U3 not U2).

Isolators. Status contacts shall continue to use the custom numbering system designated by the respective

contact types: 1G – 1GA etc.

3.24 Wiring terminations and supports

See document *240-64636794 Standard for Wiring and Cable Marking in Substations* for relevant project design application aspects

3.25 Bay Allocation and Substation Equipment Identification

There is need to standardise the naming of substation bays and equipment. Standardisation of substation elements will also facilitate implementation of IEC 61850 standard in order to achieve substation and control automation.

The current practice used within Eskom (though not universally applied within the wires business), to allocate bays is to start from one end of a substation and name the bays in an alphabetical order as A, B, C, etc. to denote Feeder and Transformer bays. In instances where bay allocation is done on the other side of the Bus Section, the allocation is started over, i.e. A , B, C ,(Bus Section1) then A1 ,B1 , C1 etc. and if needed (Bus Section 2) A2, B2 ,C2 etc.

Letters “I” and “O” are not used so as not to create confusion with numbers one and zero.

The letter: ”X” is reserved for the Bus Coupler bay allocation whilst letter “Y” is reserved for the Bus Section.

Whilst the above mentioned method works well and has been used for a long time in Eskom, it suffers from lack of consistency. The starting point and direction to follow to allocate bays is not clearly defined and is thus dependent upon the application or planning engineer.

The Western and Eastern Cape Operating Units have developed their own bay and cable numbering systems. Whilst these systems have and continue to work well for their respective areas of jurisdiction, the need for an overarching standard applicable throughout the Eskom business cannot be overemphasised.

It is now imperative, in light of our intended migration to the IEC 61850 SA, to define substations topologies and primary as well as secondary equipment in a way that defines the association between them.

The IEC 61346 standard defines how substation elements or equipment such as breakers, isolators etc. should be named. A brief overview of the IEC 61346 Standard, as used to designate and identify substation elements, is described in Annex D.

Future efforts at bay and equipment naming and standisation should be guided by the above IEC standard in order to come up with a consistent and simple way of naming and identifying substation equipment going forward.

3.26 Power Transformer Earthing

There are two prime objectives of system earthing, viz.:

- To limit the potentials between the current carrying conductors of the system and the general mass of earth. This applies to both power frequency and transient potentials.
- To comply with the law by providing a path for earth-fault currents so that automatic protective devices may be able to detect and isolate faulty plant.

The detailed requirements of transformer neutral earthing are described in document DPL 34-2149: *Policy for Neutral earthing of Electrical Networks.*

3.27 Bus Zone Protection Application Philosophy

On Distribution related projects, the *Distribution Standard For The Application Of Bus Zone Protection* [DST 34_461] document shall be used when deciding whether or not to implement bus zone protection in outdoor Distribution substations. In particular, the document serves to identify those factors that shall be considered when determining the requirement for unit-type busbar protection at a substation.

3.28 Impedance versus current differential protection

When choosing a protection scheme, due regard must be given to the nature or type of equipment to be protected. Current differential protection is preferred over impedance on network sections that are up to 10km in length where it is deemed that impedance protection is unlikely to conform to the basic protection requirements of speed, selectivity and sensitivity.

A detailed guideline outlining the criteria to be used in selecting current differential or impedance protection will be compiled in due course. Refer to 240-76429732.

3.29 Documentation

It is important to ensure that a project file is created for each and every project undertaken. This is consistent with the ISO 9001 Quality Management system. The project file contains project related information such as all correspondence relating to the project, and minutes of meetings held on or off site. Electronic soft copy project files with adequate back up are preferred.

4. Authorization

This document has been seen and accepted by:

Name and surname	Designation
Prince Kara	PTM&C Protection Technology Manager
Graeme Topham	SCOT Protection and Automation SC Chairperson
Richard McCurrach	Senior Manager PTM&C
Cyril Mkhwanazi	NED Head of Design - KZNOU
Leon Drotsche	NED Head of Design - WCOU
Peter West	NED Head of Design - FSOU
Frans Ratau	NED Head of Design - NWOU
Rudi Jacobs	NED Head of Design – GOU
Sydney Mamosadi	NED Head of Design - LOU
Willie Van Heerden	NED Head of Design - ECOU
Koos Havenga	NED Head of Design - NCOU

5. Revisions

Date	Rev.	Compiler	Remarks
Aug 2014	1	H Sithole	New consolidated standard applicable to the Distribution and Transmission divisions. This document has been integrated with and now replaces documents 41-941 Transmission Protection Application Guideline and document SCSASACJ0 rev 0 Protection Application Philosophy

6. Development team

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

- J Cunnington
- H Sithole

7. Acknowledgements

This document is based on material obtained from different sources in the Distribution and Transmission divisions. Contributions from the Distribution Project Engineers' Forum members, Stuart van Zyl and Karuna Govender are greatly appreciated. Inputs and comments from Messrs Bernard Mitton and Richard Taylor (GOU-NED) are also acknowledged.

Annex A – Typical Electrical Cable Properties and Volt Drop Calculation

Cable Size (mm^2)	Current Ratings			Impedance (Ω/km)	Volt drop (mV/A/m)	1 Sec short circuit rating (kA)
	Ground (A)	Ducts (A)	Air (A)			
1.5	23	18	18	14.48	25.080	0.17
2.5	30	24	24	8.87	15.363	0.28
4	38	31	32	5.52	9.561	0.46
6	48	39	40	3.69	6.391	0.69
10	64	52	54	2.19	3.793	1.15
16	82	67	72	1.38	2.390	1.84
25	126	101	113	0.8749	1.515	2.87
35	147	120	136	0.6335	1.097	4.02

Example: Determine suitable 50m length of cable required to carry 80A. Volt drop is calculated using formula:

V_d = Volt Drop = Cable Constant (from table) X Current X Length, and

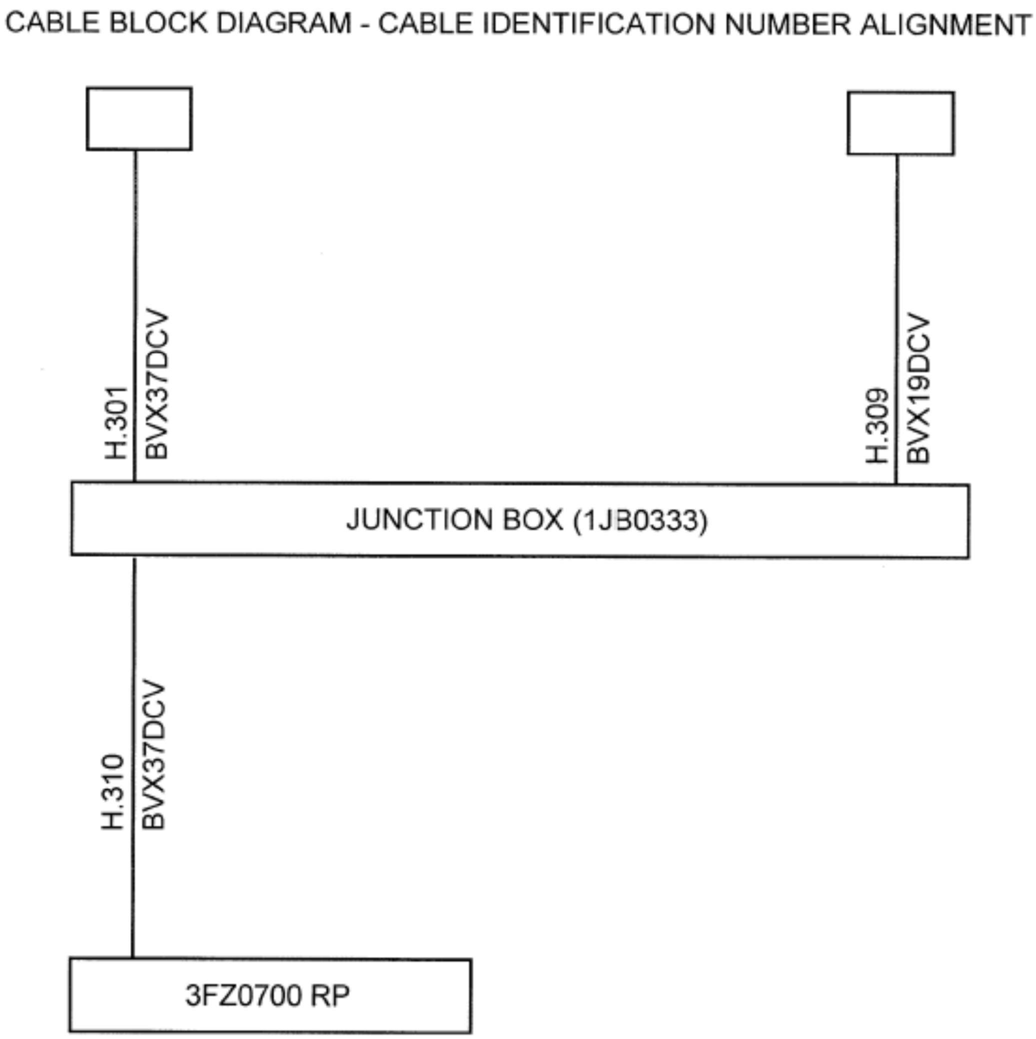
$$\%Vd = \frac{Nominal\ voltage\ - Voltage\ drop}{Nominal\ voltage} X100$$

Where Nominal voltage = 230V AC

Use the above formula in conjunction with the cable technical data for permissible current under normal condition.

Evaluation	**%Volt Drop** %Vd	**Volt Drop** Vd	**Constant from Table** mV/A/m	**Current** (A)	**Length** (m)	**Cable Size** (mm^2)
Use larger cable	45.60	100.32	25.08	80	50	1.5.
Use larger cable	27.94	61.452	15.363	80	50	2.5
Use larger cable	17.39	38.244	9.561	80	50	4
Use larger cable	11.62	25.564	6.391	80	50	6
Use larger cable	6.90	15.172	3.793	80	50	10
Use smaller cable	4.35	9.56	2.39	80	50	16
Use smaller cable	2.76	6.06	1.515	80	50	25
Use smaller cable	2.00	4.388	1.097	80	50	35
Use smaller cable	1.49	3.268	0.817	80	50	50

Annex B - Cable identification example:



Annex C – Auxiliary Contacts Types and Usage

The complement of auxiliary contacts provided in most HV disconnectors (i.e. 8G, 5M, 2N, 1F) was standardised in 1998 based on the following requirements:

<u>VT selection</u>
VT selection done with a latching relay:
1 x F (reset)
1 x M (set)

NOTE: an F-type (late break) contact must be used to reset the latching relay so as to prevent back-energisation of an isolated busbar via the VT secondary circuits (i.e. VT selection is reset prior to the main contacts separating). Back-energisation of a busbar via the VT circuits is a safety hazard, and will often lead to VT fuse or MCB operation.

VT selection done via disconnector contacts
3 x M

Total contacts for VT selection via disconnector / via relay
1 x F
3 x M

<u>High impedance Bus Zone protection</u>
New high impedance Bus Zone protection
8 x G (3 x 2 contacts for CT selection, one each for trip selection and breaker fail selection)

Old high impedance Bus Zone
7 x G (3 x 2 contacts for CT selection, one for trip selection and breaker fail selection)

NOTE: G-type (early make) contacts must be used for CT selection so as to ensure that the secondary circuits are closed before any primary arcing takes place (which could otherwise cause a Bus Zone operation during switching)

Total contacts for old / new high impedance Bus Zone
8 x G

<u>Supervisory indication</u>
Total contacts for Supervisory indication
1 x M
1 x N

<u>Low impedance Bus Zone protection</u>
Total contacts for low impedance Bus Zone (This requirement was for a low impedance Bus Zone that was on ENC at that time)
1 x M
1 x N

Contact requirement that can cater for all of the above scenarios
1 x F
8 x G
2 x N
5 x M

Disconnector auxiliary contact definitions and intended applications

Type	**Form**	**Action**	**Permissible Range***	**Relation to Main Contacts**	**Typical Application**	**Symbol**
G	Normally Open N/O	Early make	45° – 100°	Makes before main contacts make. Breaks after main contacts break. (Margin not less than 20% of main contact travel)	Bus Zone protection AC and DC circuits	
M	Normally Open N/O	Late make	165° – 170 °	Makes after main contacts make. Breaks before main contacts break.	Disconnector Closed indication. VT selection	
F	Normally Closed N/C	Late break	145° – 155 °	Breaks after main contacts make. Makes before main contacts break	VT selection via aux relay (Reset)	
N	Normally Closed N/C	Early break	17° – 30°	Breaks before main contacts make. Makes after main contacts break. (Margin not less than 30% of main travel)	Disconnector Open indication Special functions e.g. Carrier switching	

** Ranges quoted assuming the disconnector is fully open at 0° main contacts touch at 145°, and main contacts are fully closed at 180°.*

Annex D – IEC 61346 Bay Equipment Labelling Standard

(Information)

The naming of substation elements follows a hierarchical structure that builds on component relationships. The elements in a lower order level are a component of the next higher level.

Aspects

In defining designations, prefix aspects are used:

Prefix	**Aspect**
[=]	Function - what does the product do
[-]	Product - how is the object constructed
[+]	Location - where is the object located

Examples:

Object Code	**Examples of typical equipment**
B	Measuring transformers such as VTs and CTs
Q	Power circuit breakers and disconnectors
W	Busbars, cables, conductors

Power Distribution Voltage codes

Voltage Code

AA1 – Substation name

General distribution boards/enclosures

B	Installations for >420 kV
C	Installations for380 kV... _420 kV
D	Installations for 220 kV... <380 kV
E	Installations for 110 kV... <220 kV
F	Installations for 60 kV... <110 kV
G	Installations for 45 kV... <60 kV
H	Installations for 30 kV... <45 kV
J	Installations for 20 kV... <30 kV
K	Installations for 10 kV... <20 kV
L	Installations for 6 kV... <10 kV
M	Installations for 1 kV... <6 kV
N	Installations for <1 kV

The philosophy below shall be followed when labelling equipment in a substation.

- First identify the substation
- Then identify the voltage
- Then identify the bay
- Then identify the specific function of the equipment.

All labelling must provide positive identification of individual equipment and must not conflict with other labelling.

An example of a designated single line diagram according to IEC 81346 is given below. The circuit breaker on the first bay, Bay1 is identified according to the substation name, voltage level, bay number and object number thus: It is noted that the object identification process interpretation is always from the left to right as follows:

Substation Name [AA1] >Voltage Level [**E1]** > Bay [**Q1]** > Object/Equipment [**QA1]**

Thus;

AA1**E1Q1QA1** translates to the 132kV circuit breaker on bay 1 connected to busbar 1 at substation AA1

Similarly, the current transformer on bay number 2 will be identified thus:

AA1E1Q2BI1

Extending the same principle to the present Eskom standard naming convention, e.g. for a cable,

AA1E1Q1W1 – cable between the Red Phase CT and the CT Junction Box on bay Q1

AA1E1Q1W2 - cable between the White Phase CT and the CT Junction Box

AA1E1Q1W3 - cable between the Blue Phase CT and the CT Junction Box

AA1E1Q1W4 - cable between the Neutral JB and the CT Junction Box

AA1E1Q1W5 - cable between the Red Phase VT and the VT Junction Box

AA1E1Q1W6 - cable between the White Phase VT and the VT Junction Box

AA1E1Q1W7 - cable between the Blue Phase VT and the VT Junction Box

A Junction Box would be labelled **AA1E1Q1A1 using** the same convention.

Registration of Substation Codes

In order to avoid duplication, all substation names and codes must be registered with the Planning department.