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INDEPENDENT POWER TRANSMISSION OPERATOR SA

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SPECIFICATION SS – 108/5

NUMERICAL DISTANCE PROTECTION RELAYS FOR THE 400KV TRANSMISSION LINES

I. SCOPE

This specification covers the required technical, operational and constructional characteristics and testing of numerical distance protection relays for 400KV transmission lines.

II. KEY WORDS

Numerical relays, distance protection relays, relays, digital relays.

III. USE

The distance protection relays are to be used for the protection of each 400KV transmission line of the 400KV double circuit against phase to phase and phase to ground faults.

It should be noted that for reasons of increased reliability, two (2) redundant distance relays of the same type but of different manufacturer are employed for the protection of each transmission line. One used as back-up.

IV. STANDARDS

The relays shall conform to the latest IEC standards. Relays based on ANSI / IEEE or DIN / VDE standards can be offered, subject however, to the Purchaser's approval.

V. OPERATING CONDITIONS

- | | |
|----------------------|--|
| 1. Installation | : Indoors |
| 2. Temperature range | : -5 ⁰ C to 55 ⁰ C |
| 3. Relative Humidity | : 5% to 85 % |

VI. CHARACTERISTICS OF THE ELECTRICAL SYSTEM

1. Rated Voltage (phase to phase) : 400 KV rms
2. Maximum Operating Voltage (phase to phase) : 420 KV rms
3. Voltage operating range : 380 to 420 KV
4. Rated frequency : 50 Hz
5. Number of phases : 3
6. System Neutral : Solidly Earthed
7. Frequency Range : 50 Hz \pm 0.2 Hz
8. Rated short circuit level : 40KA at 420 KV
9. Maximum permissible duration of fault to maintain stability : \leq 500 msec
10. Circuit breaker tripping scheme : 1 pole and 3 pole

VII. CHARACTERISTICS OF THE 400KV TRANSMISSION LINES

The 400KV double circuit transmission lines are not transposed and consist of twin bundle ACSR conductors, of 954 MCM each. The double circuit line is effectively protected by shield wires and the towers have a ground resistance up to 20 Ohms maximum.

No of circuits	: 2
Cross Section, MCM	: 954 MCM*
R1, Ohms / Km	: 0.03293*
X1, Ohms / Km	: 0.3184*
Ro, Ohms / Km	: 0.2587*
Xo, Ohms / Km	: 1.1740*
Ro _m , Ohms / Km	: 0.2262**
Xo _m , Ohms / Km	: 0.7568**
B1, μ mhos / Km	: 3.57*
Bo, μ mhos / Km	: 2.168*
Bo _m , μ mhos / Km	: -0.5762**
Length Range	: 10 to 180 Km

* Values are for one circuit of a double circuit line.

** Mutual zero sequence quantities between the two circuits.

VIII. INSTRUMENT TRANSFORMER CHARACTERISTICS

The distance protection relays shall be used in conjunction with instrument transformers which have the following characteristics

1. Voltage Transformers

- Type : Single-phase, oil immersed of the inductive type
- Connection : Wye grounded
- Number of secondary windings : 3

- Rated output per secondary winding and class:
 - Windings 1 and 2 (for metering) : 150 VA, class 0.5
 - Windings 3 (protection) : 100 VA, class 3P / 0.5
- Rated transformation ratio : $\frac{400}{\sqrt{3}} KV / \frac{100}{\sqrt{3}} - \frac{100}{\sqrt{3}} - \frac{100}{\sqrt{3}} V$

2. Current Transformers

- Type : Single-phase, oil immersed
- Connection : Wye grounded
- Number secondary windings : 4
- Rated output and class per winding
- Winding No1 (for metering) : 60VA, class 0.5
- Winding No2 (for distance protection) : 60VA, class 5P 20
- Winding No3 (for distance protection) : 60VA, class 5P 20
- Winding No4 (for bus differential protection) : 30VA, class 5P 20
- Rated transformation ratio : 1600 – 800A / 1-1-1-1A

IX. DISTANCE RELAY REQUIRED CHARACTERISTICS

1. Analog inputs

- a. Rated Current : 1A AC
- b. Rated Voltage : $100 / \sqrt{3} V AC$

2. Binary (Digital) Inputs

- a. Rated Voltage : 220V DC
- b. Rated Voltage tolerance : +10%, -15%
- c. Number of digital inputs : 12

3. Output Contacts

- a. Heavy duty contacts (for breaker operation)
 - Six (6) N.O., heavy duty contacts with the following characteristics:
 - Maximum rated voltage : 250 V DC
 - Continuous Current : 5A
 - Short-time current, for 0.5 sec : 30A
 - Switching making capability : 4A at 250 V DC
 - Switching breaking capability (for DC with L/R <40 msec) : 0.15A at 250V DC
- b. Signalling (indication) configurable contacts.
 - Ten (10) (NO.) contacts with the following characteristics:
 - Maximum rated voltage : 250 V DC
 - Continuous Current : 1A

- Switching making capability : 0.10A at 250 V DC
- Switching breaking capability : 0.10A at 250V DC
(for DC with L/R <40 msec)

4. Auxiliary supply voltage

- a. Rated Voltage : 220V DC
- b. Voltage tolerance : +10%, -15%

5. Constructional characteristics

- a. The distance relay shall preferably be of modular design with plug – in units. This facilitates repairs and fault tracing.
- b. The distance relay shall be suitable for panel flush mounting or semi-flush mounting or surface panel mounting.
- c. Automatic short – circuiting of the current contacts must be foreseen in the case where the current input unit is of the draw – out type.
- d. The relay case shall provide degree of protection IP 51 as per IEC.
- e. The distance relay shall be equipped with screw type terminals suitable for 2.5 mm² conductors.

6. Operating Characteristic.

The operating characteristic shall be quadrilateral (polygonal) for all types of faults or mho only for phase-to-phase faults.

7. Zones

The distance relay shall have at least three (3) distance zones, two (2) in the forward direction and one (1) in the forward-reverse direction for all type of faults (phase to phase and phase to earth).

The reach of the distance zones shall be selectable within the range of 0-90: Ω secondary in the X axis and within the range of 0-30 Ω secondary in the R-axis.

8. Type of distance relay and phase selection

The distance relay shall be of the numerical type and shall ensure clearance of all types of phase and earth faults in the protected zone and direction with selective three-phase tripping or single-pole tripping with auto-reclosing. The fault detection shall be done with impedance excitation and overcurrent criteria. A phase selection shall be included to provide reliable identification of fault and phase involved, for correct single-pole tripping.

9. Operating Time of the distance relay

The operating time of the relay shall be ≤ 20 msec

10. Configuration of the distance relay

All settings (parameterization) shall be input by means of an integrated keyboard and display and by a PC. The settings shall be stored in a non-volatile memory, so that they cannot be lost even during interruption of the substation auxiliary voltage and relay's internal battery (if available)

11. Protection against Noise and Transients

The distance relay shall be capable of suppressing the influence of switching currents, transient DC current components, high-frequency transients and harmonics and in general, shall be capable of operating without problems in a substation environment.

X. *ADDITIONAL REQUIRED DISTANCE RELAY FEATURES*

In addition to the basic distance protection features, the distance relay shall have the following additional features:

1. Switch – on – to – fault protection (SOFT)

By monitoring the manual close command over a defined period, the switch – on – to – fault feature shall ensure instantaneous tripping without autoreclosing when the circuit breaker is closed on to a fault.

2. Trip circuit Supervision

3. Teleprotection (carrier interface)

a. The cooperation between the distance protection relays of two circuit breakers protecting the same circuit and located at its opposite ends, shall be accomplished by H.F. carrier. The distance relays shall be designed in a such way as to allow adaptation to the following possible transfer tripping techniques.

The distance relay sensing a fault in its first zone, trips its respective circuit breaker instantaneously and simultaneously sends a signal via carrier to the distance relay of the remote end. In case this relay has also started its operation by sensing the fault in the proper direction, then the incoming signal shall either trip the circuit breaker (permissive under reaching transfer trip) or shall extend the measuring range of the first zone.

In case of absence of the H.F. carrier the distance relays shall be capable of operating independently.

b. Modes of operation

- PUTT (Z1B acceleration) and
- PUTT (acceleration with pickup)

For permissive tripping schemes, during weak infeed conditions, an echo function will be provided, enabling a fast tripping command back to the remote end of the line.

4. Auto reclosure

The range of operational modes shall, be as follows:

- a. Fast single-pole auto reclosing for single-phase faults
- b. Fast three-pole auto reclosing for multi-phase faults
- c. Fast three-pole autoreclosing for all fault types
- d. Single or multi shot autoreclosing, up to 3 shots.

5. Synchrocheck

6. Power swing blocking / tripping

7. Fault locator

8. Directional earth fault protection

Directional earth fault protection designed to protect against faults that are highly resistive and can not be detected by the distance protection function. The directional earth fault shall have the following selectable feature:

- Time delayed three-pole tripping, either definite time or inverse time using a selection of IEC or ANSI curves

9. Self monitoring (checking)

During operation, self-monitoring shall be performed and in case of an internal fault or loss of the D.C. auxiliary supply, a signal shall be issued for protection blocking and / or alarming.

10. Breaker failure protection.

The breaker failure protection by detecting the current flowing through the corresponding circuit breaker will operate, through a timer, an output contact should the circuit breaker fails to operate.

11. Disturbance recording (fault recording)

Any disturbance (fault) shall be recorded and stored for analysis. The capacity of memory shall permit the storage of at least four (4) faults.

In the technical offer, the memory capacity and time length of the faults that can be stored must be clearly indicated.

Capability shall exist so that the disturbance (fault) data can be read remotely via modem.

The recording shall include both analog and digital signals. The synchronization source must be an internal clock and a GPS radio clock.

12. Measurements (Metering)

The measurement function shall be capable of measuring analog quantities, that is frequency, voltage, current active and reactive power in real time.

13. Emergency overcurrent protection

Emergency overcurrent protection in the event of loss on AC voltage.

14. Compensation of mutual zero sequence impedance

Compensation of mutual zero sequence impedance between the two parallel circuits of a double line with the capability to deenergize this function if needed.

XI. COMMUNICATIONS

The relay shall be fitted with two serial ports for reasons of interfacing and specifically with:

1. One serial port suitable for connection to a PC.

An operator program, running under WINDOWS shall be available to enable user-friendly parameter setting, analysis of fault data and records and commissioning either locally or remotely via modem.

2. One serial port suitable for system interface. (fiber optic) shall be available for connection to a digital computerized substation control system. The communication protocol shall be as per IEC 61850.
3. Besides an internal synchronization clock, the relay must be capable of being synchronized, via a substation automation control system's master clock, which has the capability of GPS synchronization besides of its own.
4. A number of 20 cables for the communication of the relay with PC must be included in the offer.
5. The offered relays shall be certified by conformance test performed in accordance with IEC-61850-10. The certificate must be of level A (level A means independent Lab. e.g. KEMA).
The certificate can be of level B (manufacturers Lab) if that has been qualified by USA International Users Group.
In the second case, the certificate of level B must be submitted in the technical offer along with the UCA International Users Group certification to the manufacturer.

XII. SOFTWARE

Software, WINDOWS based (3 copies at least), for the parameter setting, 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 PPC.

The software shall be user friendly and displaying on VDU (screen) all analog waveforms and digital signals. The software shall be menu-driven.

XIII. TESTS

1. Routine Tests as per IEC 60255-5

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|------------------------------|---|
| a. Dielectric Withstand test | : 2KV rms, 50Hz, 1 minute, between all terminals and case earth |
| b. Impulse Voltage test | : 5KV peak, 1.2 / 50μs, 0.5J |

2. Type tests.

- | | |
|--|---|
| a. Impulse Voltage test as per IEC-60255-5 | : 5KV peak, 1.2 / 50μs, 0.5J |
| b. High Frequency test as per IEC-60255-22-1 | : 2.5 KV peak, 1MHz, t = 15μs, 400 shots/sec, duration = 2sec |
| c. Electrostatic Discharge test | |

- as per IEC-60255-22-2 class III : 4KV contact discharge, 8KV air discharge both polarities.
- d. Fast Transient test as per IEC-60255-22-4 class III : 2KV, 5KHz, burst length = 15 ms, repetition rate = 300ms, both polarities, duration = 1min
- e. Vibration test as per IEC-60068-2-6: 60Hz to 150Hz, 0.5 acceleration, sweep rate = 10 octaves / min, 20 cycles in 3 orthogonal axes
- f. Radio interference field strength: 30 to 1000MHZ – limit class B as per IEC-CISPR 22

NOTE: In case of lack of IEC testing standards, the only other standards that could be considered are VDE and ANSI / IEEE, subject, however to the purchaser's approval.

XIV. INFORMATION WHICH MUST BE PROVIDED BY ALL BIDDERS

1. All necessary technical pamphlets and technical information so that the technical evaluation of the offered distance relay can be carried out.
2. Outline drawings with over-all dimensions and wiring diagrams of the offered distance relays.
3. Any test certificates for all specified type tests in this hereby specification may be submitted along with the technical offer.
Acceptance or not of the submitted test certificates will be subject to the purchaser's approval.
4. A reference list shall be submitted and in which the following shall be included:
 - Country and buyer
 - Type of the relay
 - Number of units sold
 - Year of sale.
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5. Guarantee of good operation for a period of at least 5 years.
6. The cost of training in the premises of the supplier of 3 engineers covering the cost of transportation and accommodation, for 3 days.
7. All bidders are required to complete attachment "A". Failure to comply with this request or submission of attachment "A" incomplete shall constitute sufficient reason for rejection of the offer.

XV. DATA WHICH MUST BE PROVIDED BY THE SUCCESSFUL BIDDER.

1. Complete functional and wiring drawings for approval before shipment of the relays.
2. Complete outline dimensional drawings for approval before shipment of the relays.
3. All necessary documentation concerning installation, commissioning, operation, maintenance, parameter setting and trouble shooting of the relay.
4. Complete instructions for the operation and application of the related software.

XVI. PACKING

Each relay with all of its units (if any) shall be packaged separately inside a robust box properly labeled.

ATTACHEMENT “A”

1. Type of the offered relay :
2. Temperature tolerance range :
3. Analog Inputs of the relay:
 - a. Rated current :
 - b. Rated voltage :
4. Digital Inputs:
 - a. Rated voltage :
 - b. Rated voltage tolerance :
 - c. Number of inputs :
5. Heavy duty Output Contacts
 - a. Number of heavy duty contacts :
 - b. Continuous current :
 - c. Short-time current (0.5 sec) :
 - d. Switching making capability :
 - e. Switching breaking capability :
6. Signaling contacts
 - a. Are they configurable? :
 - b. Number of signaling contacts :
 - c. Rated voltage :
 - d. Continuous current :
 - e. Switching making capability :
 - f. Switching breaking capability :
7. Auxiliary supply voltage :
8. Auxiliary supply voltage tolerance :
9. Is the offered relay of the modular design type? :
10. Is the offered relay suitable for panel flush mounting? :
11. Is automatic short-circuiting of the current contacts available in the case where the current input unit is of the draw out type? :
12. Degree of protection of the relay case :

13. Is the relay equipped with screw type terminals suitable for 2.5mm² conductors :
14. Type of measurement characteristic :
15. Number and description of the zones :
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16. Reach of the zones :
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17. Are the zones selectable? :
18. Criteria used for fault detection :
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19. Operating (response) time of the relay :
20. Reset time of the relay :
21. Is the relay equipped with an integral keyboard and display for parameter setting?:
22. Can the relay be set by PC? :
23. How is the relay protected against electrical noise and transients? :
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24. Is the relay equipped with switch onto fault protection? :
25. Is the relay equipped with trip circuit supervision? :
26. Does the offered relay comply with the requirements of paragraph X-3? :
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27. Describe the autoreclosure feature of the offered relay :
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28. Is the offered relay equipped with synchrocheck? :
29. Is the offered relay equipped with Power swing blocking? :
30. Is the offered relay equipped with fault locator? :
31. Is the offered relay equipped with directional earth fault protection? :
32. Is the offered relay equipped with self monitoring (checking) feature? :
33. Is the offered relay equipped with breaker failure protection? :
34. Describe how the breaker failure protection feature operates :
:
:
:
35. Is the offered relay equipped with disturbance recording? :
36. Is the offered relay equipped with internal synchronization clock? :
:
37. Can the offered relay be synchronized via a master clock belonging to a substation automation control system? :
38. Is the offered relay equipped with measurement feature? :
39. Is the offered relay equipped with two serial ports? One for connection to a PC, the other for connection to a digital computerized substation control system? :
:
:
40. What is the communication protocol used for the connection of the relay to the digital computerized substation control system? :

41. Is software provided? :
42. Is a number of cables for the communication of the relay with PC provided? :
43. Is the software windows based? :
44. Can the software be used for parameter settings, analysis of fault data and record and commissioning? :
45. What is the memory capacity of the disturbance recorder? :
46. How many faults can be stored in the memory of the disturbance recorder? And what is the time length of fault? :
47. For the teleoperation function, indicate modes of operation :
48. Guarantee of five (5) years at least? :
49. -Have the offered devices been certified by conformance test performed in accordance with IEC 61850-10? :
- Are certificates provided? :