

## **BUSBAR PROTECTION**

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### **PURPOSE AND SCOPE**

This document describes the technical requirements for User's equipment directly connected to the England and Wales Transmission system within NGET's (National Grid Electricity Transmission) busbar protection zone. Nominal voltages of 400 kV, 275 kV, 132 kV and 66 kV apply unless otherwise agreed with the user as defined in the Bilateral agreement. This shall include all protection and control devices operating NGET Switchgear. The principles of this document also applies to the equipment connected at other voltages".

The Specification describes the functional and performance requirements and the facilities to be provided for the protection of busbars at 400 kV, 275 kV 132 kV and 66 kV double busbar switching stations. It defines the interfaces to the appropriate bay level specifications.

### **PART 1 – GENERAL REQUIREMENTS**

#### **1 FUNCTIONAL REQUIREMENTS**

##### **1.1 Busbar Protection System**

- 1.1.1 Busbar protection shall provide fully discriminative protection for phase-to-phase and phase-to-earth faults occurring within the substation.
- 1.1.2 Where the primary arrangement of the substation permits the substation to be split into a number of sections delimited by circuit breakers or disconnectors, the busbar protection shall provide fully discriminative protection for phase-to-phase and phase-to-earth faults occurring within each section.
- 1.1.3 The busbar protection shall discriminate between faults in the protected busbar section and faults elsewhere in the substation or the primary system.

- 1.1.4 Where numerical busbar protection is used, this shall employ a minimum of two different fault detection algorithms which must both be satisfied for tripping to occur.
- 1.1.5 If a biased differential principle is used, the protection shall comply with the requirements of IEC 60255-13.
- 1.1.6 The minimum operating current of the busbar protection shall be settable in the range 10 – 200% of nominal current.
- 1.1.7 When a busbar fault occurs, all circuit breakers connected to the faulted busbar shall be tripped simultaneously.
- 1.1.8 The busbar protection shall be able to correctly detect a fault condition occurring during an on-load busbar changeover and issue trip commands to the connected bays.
- 1.1.9 Where necessary and applicable, end fault protection shall be provided.

*Informative – End fault protection is provided to cover for faults where a busbar protection trip will not clear the fault, and/or will trip beyond open switchgear, and/or may not be sensitive enough to trip; for example a fault between the circuit breaker and line side CTs when the circuit breaker is open.*

## **1.2 Switchgear Positional Information**

- 1.2.1 Where a fault occurs in the overlap between two zones, e.g. at a Bus-section or Bus-coupler, with the circuit breaker closed, both zones shall be tripped simultaneously.
- 1.2.2 Switchgear positional information shall be used to determine the primary arrangement of each busbar section using busbar disconnectors and/or circuit breaker auxiliary contacts, and to determine the selection of end fault protection.

*Informative: The selected disconnector auxiliary switches must ensure correct zone selection for all fault conditions including 1.9. In the closing cycle the correct zone must be selected prior to the primary contacts being able to carry current.*

- 1.2.3 Where circuit breaker positional information affects the selection of CT's to the algorithm a means of ensuring advance selection prior to circuit breaker closure shall be provided.

*Informative – Pre-close repeat relay contacts can be used to give advance information of circuit breaker closing to cover for slow circuit breaker auxiliary switches.*

- 1.2.4 Where a discrepancy (DBI) in switchgear positional information occurs, the busbar protection shall have user selectable options either to remain in service using the last verified switchgear position or to block protection operation for the affected zone. Unaffected zones shall remain in operation
- 1.2.5 Where the supply for switchgear positional information is interrupted the bay unit shall retain correct status during the power down cycle.

*Informative – a single MCB operation on a bay unit shall not affect the ability of the central unit to determine last known state of any switchgear connected to that bay unit.*

## **1.3 Differential Current Supervision**

- 1.3.1 Where necessary and applicable, differential current supervision shall be provided on each zone.
- 1.3.2 The differential current supervision shall be settable in the range 2 to 20% of nominal current.

1.3.3 Where operation of the differential current supervision occurs, the busbar protection shall have user selectable options either to remain in service or to block protection operation.

1.3.4 Operation of the differential current supervision shall generate an alarm after a time delay settable in the range 0 - 10 s.

#### **1.4 Circuit Breaker Fail**

1.4.1 Where integral circuit breaker fail is provided this shall comply with TS 3.24.39 (RES).

#### **1.5 Physical Arrangement**

1.5.1 If and where numerical protection is used, the system shall consist of a distributed set of bay units and a single central unit. A duplicate standby central unit shall be provided if applicable. Both central units shall be identical and interchangeable but only one shall be in operational service at any time. Facilities shall be provided to allow physical transfer of either to service within 4 hours.

1.5.2 Where numerical busbar protection is used, individual bay units shall be provided on a per circuit basis and shall only be used for input/output on that circuit.

*Informative – a main busbar section shall have a separate bay unit to a reserve busbar section.*

*Informative: A typical arrangement of bay units and duplicate central units is shown in Figure 1. The System 2 central unit is provided to allow fast return to service of the system for a failed system 1 central unit and vice versa.*

1.5.3 Where numerical busbar protection is used, the following shall apply:

- a) The protection shall collect current and switchgear positional information at the bay units
- b) Bay units shall preferably be mounted with the bay secondary equipment.
- c) The central unit shall perform the busbar protection algorithm using the current and positional information transmitted from the bay units.
- d) The central unit shall transmit tripping commands to the required bay units to operate the required outputs.
- e) The System 2 central unit where provided shall be provided in a separate cubicle to the System 1 central unit.
- f) Communications between bay units and central unit shall be immune to electrical noise.

1.5.4 Separate multicore cables shall be employed and the wiring and terminals shall, as far as reasonably practicable, be segregated from other circuits.

1.5.5 Where applicable, the auxiliary supply to each bay unit shall be provided from the 110 V D.C first tripping supply for the bay for distributed relay room applications. For common relay room applications, duplicate supplies with automatic changeover shall be provided to the bay units. The changeover shall be such that the busbar protection remains in service throughout.

1.5.6 Where applicable, the auxiliary supply used for switchgear positional information shall be provided with a separate MCB to allow isolation of such circuits without affecting the auxiliary supply.

- 1.5.7 Where numerical busbar protection is applied, the auxiliary supply to the System 1 central unit shall be taken from duplicate 110 V D.C supplies with an automatic changeover. The System 2 central unit shall use the same supplies but with discrete MCBs. The changeover shall be such that the busbar protection remains in service throughout.

*Informative: It is preferred that the central unit and bay units in a common relay room shall have duplicated energising supplies with automatic changeover facility.*

- 1.5.8 The equipment for busbar protection shall be electrically and physically independent from other equipment as far as practicable.
- 1.5.9 Where numerical busbar protection is applied, the following bay unit failure modes shall only block busbar protection for the affected zone:-
- a) Failure of a Bay Unit
  - b) Loss of DC supply to a Bay Unit causing the Bay Unit to power down.
  - c) Loss of communication between the Central Unit and the Bay Unit

## **1.6 System 1 and System 2 Central Units**

- 1.6.1 The System 2 Central Unit shall have permanent fibre connections run to each bay unit, disconnected at the bay unit end parked in a position to allow easy transfer.

*Informative - For star topology spare fibres in the same cable as the main fibres can be used for the system 2 central unit to bay unit connections. For a redundant ring topology a connection of the existing fibres at the central units is accepted.*

- 1.6.2 Fibres and connectors shall be sufficiently durable to allow multiple disconnection and re-connection to/from the IEDs.

*Informative: This would likely use ruggedised patch cords with standard ST connections.*

## **2 INTERFACE REQUIREMENTS**

*Informative: Figure 2 shows the interfaces to a typical bay unit.*

### **2.1 Current transformer Inputs**

- 2.1.1 There shall be one current transformer input for each bay except that bus section and bus coupler bays shall have a current transformer input from each side of the circuit breaker.

*Informative: Separate Current Transformers are used for check and discrim zones in high impedance schemes, where for numerical protections the same set of CTs are normally used for independent protection algorithms e.g., Check and Discrimination.*

- 2.1.2 The busbar protection system shall be capable of operating from Measurement/Protection current transformers as defined in TS 3.2.4 (RES).

- 2.1.3 The busbar protection system shall be capable of accepting inputs from current transformers having different ratios in different bays.

### **2.2 In/Out Switching, Test and Maintenance Facilities**

### **2.3 Switchgear Positional Information**

- 2.3.1 Switchgear positional information shall be determined by double point inputs as specified in TS 3.24.04 (RES)

*Informative: Double point inputs have an association with two physical inputs and are used when there is a need to detect an on / off condition, and any intermediate state.*

- 2.3.2 Double point inputs shall be used for receiving:
- a) Plant and status inputs
  - b) Control and Protection inputs
- 2.3.3 States 1 and 2 shall be used to represent normal conditions.
- 2.3.4 States 0 and 3 shall be classified as “DBI” (Don’t believe it).
- 2.3.5 Full isolation shall be provided between double pole inputs and all other circuits.
- 2.3.6 Where required by the application or contract, full isolation shall be provided between double point inputs, or groups of double point inputs.
- 2.3.7 Discrepancies in switchgear positional information shall generate an alarm after a time delay settable in the range 0 - 10 s.

## **2.4 Outputs**

- 2.4.1 Where numerical busbar protection is applied, each bay unit shall provide a minimum of three single point outputs, for tripping, two operating from the busbar protection and one from the circuit breaker fail protection. Where the busbar protection uses multiple input/output cards, these tripping contacts shall be from different input/output cards.
- 2.4.2 The following alarm outputs shall be provided :-
- a) Disconnecter auxiliary switch discrepancy alarm.
  - b) Equipment inoperative, for the loss of D.C. auxiliary energising supply and internal relay failures. These alarms must be circuit specific
  - c) Bay unit maintenance mode in/out of service (numerical schemes only).
  - d) Bay unit in test
  - e) Bay unit alarms shall allow correct identification of equipment which is either out of service, in test mode or faulty.

*Informative: Figure 3 shows the interfaces to a typical central unit.*

- 2.4.3 Where de-centralised numerical busbar protection is applied, the central unit shall provide the following alarm outputs:-
- a) Busbar protection zone operation and faulty alarms. These must be zone specific.
  - b) Differential current supervision.
  - c) Disconnecter Auxiliary Switch discrepancy alarm.
  - d) Equipment inoperative, for the loss of D.C. auxiliary energising supply and internal relay failures. For system 1 and 2 central units these alarms must be continuously provided regardless of which central unit is in service.
  - e) System 1 and system 2 central unit in/out of service.

- f) For system 1 and 2 central units, alarms (a), (b), (c) above are only required for the central unit in service. A means of transfer and isolation shall be provided.

## 2.5 Inputs

- 2.5.1 Where required, pre-close inputs shall be provided to give the protection advance circuit breaker closing as per section 1.2.3. This shall allow double pole connection or shall use an interposing relay to class EB2.
- 2.5.2 An input shall be provided on each bay unit to allow backtripping initiation from an external source. This shall allow double pole connection or shall use an interposing relay to class EB2.

## 2.6 Informative Interface

- 2.6.1 Where applicable, for numerical busbar protection, the following information shall be provided:

- a) Faulted zone.
- b) Fault type, e.g. R – E or Y – B.
- c) Current substation configuration.

*Informative: To minimise future database changes where only the circuit name has changed; references to bay names should revert to plant nomenclature not circuit name - e.g. "X105 Bay"*

- a) Differential currents for each zone.
- b) Records of recent faults shall be stored and be available for downloading either locally or remotely. This shall include oscillographic records of each phase, differential and bias currents and status of trip outputs and CB status.

## 3 PERFORMANCE REQUIREMENTS

- 3.1.1 The protection system shall perform correctly in accordance with the requirements of this Specification for the range of power system conditions specified in TS 1 (RES) and the range of environmental conditions specified in TS 3.24.15 (RES).
- 3.1.2 The protection system shall perform correctly under the conditions of current transformer saturation and magnetising inrush.

### 3.2 Accuracy

- 3.2.1 The accuracy of the busbar protection shall be such that, when set appropriately, and over the range of conditions referred to, it shall perform correctly and in accordance with this specification.
- 3.2.2 The accuracy shall not be affected by more than  $\pm 10\%$  ( $\pm 2\%$  for auxiliary power supply variations) under the range of system and atmospheric conditions specified in TS 1 (RES).

### 3.3 Reliability

- 3.3.1 Upon recovery of the input energising supply from a failure condition, the full discriminative protection system shall come into operation within 10 s.

### **3.4 Operating Time**

3.4.1 The operating time of the busbar protection shall be not greater than 30 ms.

*Informative: This is the operating time of the protection from fault inception to trip output initiation.*

The resetting time of the busbar protection shall be not greater than 50 ms.

3.4.2 Where a change of setting, a configuration change or other software change requires the busbar protection to be temporarily out of service, the period of non-availability shall not exceed 30 minutes.

## **4 TEST REQUIREMENTS**

### **4.1 Power System Conditions**

4.1.1 The busbar protection shall be demonstrated to operate correctly for the range of system fault infeeds, X/R ratios, balanced and unbalanced load currents, offsets, voltage levels, shunt capacitance currents, harmonic currents, oscillatory currents, resonance conditions and travelling wave effects that are defined in TS 1 (RES).

4.1.2 The busbar protection shall be demonstrated to operate correctly under the conditions of current transformer saturation and inrush.

### **4.2 Protection System Characteristics**

4.2.1 The characteristics of the busbar protection and its accuracy and repeatability shall be demonstrated.

4.2.2 The presentation of these characteristics shall make it possible to verify that the performance meets the requirements as specified in Section 3.

### **4.3 Operating Time**

4.3.1 The requirements of clauses 3.4.1 and 3.4.2 shall be demonstrated for the range of influencing quantities as specified and over a reasonable range of settings.

## **5 FORMS AND RECORDS**

Not Applicable.

## **PART 2 - DEFINITIONS AND DOCUMENT HISTORY**

### **6 DEFINITIONS**

BC	Bus Coupler
BS	BUS SECTION
CB	Circuit Breaker
CBF	Circuit Breaker Fail
CT	Current Transformer
CTS	CT Supervision

DTT	Direct Transfer Trip
ENCC	Energy Network Control Centre
HV	High Voltage
MB	Main Bar
RB	Reserve Bar
RS	Reserve Section
LV	Low Voltage
OC	Over Current
TS	Technical Specification

## 7 AMENDMENTS RECORD

Issue	Date	Summary of Changes / Reasons	Author(s)	Approved By (Inc. Job Title)
1	October 2014	New Document	Simon Pomeroy/ Richard Poole	GCRP

### 7.1 Procedure Review Date

5 years from publication date.

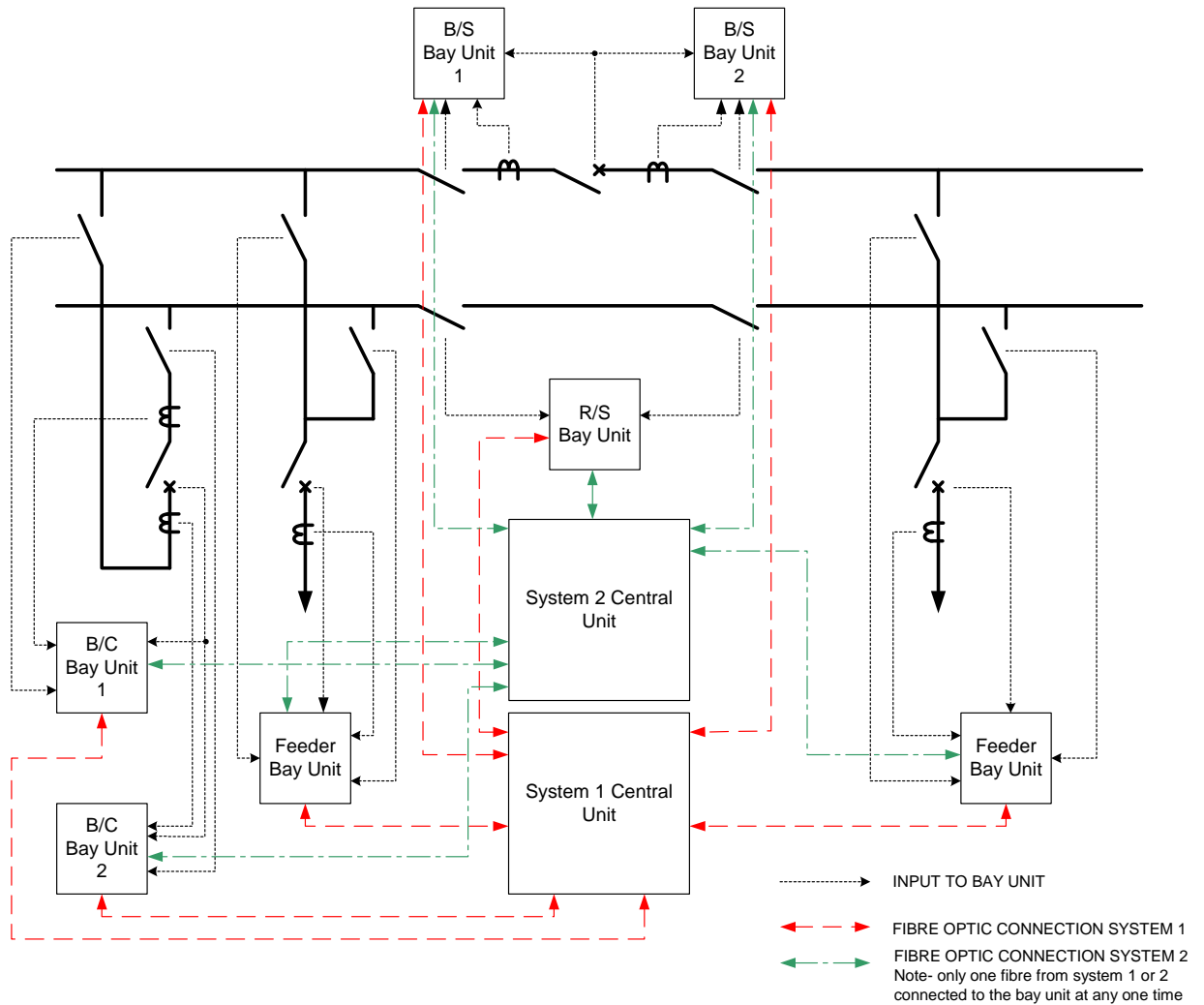
## PART 3 - GUIDANCE NOTES AND APPENDICES

### 8 REFERENCES

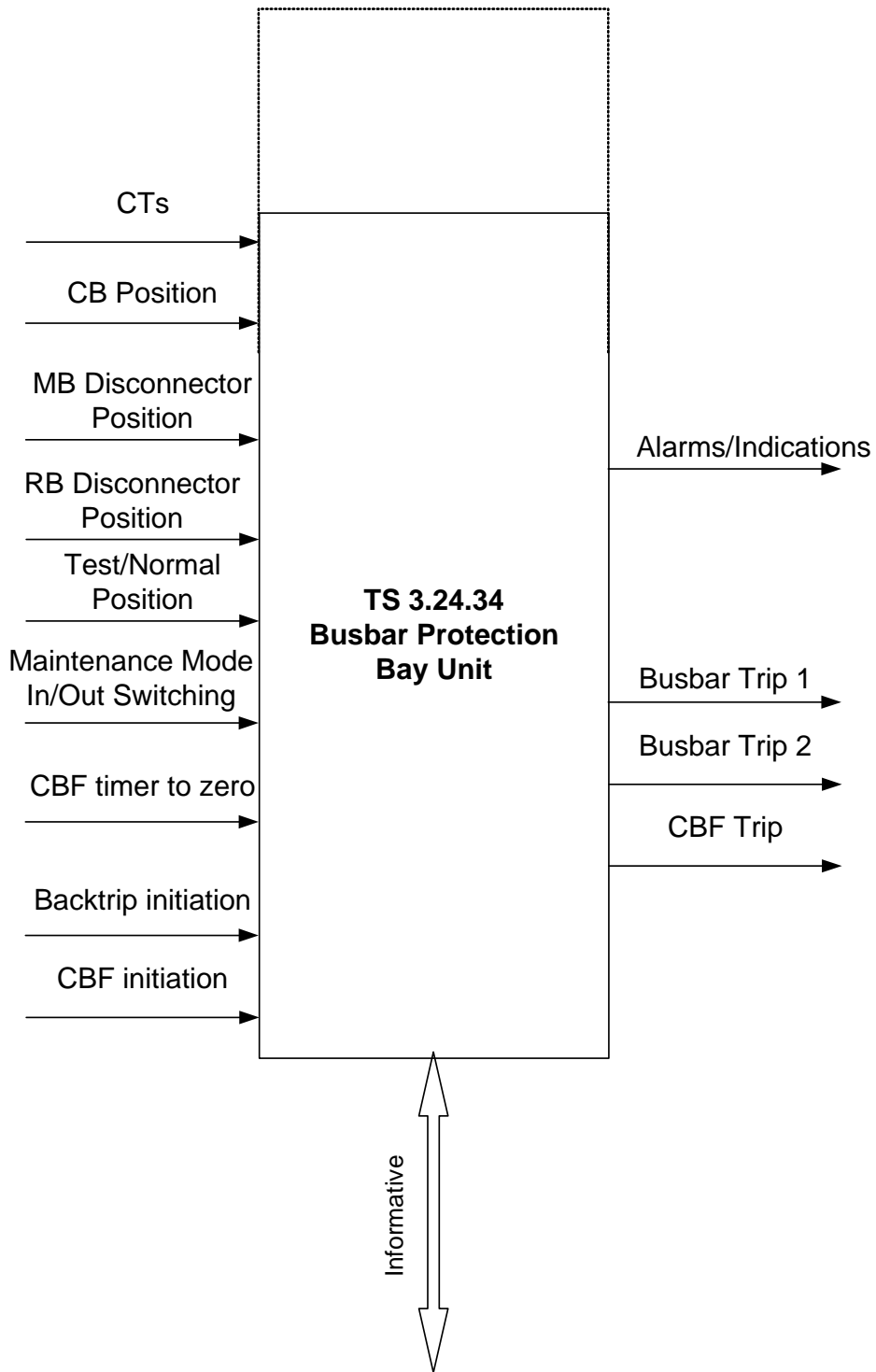
TS 1 (RES)		Ratings and General Requirements for Plant, Equipment and Apparatus for the NGT System and Connection Points To It
TS 2.19 (RES)		Ancillary Light Current Equipment
TS 3.2.4 (RES)		Current Transformers for Protection and General Use
TS 3.24.15 (RES)		Environmental and Test Requirements for Electronic Equipment
TS 3.24.39 (RES)		Circuit Breaker Fail
IEC 61810-1	-	Electromechanical elementary relays – Part 1: General requirements - Edition 3.0.
IEC 60255-1	-	Measuring Relays and Protection Equipment – Part 1: Common requirements – Edition 1..
IEC 60255-13	-	Biased Differential Relays.



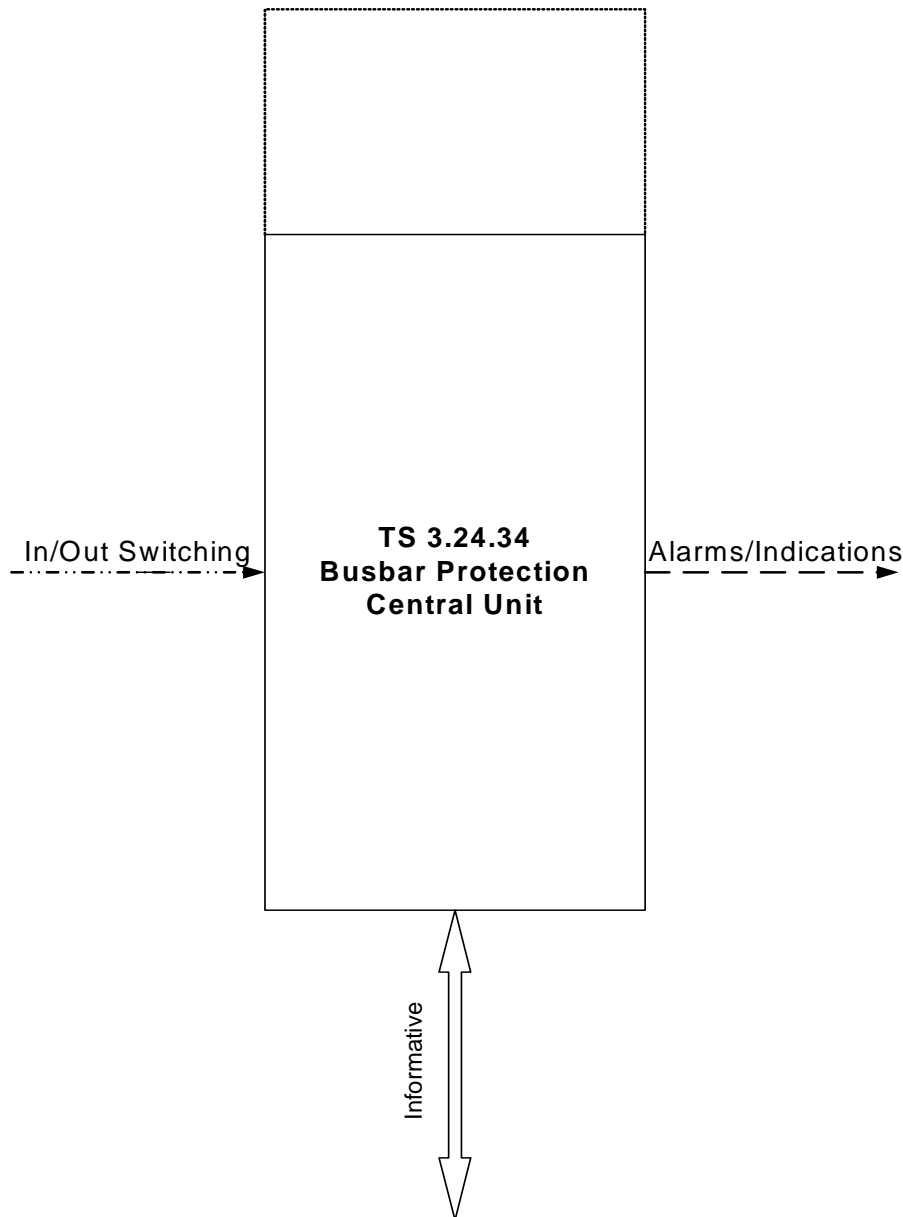
9 DIAGRAMS



**Figure 1 - Typical Block Diagram of Connections for Numerical Busbar Protection Star Topology with Duplicate Central Units**



**Figure 2 - Interface Diagram - Typical Bay Unit**



**Figure 3 - Interface Diagram - Central Unit**

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