INDEPENDENT POWER TRANSMISSION OPERATOR S.A.
TNPRD/ SUBSTATION SPECIFICATION SECTION

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SPECIFICATION SS-55 / 9

NUMERICAL
BUSBAR DIFFERENTIAL PROTECTION SYSTEM

I. SCOPE

This Specification covers the requirements concerning the general and functional characteristics of a numerical busbar differential protection system for installation in a busbar system consisting of one, two, or three operating busbars, with or without bus coupler and bus sectionalizing isolators or circuit breakers, as shown specifically on the single line diagram for each substation (attached each time to the inquiry).

II. KEYWORDS

Protection, busbar protection, busbar differential protection.

III. USE

The busbar differential protection system shall be used to detect all kinds of faults between phases and between phases and ground for 400 kV or 150 kV busbars.

IV. OPERATING CONDITIONS

1.	Installation	:	Inside the substation's control room or inside the protection & control kiosks.
2.	Ambient temperature		
	- during installation	:	-10°C to +50°C
	- during storage	:	-25°C to +55°C
3.	Altitude	:	Up to 1000 m above sea level.
4.	Relative humidity	:	10%-90%
5.	Pollution level	:	Moderate.

V. ELECTRIC POWER SYSTEM CHARACTERISTICS

The main data of the networks (to be specified in the inquiry) in which the subject protection system shall be called upon to operate are the following:

NETWORK	400 kV	150 kV
Nominal voltage	400 kV	150 kV
Max operation voltage	420 kV	170 kV
Number of phases	3	3
Frequency	50 Hz	50 Hz
Frequency during disturbances	47.5 Hz – 51 Hz	47.5 Hz – 51 Hz
Grounding	Solidly earthed neutral	Solidly earthed neutral
Short-circuit level	40 kA at 420 kV	31.5 kA at 170 kV
C.B. reclosing duty cycle	Three phase and single phase. 0-0.3sec-CO-3min-CO	Three phase 0-0.3sec-CO-3min-CO

VI. ELECTRIC AUXILIARY SUPPLY CHARACTERISTICS

The available D.C. auxiliary supply voltage is 110 V +10% -15% for 150 kV substations and 220 V +10% -15% for 400 kV substations.
Any variation from the above auxiliary voltage will be mentioned each time in the inquiry.

VII. MAIN CURRENT TRANSFORMERS

The busbar differential protection system shall be used in conjunction with separate CTs or separate CT windings of unequal ratio. The range of CT ratio will at least be in the range of 200/1 to 2500/1. The CT ratio will be settable for each bay.
The characteristics of the CTs will be included each time in the inquiry.

VIII. REQUIRED TECHNICAL CHARACTERISTICS, FUNCTIONS AND ACCESSORIES OF THE BUSBAR DIFFERENTIAL PROTECTION SYSTEM

1. Tripping time.
   Tripping time from occurrence of fault to energizing of circuit breaker trip coil shall be ≤15 msec for all kinds of internal faults.

2. Stability - Selectivity.
   The busbar differential protection system must be stable against external faults even in case of saturated CTs. The protection system shall not respond at all to faults outside the protected zone and shall only disconnect those busbars that are affected by the fault.

3. Sensitivity.
   High sensitivity for internal faults, adjustable and closely adaptable to the existing exploitation conditions. The sensitivity must be unaffected by the

number of feeders included in the protective scheme.

4. Measuring principle:
Low-impedance.

5. Reliability.
The protection system must provide maximum security against false tripping and must decide positively whether the fault is inside or outside the protected zone.

6. Operational criteria.
At least two independent criteria of different nature and principle, both simultaneously present, must be fulfilled in order to achieve tripping (for example the simultaneous presence of differential current in a protection zone and differential current in the substation –checkzone-).

7. Flexibility in operation.
The busbar differential protection system must remain in operation during all switching operations (transfer of a feeder from one bus to another, switching "off" and "on" of the bus coupler etc). Protection should adjust itself automatically to changing exploitation conditions without interruption. This adjustment must occur without the use of external auxiliary relays.

8. Isolator (disconnecting switch) replica.
The busbar isolator positions (open or closed) are inputs to the busbar differential protection system. Separate digital inputs must be used for the "open" and "closed" positions of each isolator.
In case the isolator position cannot be determined (e.g. loss of the auxiliary DC supply or wiring fault), the busbar differential protection system must produce an appropriate alarm. Moreover, with the use of appropriate settings, the user will decide if the isolator discrepancy will block the differential protection or if this discrepancy will result in tripping all the substation bays (in case of internal fault in a substation bus).

9. Circuit - breaker failure protection.
The busbar differential protection system shall be equipped with breaker failure protection with adjustable time delay for each bay (C.B.). Specifically, if a breaker fails to open after a tripping command, then the busbar protection system must issue a trip command to the failed C.B. (re-trip) after a settable time delay. If the failed C.B. does not respond to the second trip command, the busbar protection system, after a settable time delay, must trip the appropriate circuit breakers (bus-trip) in order to isolate the fault.
The C.B. position ("open" or "closed") will be selected either with the use of current criteria (separate for each bay), or with the use of C.B. auxiliary contacts. With appropriate settings, the user must be able to choose the above current setting and which criteria (current or C.B. auxiliary contacts) will be used.

If the bay belongs to equipment that, although energized, may be with little

or no current (transformer bay etc), the C.B. position criteria will be the breaker position (through its auxiliary contacts) together with a busbar isolator position (through its auxiliary contacts). In other words, the busbar protection system must "see" both the circuit breaker and a busbar isolator (of the same bay) as closed, in order for the C.B. failure function to consider the circuit breaker as "closed". The bays, for which this logic must be implemented, will be mentioned each time in the inquiry.

10. Overcurrent function.

The busbar protection system must include an independent overcurrent function. At least one phase overcurrent element must be included. The user must be able to activate and set this overcurrent element separately for each bay. The available settings must include definite time operation and inverse time curves (IEC and IEEE).

11. Additional features of the busbar protection system.

a. The busbar differential protection system must respond and trip only the breakers of the bus section that is affected by the fault regardless of whether the bus coupler is opened or closed.
b. The busbar differential protection system shall be capable of clearing all faults between the current transformer and the bus coupler circuit breaker.
   This capability should overcome the blind spot between the current transformers and the bus coupler circuit breaker, which occurs when the current transformers are positioned on one side only of the bus coupler.
c. There must be a current circuit monitoring function, which will detect any failures in the current circuit (wiring etc). This function should, with appropriate settings by the user, either block the busbar differential protection, or produce an alarm.
d. The busbar protection system must include the ability of adding custom functions using logic and mathematical equations.
e. All the individual relays, which constitute the busbar differential system, must have a housing of IP30 degree of protection (according to IEC).
f. Besides an internal clock, the busbar differential system must be capable of being synchronized via an external GPS clock and via a substation control system.

12. Facilities of modification and extension.

The offered busbar protection system must allow expansion, in case more bays are added in the substation, even if these new bays have different CT ratio and characteristics than those already installed. Everything needed for the expansion of the busbar protection system (software, manuals, files, special licenses etc) must be provided also.

13. Continuous Monitoring.

Continuous monitoring function should be included. This function shall always monitor the ability of the protection to operate correctly and if there is a failure in the protection system, shall give an alarm and / or block the tripping circuit. Means shall also be provided in order to indicate

failure of D.C. control voltage.
In case of an error, the busbar protection system must produce different alarms, depending on the error type (internal relay error, communication between relays error) and the part of the system that has malfunctioned, in order to facilitate troubleshooting.

14. Interference.

The busbar differential protection system shall be immune against any external interference, coming either from the D.C. supply or from the measuring circuits or any other cause.

15. Terminal blocks.

The relay terminal blocks must be screw type, suitable for 2.5 mm^2 cables (4 mm^2 for the current connections).

16. Trip output contacts.

The trip output contacts will be of heavy duty with the following minimum requirements:

- Current carrying capacity : 5 A
- Making capacity : (L/R=40 ms) 1000 W/VA
- Breaking capacity : (L/R=40 ms) 30 W/VA
- Number of trip outputs : 2 (for each bay)

These outputs must be able to trip directly the C.B. trip coils, without the use of auxiliary relays.

The switching/ breaking capacity of the contacts must be mentioned in the offer.

17. Type of circuit.

The busbar differential protection system shall be of the numerical type.

18. Settings & Configuration of the busbar differential protection system - Software

All settings and programming shall be carried out by an embedded keyboard and display and by PC. Everything needed (software, communication cables, licenses etc) for the above purpose shall be provided as well (at least five items).
Software, WINDOWS based, for parameter setting, configuration, analysis of fault data and records and commissioning shall be provided on the basis of a royalty free, non-exclusive with irrevocable license to use by IPTO. The software must be user friendly and menu driven. The software must display on screen all analog waveforms and digital signals. The software must also support a dynamic representation of the substation status (display on PC screen the position of busbar isolators and analog signals). Furthermore, the software must support record extraction to comtrade format.
Finally, the software and everything else (communication cables, files, licenses etc) needed for the expansion of the busbar differential protection system must be provided on the basis of a royalty free, non-exclusive with irrevocable license to use by IPTO.

19. Interfaces

Every busbar differential relay (that constitutes the busbar differential protection system) must have on the front face a communication port for connection with a PC. This port must be of USB or Ethernet RJ-45 type. If the port type is not one of these types, suitable USB or Ethernet RJ-45 adaptor cables must be provided. Relay setting, configuration and recordings extraction will be available through this port with the use of the appropriate software (see also VIII/18).

Every busbar differential relay must have on the front face a suitable interface for parameter setting, for display of measurements, for display of event and fault data (VIII/20), and for monitoring the operation of the relay (display of trips, alarms, internal problems etc). This interface will consist of a keyboard, a display (screen), and programmable LEDs.

The busbar differential relays must have suitable optical ports for connecting to a substation automation system according with IEC 61850 communication protocol, using PRP redundancy (IEC 62439-3).

For proving conformity with communication protocol IEC 61850, conformance tests according to IEC 61850-10 must be performed, and the relevant UCA level A test certificates must be submitted. The test certificate can be of level B, only if the manufacturer's lab is qualified by the UCA International Users Group.

20. Event and Disturbance recording – Measurement display

The busbar differential protection system must be equipped with event and disturbance recording capability.

The busbar protection system must be able to measure and display in real time the analogue inputs (phase currents for each phase), the differential current and the restraint current for each protection zone.

21. Special tools and accessories

Every special tool or accessory needed for the installation, wiring, programming/configuration, testing and expansion of the busbar protection system must also be provided.

22. Centralized or distributed type

Whether the busbar differential protection system is of the centralized or distributed type, will be indicated each time in the inquiry.

IX. CABINET CHARACTERISTICS

1. The entire busbar differential protection system will be housed in cabinets of class protection IP52 and of the following approximate dimensions: 2200 mm (height) x 800 mm (wide) x 600 mm (depth).

   The protection system shall be completely wired, tested and ready for connection to the external circuits.

2. Appropriate test sockets must be installed on the front face of the cabinets, in order to facilitate the testing of the busbar protection system. Suitable test plugs must also be provided. There will be enough test plugs, so that the simultaneous testing of five (5) bays can be achieved. The test sockets and plugs shall follow IPTO requirements. It should be noted that testing

terminal blocks are not acceptable.

3. Suitable switches must be installed on the front face of the cabinets, so that the busbar protection system can be "turned off". Moreover, switches must be installed so that each bay can be switched to "off" ("off" meaning that the busbar protection system does not take into account the isolator and circuit breaker positions and the current measurements from this specific bay).

X. STANDARDS

The items to be offered (hardware/software) will conform to the international standards and codes of practice. Specifically:

- Currently valid IEC standards applicable for such devices. Indicatively:

IEC 60255-26
IEC 60255-27
IEC 61000

In case of lack of international regulations, conformity to the national standards (i.e. the manufacturer's country standards – ANSI, VDE etc) can be accepted, subject, however, to IPTO's approval.

Finally, conformity statements for 2014/30/EU and 2014/35/EU directives are required.

XI. TESTS

A. Type tests.

1. Impulse voltage withstand test:
   5 kV peak 1,2/50 μs, as per IEC 60255-27

2. Power frequency voltage withstand test:
   2 kV rms, 50 Hz, 1 min, as per IEC 60255-27

3. Electromagnetic immunity and emission tests, as per IEC 60255-26 and relevant IEC 61000 standards.

4. Vibration/ shock/ bump tests, as per IEC 60255-21-1 and IEC 60255-21-3

B. Routine Tests.

1. Protective bonding continuity test, as per IEC 60255-27

2. Power frequency voltage withstand test:
   2 kV rms, 50 Hz, 1 min, as per IEC 60255-27

NOTE Bidders are required to submit any official test reports for all of the above tests, along with their technical offer.

XII. ADDITIONAL DATA TO BE SUBMITTED BY BIDDER

1. Reference list.
A reference list, of the busbar differential protection system offered, shall be submitted and in which the following data shall be included:

- Country and customer.
- Network voltage.
- Number of busbars protected (zones).
- Number of feeders.
- Number of bus couplers.
- Number of bus sectionalizing isolators.
- Year of commissioning.

2. Spare parts.
The Manufacturer shall submit a complete list of recommended spare parts, with unit prices, that - according to his opinion - should be purchased for a period of five years operation.
This list must include at least one (1) item for each relay or other IED type that is part of the busbar differential
IPTO maintains the right to purchase or not these spare parts.

3. Drawings - Pamphlets.
Bidders are requested to submit attached to their offers, outline drawings, over-all dimensions of the complete equipment for erection purposes as well as any information, sketches and data necessary for the complete description of the busbar differential protection system offered by them.

4. Test reports.
Test reports must be submitted for all tests described in paragraph XI. Conformity statements for 2014/30/EU and 2014/35/EU directives are also required.

5. IEC 61850 certificates.
According to paragraph VIII/19 the relevant UCA level A or B test certificates must be submitted. In case a level B certificate is submitted, the required manufacturer's lab certificate from the UCA International Users Group must also be submitted.

6. Furthermore, all bidders must indicate every deviation from this hereby specification along with the reasons for the deviations.

7. All bidders are required to answer all items of Attachment "A". Failure to comply or partial filling of the Attachment will constitute sufficient reason for rejection of the offer.

XIII. DATA TO BE SUPPLIED BY SUCCESSFUL BIDDER

1. Drawings.
The successful bidder, after the signing of the contract, must submit three (3) sets of drawings (schematic, wiring and physical) for approval prior to the shipment of the busbar differential protection system. These drawings

must be submitted in printed and digital format.
The successful bidder must also provide the above drawings "as built". These drawings must be provided in printed (2 copies) and digital format.

2. Maintenance Instructions.
Maintenance Instructions for the busbar differential protection system.

3. Instructions for setting, configuration and commissioning.
Instructions for setting, configuration and commissioning of the busbar differential protection system.

4. Technical manuals.
The successful bidder, after the signing of the contract, must provide all the available technical manuals in digital and printed (2 copies) format.

"ATTACHMENT A"

NUMERICAL
BUSBAR DIFFERENTIAL PROTECTION SYSTEM

1. Type :……..……

2. Manufacturer :……..……

3. System operation voltage and number of bays :……..……

4. Tripping time (from occurrence of fault to energizing of circuit breaker trip coil) :……..……

5. Is the busbar differential protection system extremely stable against external faults even in the case of saturated CTs? :……..……

6. Is the sensitivity for internal faults, adjustable and unaffected by the number of feeders? :……..……

7. Measuring principle (low-impedance) :……..……

8. Is secure operation provided against false tripping? :……..……

9. Operational criteria to be fulfilled in order to achieve tripping :……..……

10. Does the protection adjust itself automatically to all switching operating conditions without interruption? :……..……

11. Does the busbar protection system include a function to a form a replica of the busbar switching arrangements (VIII-8)? :……..……

12. Is the busbar differential protection system equipped with breaker failure protection according to paragraph VIII-9? :……

13. Does the busbar protection system include an independent overcurrent function according to paragraph VIII-10? :……

14. Does the busbar differential protection system respond and trip only the breakers of the bus section which is affected by the fault? :……..……

15. Is the busbar differential protection system capable of overcoming the blind spot between current transformers and bus coupler? :……..……

16. Does the protection scheme permit expansion? :……...……..…….

17. Is there a continuous monitoring function included that produces an alarm even in the case of D.C. control voltage failure? :……...……

18. Is the protection system immune against any external interference? :……..……

19. Trip output contacts:
    - Current carrying capacity (A) :……..……
    - Making capacity (L/R=40 ms) (W/VA) :……..……
    - Braking capacity (L/R=40 ms) (W/VA) :……..……
    - Number of trip outputs :……..……

20. Can all the settings and programming be performed by an embedded keyboard and display as well as by a PC? :……..……
    -Is the software WINDOWS based, user friendly and menu driven? :……..……
    -Can all analog waveforms and digital signals be displayed on screen? :……..……
    -Is the relevant software provided? :……..……

21. Does the offer include cables for the communication of the relay with a PC? :……..……

22. Communication protocols of the system :……..……

23. Is the busbar differential protection system equipped with event and disturbance recording capability? :……..……

24. Is the busbar differential protection system of the centralized or distributed type? :……..……

25. Protection class (IP) of the relays which constitute the busbar differential system: :……..……

26. Cabinets of the protection system housing:
    - Number :……..……
    - Dimensions :……..……
    - Protection class (IP) :……..……

27. Are the means provided in order to have the system tested during maintenance? :……..……

28. Are test sockets for the voltage, current and tripping protection circuits included? :……...……

29. Are the required test plugs included in the offer? :……...……..……

30. Is the offered system completely wired tested and ready for connection to the external circuits? :……...……

31. Can the busbar differential relays be connected to an IEC 61850 substation control system with PRP redudancy through optical ports? :……...……..……

32. Deviations, if any, from the present specification and the reasons thereof :……...……
……...……
……...……