

BUSBAR PROTECTION

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PURPOSE AND SCOPE

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

PART 1 – GENERAL REQUIREMENTS

1 FUNCTIONAL REQUIREMENTS

1.1 Busbar Protection System

- 1.1.1 Numerical 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 numerical 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 Scheme shall be capable of being extended to accommodate any planned future Primary Plant extensions.
- 1.1.4 The numerical busbar protection shall discriminate between faults in the protected busbar section and faults elsewhere in the substation or the primary system.
- 1.1.5 The busbar protection shall employ a minimum of two different fault detection algorithms which must both be satisfied for tripping to occur.

- 1.1.6 If a biased differential principle is used, the protection shall comply with the requirements of IEC 60255-13.
- 1.1.7 The minimum operating current of the busbar protection shall be settable in the range 10 – 200% of nominal current 1A.
- 1.1.8 When a busbar fault occurs, all circuit breakers connected to the faulted busbar shall be tripped simultaneously, whether they can feed fault current or not.
- 1.1.9 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.
- 1.1.10 End fault protection shall be provided in accordance with PS(T)010.

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 Low impedance busbar protection schemes where bus section and couplers with CTs on either side are used to provide overlapping zones, shall take due cognisance of “small” zone faults with associated disconnector combinations in open and/or closed states. The scheme shall achieve correct discrimination to prevent nuisance or unwanted tripping following a busbar fault.
- 1.2.3 Switchgear positional information shall be used to determine the primary arrangement of each busbar section using busbar disconnectors and/or circuit breakers, 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 1.1.9. In the closing cycle the correct zone must be selected prior to the primary contacts being able to carry current.

- 1.2.4 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.

- 1.2.5 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

Informative – Where a bay unit connected to busbar section Main 1 fails, all other busbar sections shall remain operational in a reduced mode – e.g. without check zone.

- 1.2.6 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 the last known state of any switchgear connected to that bay unit.

1.3 Differential Current Supervision

- 1.3.1 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 1A.
- 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.

1.5 Physical Arrangement

- 1.5.1 The functionality shall be implemented in accordance with the Hardware Platform specification, TS 3.24.04.
- 1.5.2 The system shall consist of a distributed set of bay units and a single central unit. A duplicate standby central unit shall be provided, where requested by application policy, The first central unit shall be termed "System 1 central unit" and the second central unit "System 2 central unit" Both 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.
- 1.5.3 A site specific method statement for this changeover process shall be provided for each Busbar Protection system.
- 1.5.4 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.

- 1.5.5 A hot standby bay unit shall be provided for the BBP system. The standby bay unit shall be powered and its health monitored by a suitable watchdog alarm. Where multiple types of bay unit are required the scope of provision shall be agreed with NG. The spare BU shall be installed in such a way that allows its removal, (when replacing another faulty BU on site), without affecting the operation of any other equipment.

Informative – The purpose of providing a spare bay unit is to enable NG to respond to a bay unit failure by replacing the failed bay unit with a hot spare held on site.

A method statement for this process shall be delivered with each installation.

- 1.5.6 The protection shall collect current and switchgear positional information at the bay units.
- 1.5.7 Bay units shall preferably be mounted with the bay secondary equipment.
- 1.5.8 The central unit shall perform the busbar protection algorithm using the current and positional information transmitted from the bay units.

- 1.5.9 The central unit shall transmit tripping commands to the required bay units to operate the required outputs.
- 1.5.10 The System 2 central unit where provided shall be provided in a separate cubicle to the System 1 central unit.
- 1.5.11 Communications between bay units and central unit shall be immune to electrical noise.
- 1.5.12 Separate multicore cables shall be employed and the wiring and terminals shall, as far as reasonably practicable, be segregated from other circuits.
- 1.5.13 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.
- 1.5.14 The auxiliary supply used for switchgear positional information shall be provided with a separate MCB to allow isolation of such circuits without affecting the bay unit auxiliary supply.
- 1.5.15 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.

The equipment for busbar protection shall be electrically and physically independent from other equipment, as far as practicable.

- 1.5.16 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
- 1.5.17 A DC change-over scheme shall be provided for all busbar protection bays (RTUs) with a dedicated MCB located at the DC change-over panel. All relays and components shall be fully rated to the substation battery boost voltage of 137.5 V dc. Full separation/segregation using individual fire-proof enclosures of the two dc systems shall be achieved.
- 1.5.18 All MCBs for the busbar protection scheme shall be pad lockable.

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 Fibre patch leads shall use discreet colours - orange for System 1 central unit and green for the system 2 central unit. Both shall have permanent FO connectors.
- 1.6.3 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.

- 1.6.4 Future firmware and hardware upgrades of the busbar protection type shall be backwards compatible.

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: Figure 1 shows one bay unit for each three phase set of current transformer inputs and, hence, two bay units are shown for a bus-section or bus-coupler bay.

- 2.1.2 The busbar protection system shall be capable of operating from Measurement/Protection current transformers as defined in TS 3.2.4.
- 2.1.3 The busbar protection system shall be capable of accepting inputs from current transformers having different ratios in different bays.
- 2.1.4 There shall be no auxiliary switch contacts or relay contacts in the current transformer circuits.

2.2 In/Out Switching, Test and Maintenance Facilities

- 2.2.1 A local in/out switching facility for maintenance mode purposes, as described in TS 3.24.04, shall be provided to enable each bay unit to be taken out of service whilst the remainder of the busbar protection remains in service. In this mode the central unit shall ignore current vectors used for all algorithms e.g. for both discriminating and check zones. Circuit breaker fail and backtripping functions pertaining to the bay unit shall also be disabled from tripping via the central unit.
- 2.2.2 The maintenance mode in/out switching facility shall be activated by a control input as described in TS 3.24.4.
- 2.2.3 The maintenance mode in/out switching facility shall be common for all the functions resident in the bay unit.
- 2.2.4 A local means of isolation at each bay unit shall also be provided using a test/normal switch. This shall isolate the tripping from a bay unit. Indication of operation shall be provided by the bay unit via a control input.
- 2.2.5 Where System 1 and System 2 central units are provided, each central unit shall be provided with a means of In/Out switching.

Informative - In/Out switching of the central unit shall provide indication to the substation control system, inform the central unit it is out of service to prevent spurious diagnostic alarms and transfer common alarms as per section 2.18 (f).