Eskom	Guideline	Technology

Title: **PHASE VI LOW IMPEDANCE BUSZONE PROTECTION SCHEME : APPLICATION GUIDE**

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Content

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1. Introduction

This document provides a guide to the selection of the low impedance busbar protection and control schemes and the various options available for each scheme within the Transmission Division.

2. Supporting clauses

2.1 Scope

In this guide, the various buszone scheme types implemented on double busbar arrangements, as well as breaker-and-a-half, and the options available for each of these schemes are described. This document does not cover any non-conventional applications. This guide in no way overrides any other necessary application guidelines or commissioning procedures.

2.1.1 Purpose

The purpose of this guideline is to assist the planning/project engineer in selecting the correct Phase VI low impedance buszone scheme and to guide application staff to apply the scheme and also to describe the breaker-and-a-half and double busbar buszone protection and control schemes and the various ordering options for each of the above schemes.

2.1.2 Applicability

This standard shall apply to PTM &C Technology within the Eskom Transmission 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] CORP3158 Phase 6 Development Contract

[3] 240-65336348: Standards for Transmission & Distribution protection schemes: Common Requirements

[4] 240-68277442: Specification for Transmission Protection Schemes: Low Impedance Busbar Protection Schemes.

[5] 240-68277442 Scheme Selection & Application for Phase 6 Buszone Protection Scheme

[6] 240-64636794 Standard for wiring and cable marking in substations

2.2.2 Informative

[7] Eskom Technical Specification TSP 41-824 “Technical Specification for Low Impedance Busbar Protection Schemes”.

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2.3 Definitions

2.3.1 General

Definition	Description
Breaker-and-a-half	The breaker and a half bus arrangement is relatively simple and consists of two main busbars, each normally energised. Between each of the main busbars are similar arranged “bays” of three circuit breakers configured such that the two lines or a combination transmission line and transformer position share the centre circuit breaker.
Double busbar	A substation layout consisting of the conventional double busbar configuration with or without bus section / bus couplers etc. A set of isolator links per busbar are used to connect the transformer bay to either busbar.
Intelligent electronic device (IED)	A microprocessor-based device that encompasses all or some of the following functionalities: protection, control and automation, metering, telecontrol, substation DC and auxiliary supply systems, quality of supply monitoring, and disturbance and event recording.
Scheme	A set of components that work together in order to execute a specific behaviour under predefined power system conditions sensed through the scheme interface (Cigré Working Group B5.27). ‘Scheme’ is most commonly applied in the context of power system protection equipment where it historically applied to the secondary plant components associated with the protection and control of a specific primary bay. In the latest design philosophy each main or back-up protection module associated with a specific primary bay are designated as separate, independent schemes.

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
BU	Bay Unit
BZ	Buszone – Double Busbar
BZB	Buszone – Breaker-and-a-half
BZP	Buszone Protection Panel
CB	Circuit Breaker
CP	Control Panel
CT	Current Transformer
CTIG	Legacy Breaker Fail Relay
DC	Direct Current
EHV	Extra High Voltage
HV	High Voltage
PTM&C	Protection Telecommunication Measurements & Control

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Abbreviation	Description
SAP	Systems, Application and Products

2.5 Roles and responsibilities

Protection application design shall utilise this document as the basis for the selection of the Phase VI low impedance buszone protection schemes.

Application staff are to apply the correct busbar protection scheme at the Transmission substation level.

2.6 Process for monitoring

Not Applicable

2.7 Related/supporting documents

Not Applicable

3. Scheme Selection Guide for Transmission Phase VI Buszone Protection Schemes

The buszone protection and control schemes cater for low impedance numerical schemes ranging from 88kV to 765 kV. The different scheme permutations will provide protection and control for busbars on breaker-and-a-half arrangements, as well as double busbar arrangements. The permutations accommodate double busbar arrangements with a minimum of 8 bays and up to a maximum of 48 bays and the breaker-and-a-half arrangements with 8 or 14 bays.

The size of the central unit will be determined by the station electric diagram that includes all existing and future bays.

3.1 SAP Ordering

The Transmission contract number for the Phase VI Low Impedance Busbar Protection in SAP is 4600067750 and the product items are listed in Table 1 below.

Table 1: SAP Order Schedule

Commodity Number	Material Number 110VDC	Material Number 220VDC	Product Description - Low Impedance Busbar Protection Scheme
P19.1a	674152	674233	Scheme: 6BZ-2210 Buszone Protection scheme 8 Bay (1 Panel)
P19.1b	674158	674234	Scheme: 6BZB-2810 Buszone Protection scheme 8 Bay (1 Panel)
P19.2a	674153	674235	Scheme: 6BZ-2310 Buszone Protection scheme 16 Bay (2 Panel)
P19.2b	674159	674236	Scheme: 6BZB-2910 Buszone Protection scheme 14 Bay (2 Panel)
P19.3	674154	674237	Scheme: 6BZ-2410 Buszone Protection scheme 24 Bay (3 Panel)
P19.4	674155	674238	Scheme: 6BZ-2510 Buszone Protection scheme 32 Bay (4 Panel)
P19.5	674156	674239	Scheme: 6BZ-2610 Buszone Protection scheme 40 Bay (5 Panel)
P19.6	674157	674240	Scheme: 6BZ-2710 Buszone Protection scheme 48 Bay (6 Panel)
P19.7a	674241	674242	6BZ Scheme with 8 Bay Central Unit (no Bay Units)
P19.7b	674245	674246	6BZ Scheme with 16 Bay Central Unit (no Bay Units)
P19.7c	674249	674250	6BZ Scheme with 24 Bay Central Unit (no Bay Units)

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Commodity Number	Material Number 110VDC	Material Number 220VDC	Product Description - Low Impedance Busbar Protection Scheme
P19.7d	674251	674252	6BZ Scheme with 32 Bay Central Unit (no Bay Units)
P19.7e	674253	674254	6BZ Scheme with 40 Bay Central Unit (no Bay Units)
P19.7f	674255	674256	6BZ Scheme with 48 Bay Central Unit (no Bay Units)
P19.7g	674243	674244	6BZB Scheme with 8 Bay Central Unit only (no Bay Units)
P19.7h	674247	674248	6BZB Scheme with 14 Bay Central Unit only (no Bay Units)
P19.7i	674329		Scheme Component: Expand Central Unit with comm's card for additional 8 Bays Units
P19.8	674330		Scheme Component: Individual Bay Unit for 6BZ or 6BZB scheme
P19.9	3000018424		Engineering: 8 Bay Unit scheme
P19.10	3000018425		Engineering: 14/16 Bay Unit scheme
P19.11	3000018427		Engineering: 24 Bay Unit scheme
P19.12	3000018428		Engineering: 32 Bay Unit scheme
P19.13	3000018429		Engineering: 40 Bay Unit scheme
P19.14	3000018430		Engineering: 48 Bay scheme.
P19.15	3000018431		Engineering: Central Unit
P19.16	3000018432		Engineering: Bay Unit
P19.17	Not Required		Documentation: 6BZ
P19.18	673974		Spare: 6BZ or 6BZB Scheme 8-Bay Central Unit
P19.19	673975		Spare: 6BZ Scheme 16-Bay Central Unit / 6BZB Scheme 14-Bay Central Unit
P19.20	673976		Spare: 6BZ Scheme 24-Bay Central Unit
P19.21	673977		Spare: 6BZ Scheme 32-Bay Central Unit
P19.22	673978		Spare: 6BZ Scheme 40-Bay Central Unit
P19.23	673979		Spare: 6BZ Scheme 48-Bay Central Unit
P19.24	673980		Spare: Bay Unit for 6BZ or 6BZB scheme
P19.25	674574		Spare: Voltage Monitoring Relay
P19.26	674594		Spare: Voltage Monitoring Relay base
P19.27	674308		Spare: DCI Switch (6BZ/B)
P19.28	674309		Spare: TNS Switch (6BZ/B)
P19.29	674513		Spare: Dip Proof Capacitor Module (6BZ/B)
P19.30	674103		Spare: DC Fail Double pole 10A MCB (K - Curve) (6BZ/B)
P19.31	674104		Spare: DC Fail Double pole 6A MCB (K- Curve) (6BZ/B)
P19.32	674105		Spare: AC 230V 6A Supply Double Pole MCB (6BZ/B)

Note that when placing orders with Siemens, the PTM&C Protection Technology and Support Buszone Custodian may be contacted for guidance with respect to the application and configuration should be there any queries.

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3.2 Scheme Drawings

The following master drawing numbers may apply as depicted in Table 2 below:

Table 2: Scheme Selection

Scheme Description	Scheme Drawing Number	Scheme Type
6BZ-2210	0.52/30446	8 Bay double busbar buszone protection and control scheme
6BZ-2310	0.52/30447	16 Bay double busbar buszone protection and control scheme
6BZ-2410	0.52/30448	24 Bay double busbar buszone protection and control scheme
6BZ-2510	0.52/30449	32 Bay double busbar buszone protection and control scheme
6BZ-2610	0.52/30450	40 Bay double busbar buszone protection and control scheme
6BZ-2710	0.52/30451	48 Bay double busbar buszone protection and control scheme
6BZB-2810	0.52/30452	8 Bay breaker-and-a-half buszone protection and control scheme
6BZB-2910	0.52/30453	14 Bay breaker-and-a-half buszone protection and control scheme

3.3 Buszone Application Requirements

The Phase VI Low Impedance Buszone is a centralised busbar protection scheme that routes the main trip and main breaker fail trip to the bay protection schemes.

It can accommodate up to 12 zones and caters for 48 feeder bays with up to 5 isolator / breaker inputs per bay, 16 couplers (single CTs) and/ 8 couplers/sections (double CTs).

A single bay unit is allocated per CT input. Any bay unit can be used for either a bus coupler, bus section, feeder, transformer, reactor or shunt capacitor bank.

Bay units shall always be allocated from left to right when facing the scheme, with busbar 1 prioritised over busbar 2.

Bus couplers and bus sections with double CT's use two bay units. Busbar 1 isolator, breaker, and busbar 2 CT shall be connected to the first bay unit and busbar 1 CT and busbar 2 isolator shall be connected to the second bay unit i.e. (figure 1 bay unit 7 and 8).

The Breaker fail inputs shall be connected (paralleled) to both bay units. The tripping of both bays shall be connected (paralleled) to the bus coupler or bus section protection scheme.

In the breaker and a half busbar arrangement, the bays shall be allocated as per station design.

Feeders, Shunt Capacitor Banks, Reactors and Transformers shall be selected to specific zones via busbar isolator auxiliary contacts. Buscouplers and Bussections connect to specific zones via isolator auxiliary contacts.

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3.3.1 Primary Plant Layout

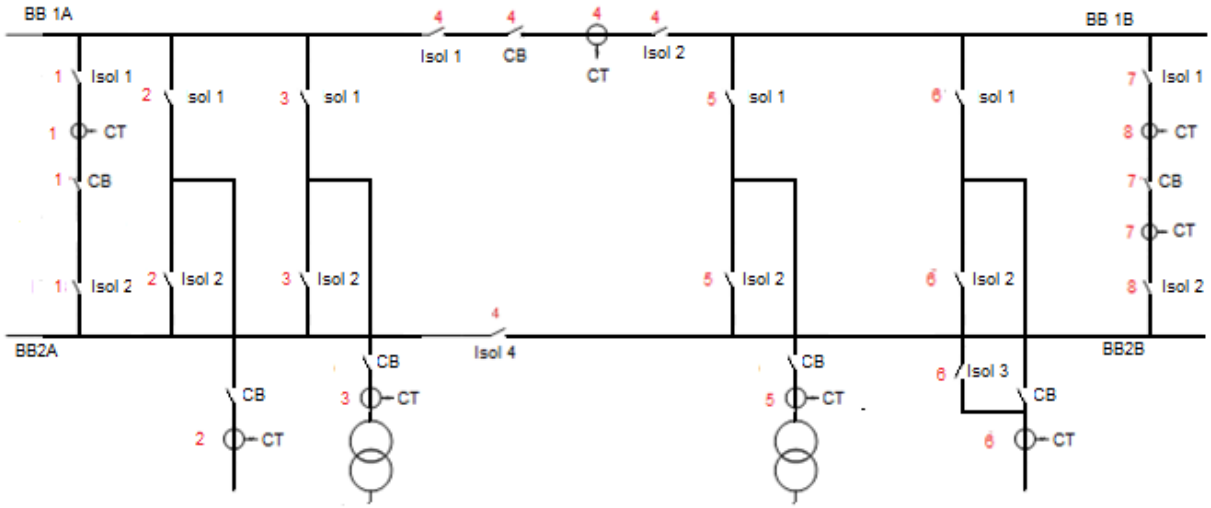

Figure 1: Primary Plant Layout

Example 1: Busbar Isolator and breaker Input selection per Bay Unit

Busbar 1: Input 1 open position and Input 2 close position isolator auxiliary contacts.

Busbar 2: Input 3 open position and Input 4 close position isolator auxiliary contacts.

Transfer Busbar or Bypass busbar: Input 5 open position and Input 6 close position isolator auxiliary contacts.

Buscoupler and Bussection Circuit Breaker: Input 9 open position and Input 10 close position circuit breaker auxiliary contacts, Input 14 Circuit breaker manual close command.

Buscoupler and Bussection Isolators single CT (Air Insulated Substations): busbar Isolator 1 Input 1 open & Input 2 close position isolator auxiliary contacts and busbar Isolator 2 input 3 open and input 4 close position isolator auxiliary contacts.

Transfer Buscoupler: busbar: Isolator 1 Input 1 open & Input 2 close position isolator auxiliary contacts and busbar Isolator 2 input 3 open and input 4 close position isolator auxiliary contacts. Isolator Transfer Input 5 open position & Input 6 close position isolator auxiliary contacts.

Buscoupler and Bussection Isolators double CT (Gas Insulated Substations & Power Stations): Use two bay units. BU1 Isolator 1 Input 1 open & Input 2 close position isolator auxiliary contacts and BU2 Isolator 2 input 3 open and input 4 close position isolator auxiliary contacts.

Buscoupler and Bussection close command

Buscouplers and bussections shall be selected to the specific zones, only when both busbar isolators and the circuit breaker are in closed positions. In some cases, the circuit breaker auxiliary contacts are slower than the main contacts. This will result in an unbalance in the buszone, to mitigate this, a close command that integrates the Bus Coupler/Section currents into the buszone protection algorithms to prevent the incorrect tripping is required. Refer to the Engineering Instruction: Phase VI Buszone Interface with Phase I & II Buscoupler and Bussection Protection Schemes. Unique Identifier: 240-170000536

Example 2: Busbar Marshalling Input per Bay Unit

Buscoupler Single CT Application (Figure 1): BU1 (1) Isolator 1 input 1 open and Input 2 close position & BU1 (1) Isolator 2 Input 3 open and Input 4 close position. The circuit breaker BU1 (1) input 9 open and input 10 close and the manual close pulse to input 14.

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Buscoupler double CT Application (Figure 1): BU7 (7) Isolator 1 input 1 open and Input 2 close position & BU8 (8) Isolator 2 Input 3 open and Input 4 close position. The circuit breaker BU7 (7) input 9 open and input 10 close and the manual close pulse to input 14.

Bus section single CT Application (Figure 1): BU 4 (4) the isolator on the left is wired to busbar 1A (Isolator 1) input (Input 1 open & input 2 close) and the isolator on the right is wired to busbar 1B isolator (Isolator 2) input (Input 3 open & input 4 close). Bus section Isolator (Isolator 4) between busbar 2A and busbar 2B shall be wired to Bay Unit 4 (Figure 1) bus section isolator input position (Input 7 open & input 8 close). The circuit breaker BU4 (4) input 9 open and input 10 close and the manual close pulse to input 14.

Feeder bay without transfer (Figure 1): BU2 (2) the Isolator 1 Input 1 open position and Input 2 close position and Isolator 2 input 3 open position and Input 4 close position.

Feeder bay with transfer (Figure 1): BU6 (6) the Isolator 1 Input 1 open position and Input 2 close position and Isolator 2 input 3 open position and Input 4 close position. Isolator 3 Input 5 open position and Input 6 close position.

Transformer Bay (Figure 1): BU3 (3) the Isolator 1 Input 1 open position and Input 2 close position and Isolator 2 input 3 open position and Input 4 close position.

3.3.2 Breaker Fail Protection

Breaker Fail Protection for EHV schemes: Providing two breaker fail contacts

The Phase VI buszone protection scheme utilizes an external breaker fail input and breaker fail initiate input from each bay protection scheme. The buszone shall issue a breaker fail trip to the relevant Zone if both pulses are initiated within a 60ms timespan. The external breaker fail input and breaker fail initiate input from the protection scheme shall be connected to the Buszone scheme specific bay unit, the breaker fail trip to binary input 16 and breaker fail initiate to binary input 15 shall be wired on the Low Impedance Buszone Scheme.

Note: The External Breaker Fail Initiate and Breaker Fail Trip input from the bay shall always be routed in separate cables as shown in Figure 2 below.

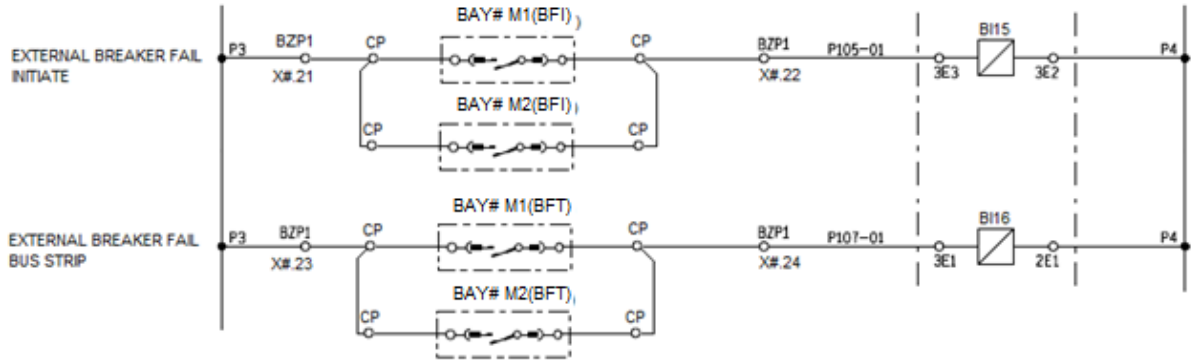

Figure 2: EHV Breaker Fail Input for Main 1 & Main 2

Breaker Fail Protection for HV schemes: Providing one breaker fail contact

Legacy HV buszone schemes use one external breaker fail input from each bay protection scheme. The external breaker fail trips from the protection schemes shall be connected to the Buszone specific scheme bay units, the breaker fail trip to binary input 16 and looped to the breaker fail initiate binary input 15 as shown in Figure 3 below.

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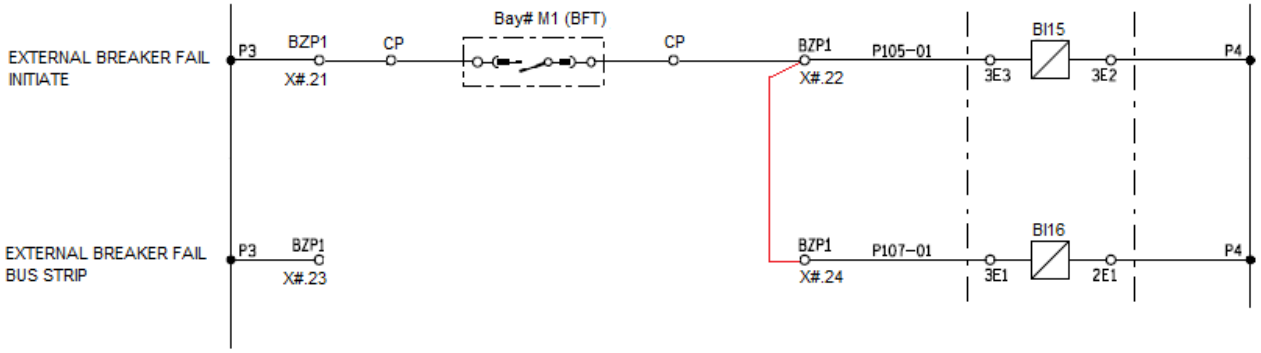

Figure 3: HV Breaker Fail Main Protection

Breaker Fail Relay (BSR) CTIG: Providing one breaker fail contact

This legacy breaker fail relay from bay protection scheme provides one external breaker fail input as shown in Figure 4 below

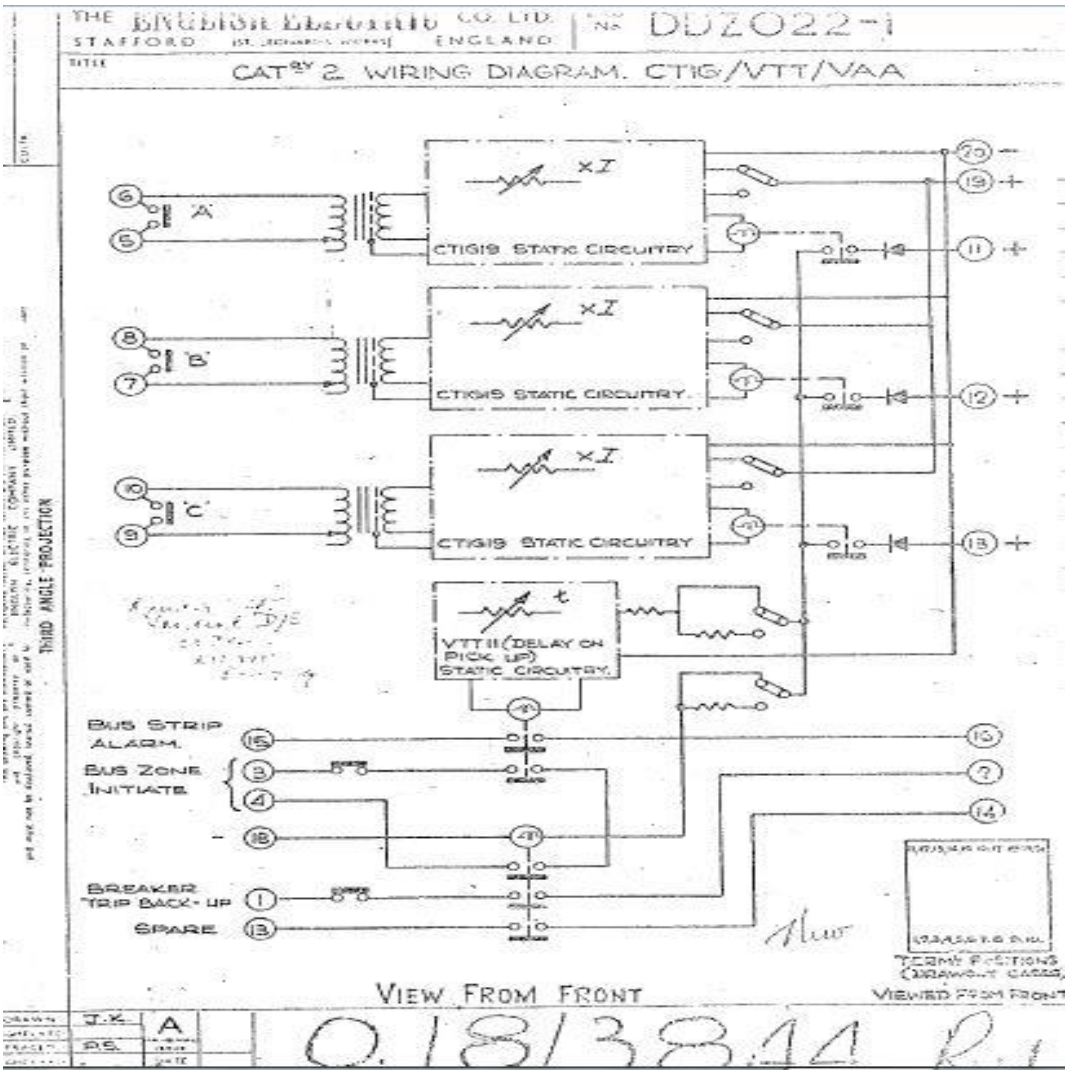

Figure 4: CTIG Breaker Fail Relay

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The phase 1 CTIG provides one breaker fail trip output from terminal 3 and 4. Terminal 13 and 14 from the CTIG relay is a spare breaker fail initiate contact. Install additional wiring from terminal 13 & 14 from CTIG relay to spare terminals in the control panel as shown in Figure 5 below.

The external breaker fail input and breaker fail initiate input from the protection scheme shall be connected to the Buszone Scheme specific scheme bay unit, the breaker fail trip connected to binary input 16 and breaker fail initiate to binary input 15 shall both be wired on the low impedance buszone scheme.

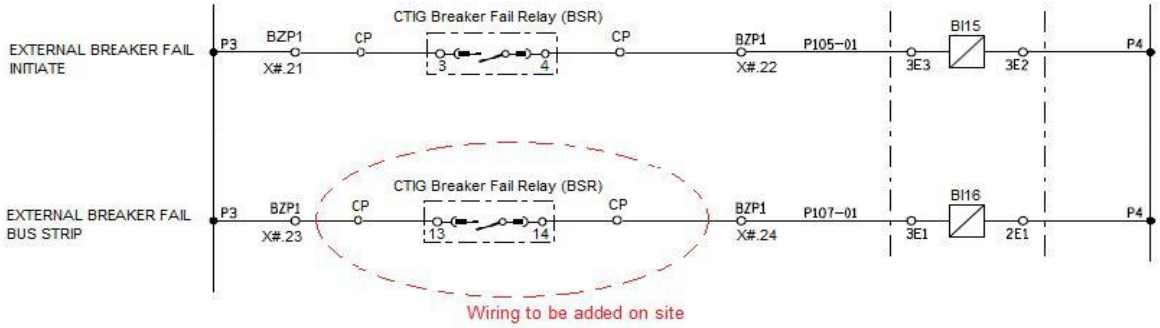

Figure 5: CTIG Breaker Fail Wiring

3.3.3 CT's and Auxiliary Supplies

CT's, Busbar Isolator Indications, AC and DC supplies shall not be routed in the same cable. Each shall be routed via its own separate cable.

3.3.4 Busbar Isolator Auxiliary Contacts and Descriptions

The diagram in figure 6 below indicates the timing of the primary contact movement at which the different types of secondary auxiliary contacts make and break. "N" contacts are "normally-closed", which breaks before the main contact is completely open. "M" and "G" contacts are "normally-open" which makes after the main contact makes.

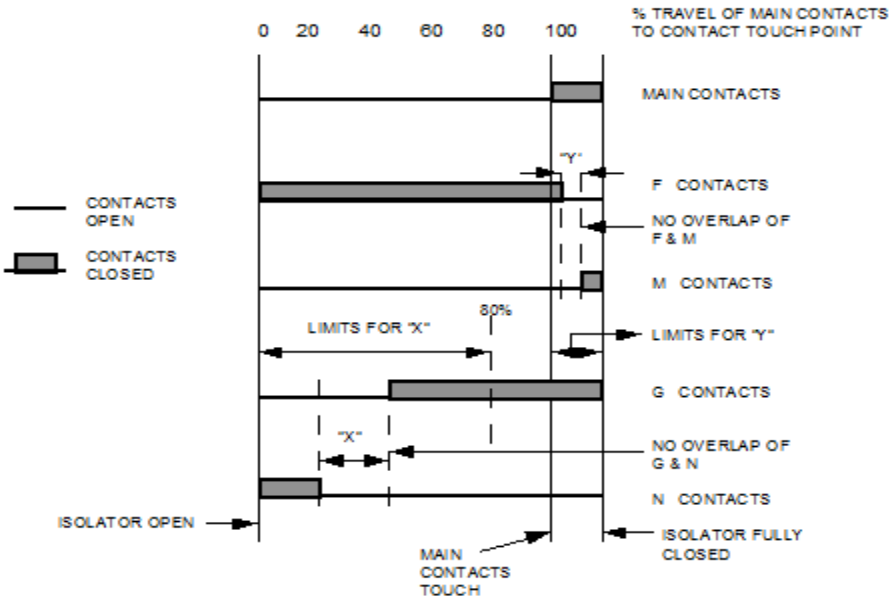

Figure 6: Isolator Auxiliary Contact Diagram

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The M and N auxiliary contacts shall be use for busbar isolator indications.

In the case where there are pantographs or three mechanism apparatus, the contacts of the different phases must be wired in series as shown below in Figure 6 A normally closed contact (N) shall be wired to a Binary Input to indicate the open position (Figure 6 & 7).

A normally open contact (M) shall be wired to a Binary Input to indicate the close position. (Figure 6 & 7)

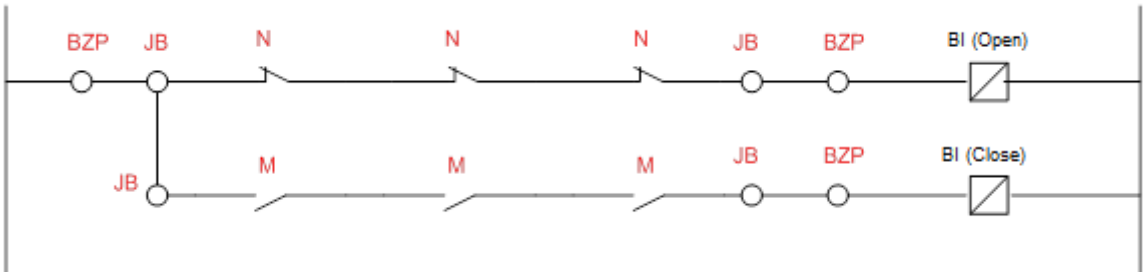

Figure 7: Auxiliary Contact Wiring

3.3.5 Cabling Requirements

Table 3: Cable Selection Schedule

Feeders And Transformers	
CT Cable	4 x 2.5 mm²
Isolators	7 x 2.5 mm²
Main 1 Trip and Breaker Fail trip	4 x 2.5 mm²
Main 2 Trip and Breaker Fail Initiate	4 x 2.5 mm²
Supervisory Alarms to IDF	10 pair cable
Single bay bus coupler/section	
CT Cable	4 x 2.5 mm²
Isolators and breaker	7 x 2.5 mm²
Main 1 Trip and Breaker Fail trip	4 x 2.5 mm²
Main 2 Trip, Breaker Fail Initiate and Breaker close command	7 x 2.5 mm²
Double bay bus coupler/section	
CT Cable bay1	4 x 2.5 mm²
CT Cable bay2	4 x 2.5 mm²
Isolator 1 and circuit breaker	7 x 2.5 mm²
Isolator 2	4 x 2.5 mm²
Main 1 trip and Breaker Fail trip	4 x 2.5 mm²
Main 2 trip, Breaker Fail Initiate and Breaker close command	7 x 2.5 mm²
Main 1 DC	2 x 4 mm²
Main 2 DC	2 x 4 mm²

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Breaker and Half Scheme	
CT Cable	4 x 2.5 mm²
Isolators	4 x 2.5 mm²
Main 1 Trip and Breaker Fail trip	4 x 2.5 mm²
Main 2 Trip and Breaker Fail Initiate	4 x 2.5 mm²
Supervisory Alarms to IDF	10 pair cable

4. Authorization

This document has been seen and accepted by:

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5. Revision History

Date	Rev	Compiler	Remarks
January 2022	1	P.T Mashigo	First Issue

6. Development team

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

- P.T Mashigo

7. Acknowledgements

Not applicable.

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