



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

TECHNICAL DESCRIPTION TD-103/2

DIGITAL LINE DIFFERENTIAL PROTECTION RELAYS
FOR 150kV TRANSMISSION NETWORK

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ATHENS

1. Introductory remarks - range of application.

This technical description concerns digital multi-terminal differential protection relays for the protection of overhead power lines and cables in IPTO transmission Power System at 150kV voltage, applicable either for two (2) or three (3) ended schemes at least and for different substation and protected unit topologies. It establishes requirements for the performance, design, testing and operation of the relevant equipment and related software. The relays are primarily intended to provide fast, selective and reliable clearance of faults in high voltage network.

The protection device shall combine both differential and a full range of back-up distance protection, allowing the use of only the differential protection or both differential and back-up distance protections in parallel.

In addition to the fundamental protection functions supplementary or optional functions are required covering the needs for operation in a modern working environment.

2. References and standards.

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

- Currently valid IEC -60255 standards applicable for such devices covering performance, insulation and disturbance requirements, indicatively :

- Insulation Withstand voltage : (IEC 255-5)
 - Industrial frequency : 2KV, 50 Hz, 1min
 - Impulse test 1,2/50 μ s, 5KV
- Interference immunity tests according to IEC 60255-6
- Disturbance tests (IEC 255-22-1,2,3,4)
 - High frequency: class III - 2,5/1,0 KV at common/differential mode
 - Electrostatic discharge: class IV - 12/8 KV at case and class III - 8/6 KV at comm. ports (air/contact discharge)
 - Radiated e/m field: class III, 10V/m
 - Fast transient: 4/2 KV at power supply / I/O and data lines
- Vibration/shock/bump requirements (IEC 255-21-1) : class I
(IEC 255-21-3) : class I
- ITU recommendation, the application of which will ensure unobstacle communication with the relays through the existing communication network.

In case of lack of international regulations, conformity to the national standards (i.e. the manufacturer's country standards) applicable for such devices could be considered, subject to purchaser's approval (ANSI, VDE etc.).

Finally, conformity statement of the manufacturer according to the provision of EU LV directive (2006/95/EC) and EMC directive (2004/108/EC) will be required.

3. Operating environment.

- Network data
The relays will be installed in the 150KV transmission network of IPTO.
The main data of this network are shown below.
Rated voltage : 150KV rms
System neutral :solidly earthed
Nominal frequency : 50 Hz (in emergency conditions frequency could be between 47.5 Hz to 51 Hz)
Short-circuit level : 6500 MVA (nominal)
- VT, CT characteristics
The secondary nominal voltage of the inductive or capacitive potential transformers is typically $120/\sqrt{3}$ or $100/\sqrt{3}$ and their class 3P/0.5.
Nominal secondary current of the CTs is 1A and their class 5P20 and burden 40VA.
- Power supply
In 150KV IPTO substation for the supply of the control/recording equipment is available a battery system providing DC voltage of a level of 110V (+10%, -10%).
- Electromagnetic interference
The relays will be installed in high voltage installation and it is the manufacturer's responsibility to provide all necessary measures (grounding, shielding) to assure reliable operation.
CE conformity marking will be available
- Ambient conditions
The relays will be designed for indoor operation over a temperature range from -5°C to 55°C and humidity range from 5% to 90%.

4. Protective functions.

The protection device shall support the following protective functions:

I. Differential protection

The measurement algorithm will offer fast detection of internal faults and stability for external faults. The differential protection shall operate determining a differential current and restraint current.

Features of differential function

- Max tripping time $\leq 30\text{msec}$

- Adaptive measuring method for distinction between load and short-circuit conditions also in case of high-resistance, weak – current fault.
- High sensitivity in weakly loaded system, high stability against load jumps and power swings.
- Phase - segregated measurement for pickup sensitivity independently of the type of fault. Phase – segregated tripping also possible on weak or zero infeed ends.
- Suitability for transformers in the protected zone
- Detection of high – resistance, weak – current faults due to high sensitivity.
- Insensitive against inrush and charge currents, also for transformers in the protected area and against higher frequency power system event.
- High stability also in case of different current transformer saturation.
- Capacitive charging current compensation allows the relay to be set according to fault detection requirements on cables and long lines.

II. Distance protection

Distance protection function will ensure clearance of all types of phase or ground faults in the protected zone and direction providing selective three phase tripping.

Fault detection will include impedance excitation and eventually underimpedance, earth - fault and overcurrent excitation.

The impedance characteristics of the relay will be quadrilateral (or mho only for faults between phases) ensuring enhanced stability in case of load encroachment.

At least 3 distance zones will be provided

The reach of the distance zones can be selectable within the range 80 Ohm secondary in X-axis and 30 Ohm secondary in R-axis. In order to prevent inadvertent tripping the distance protection function blocks in case of a failure of the measuring circuit voltage.

Maximum permissible operating time 30 msec for all types of faults.

At least four groups of settings have to be stored in the relay which must be selectable by the user during operation either locally by on-the-relay interface or remotely via external signal.

III. In addition to the basic distance and differential protection functions, a package of additional functions is requested to meet the needs for the efficient operation of the network. Analytically :

- Switch-on-to fault feature (SOTF) : by monitoring the manual close command over a defined period, SOTF will ensure instantaneous tripping without autoreclosing when the circuit breaker is closed onto a fault.
- Teleprotection: typically the permissive under-reach transfer trip (PUTT) scheme is

used. Optionally other schemes will be provided (direct transfer zone extension, overreach or blocking scheme). 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.

- Autoreclosing for overhead lines (OHL) : fast three pole autoreclose.
- Synchrocheck: feature related to the autoreclosure function (for remote control). It ensures circuit breaker closure only in synchronize conditions (selectable by the user).
- Directional earth fault (DEF) function it is used for achievement of discriminative clearance of high resistance earth fault. This function can also be configured as non-directional, sensitive earth fault protection (SEF).
- Back-up phase and ground overcurrent - time protection function either permanently parallel to the distance protection or as emergency o/c operation : it will be activated in case of failure of voltage measurement circuit.
- Fault locator.
- Fault recording : in the event of a fault and/or excitation the fault data will be stored in the relay for analysis. The fault data can be read remotely via modem. In the offer it must be clearly stated the memory capacity and the number/time length of the faults which can be stored. The capacity of the memory will permit the storage of at least four faults. It must be underlined that the fault report will include digital events and analog waveforms.
- Metering: it enables real time measurements of all analog quantities (U,I,P,Q) either locally or remotely via modem.
- Local and remote control of the Circuit Breaker. Local control will be realised through push-buttons on the relay. Remote control will be realised through the digital substation control system.
- Self-monitoring: During operation self-monitoring tests will be performed and in case of an internal fault or loss of dc supply a signal is issued for protection blocking and/or warning.
- Circuit Breaker Failure Protection : by monitoring the circuit breaker status after an issue of a trip command over a time period while the relay excitation is yet active a circuit breaker failure is issued.
- Power swing detection: Dynamic power system events can cause power swings. If power swing is detected the trip of the distance protection function is blocked. The power swing detection function could be "setting free"
- Overvoltage and undervoltage protection
- Trip circuit monitoring
- Current Transformers supervision
- Lockout function

5. Design and construction.

All functions will be included in a housing providing degree of protection IP50 at the front and IP20 at sides and rear, according to IEC.

The construction preferably will be of modular design with plug-in units facilitating repairs and providing self-diagnostic (fault tracing) for each module.

The installation will be flush mounting.

All the appropriate special accessories (special cables/ plugs interfaces, adaptors etc.) for communication and testing have to be included in the offer.

Automatic short-circuit of current contacts must to be foreseen, in the case where the current input unit is of draw out type.

The dc/dc converter accommodated in the relay housing will provide uninterrupted operation and it must have an input voltage of 110 V DC or 220 V DC.

The device shall provide four (4) current inputs and a minimum of four (4) voltage inputs.

Additionally, the device shall provide a sufficient number of freely programmable binary inputs, freely programmable output contacts and power relays.

The analog to digital converter will digitize the input signal with a resolution of 12 bits (min requirements) for reliable waveform operation.

The **heavy duty trip output contacts** will be of heavy duty with the following ratings (minimum requirements) :

- | | |
|-------------------------------|------------|
| a. Current carrying capacity | : 5 A |
| b. Making capacity (L/R=40ms) | : 1000W/VA |
| c. Breaking capacity | : 25VA |
| d. Number of contacts | : 6 |

Signalling (indication) configurable output contacts

- | | |
|--|---------------------|
| a. Rated voltage | : 110 V DC |
| b. Continuous Current | : 1A |
| c. Switching making capability | : 0.10A at 250 V DC |
| d. Switching breaking capability
(for DC with L/R =40 ms) | : 0.10A at 250V DC |
| e. Number of contacts | : 10 |

Binary (Digital) Inputs

- | | |
|-----------------------------|--------------|
| a. Rated Voltage | : 110 V DC |
| b. Rated Voltage tolerance | : +10%, -15% |
| c. Number of digital inputs | : 16 |

The switching/breaking capacity of the contacts must be mentioned in the offer. The function of the alarm contacts will be assignable and their configuration can be done easily by the software locally or remotely. Signal contacts will provide information for the status of the relay in case of maloperation. Marshalling of binary inputs, binary output indicators on the relay front panel must be possible by means of the interface on the front or remotely.

The assignments of inputs, outputs can be easily restructured for adaptation to the on site conditions.

Sixteen (16) digital inputs and Sixteen (16) digital outputs at least are required.

6. Communication and interfaces.

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

1. One digital communication port suitable for connection to a PC.
An operator program shall be available to enable user - friendly parameter setting, analysis of fault data and records and commissioning either locally or remotely via modem.
2. Serial ports suitable for system interface shall be available for connection to a digital computerized substation control system. The communication protocol shall be as per IEC 61850-8-1, supporting 2XRJ45 connections (electrical Ethernet) or 2xFO connections of optical rings.
3. The relay must have an internal clock, which will be synchronized with the clock in the relay on the other side of the protected line, by means of time telegrams through the communication link. The relay will continuously monitor the signal propagation delay, between the two relays at the end of the line. Besides this internal synchronization, the relay must be capable of being synchronized via the substation automation control system's master clock which has the capability of G.P.S. synchronization.
4. Permanent monitoring of protection data transmission for disturbance, failure or transfer time deviations in the communication network with automatic transfer time correction.
The device shall be equipped with a protection data transmission interface relating to the differential protection, providing the following features:
 - High – security synchronous communication
 - Continuous monitoring of data transmitted (rejection of erroneous telegrams)
 - In case of an extremely bad or disturbed communication channel, the differential protection will be blocked.
 - Incorrect routing cannot cause malfunctions of the protection device.
 - Unexpected data mirroring through routing errors in the communication network is detected and signalled.
 - Maximum immunity against EMC disturbances

The transfer of current vectors between all ends of the link are to be made via

communication channels and means, as specified in the inquiry. The alternative ways are:

- Twisted 2- wire link, up to 7km long, or
- Direct fiber optic link, up to 100km (or even more by using an ext. fiber optic repeater)
 - 1310 nm up to 60km single - mode
 - 1550 nm up to 100km single - mode, or
- Digital multiplexed (MUX) link according:
 - G. 703.1 (64kbit/s) or
 - G. 703.6 (E1 or T1) and
 - X. 21 (64,128 or 512 kbit/sec)

The Relay can be connected to the MUX via RS-422 link or by optical fiber (850 nm, multimode) if the MUX is IEEE C37.94 compliant.

5. The relay must be equipped with an integral keypad and display for parameter setting and alarm indications.
6. Cables for the communication of the relay with PC must be included in the offer (one communication cable per each relay).

7. Software.

Software for the operation (3 copies at least, included in the price of the offered devices) will be provided on the basis of a royalty free, non-exclusive, with irrevocable license to use for the operation of the relays. This term is applicable for the software covering all issues: Setting transmission, calibration, fault analysis, communication relay - PC and communication relay -remote station.

The software will be menu-driven, friendly to the user and easy to be followed even by an inexperienced operator. The fault analysis software will be capable of displaying on a VGA all analog waveforms and binary signals.

The menu – guided operating program will run under Windows on a commercially available PC. To provide a concise overview, only those functions that are actually required shall be displayed, while non – required functions shall be hidden and disabled.

The parameterization tool shall provide functions for simple and speedy commissioning.

8. Tests

The package to be offered will be in compliance with the standards mentioned in §2 above.

Tests certificates, issued by official laboratories, will be provided covering type and routine tests.

Existing certificates and test reports will be accepted providing that they will be found satisfactory by the purchaser. Conformity to the relevant EU directives and guidelines is

also required.

9. Additional requirements

Bidders have to provide full documentation concerning the installation, commissioning, operation, maintenance, trouble-shooting of the equipment.

Furthermore complete instructions will be delivered for the operation of the related software in Greek or English language.

Also references and documentation will be provided which demonstrate that the offered hardware/software packages have been used in commercial scale and that the offered material is part of the manufacturer's standard production.

In the references a list of users of the offered products, in the area of the power transmission networks, will be provided. The purchaser can request certifications of users concerning the good performance of the products.

After the assignment of the contract the contractor has to provide full technical documentation in Greek or English language covering all relevant issues on the/operation/testing/troubleshooting ensuring an unobstacle operation by the IPTO personnel without any intervention of the manufacturer/contractor.

Guarantee of good operation for a period of at least five (5) years.

All hardware/software features will be according to this specification. Any deviation has to be clearly described and identified in the offer.

10. Certification

The offered devices 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 (manufacturer's Lab) if the manufacturer's Lab has been qualified by the UCA International Users Group.

In the first case the certificate (level A) must be submitted along with technical offer. In the second case the certificate (level B), along with the UCA International Users Group certification to the manufacturer must be submitted in the technical offer.

ATTACHMENT “A”

1. Type of the offered relay :.....
Are the relays compliant with the remarks
of paragraph 1? :.....
2. Do the offered items conform to the :.....
international standards and codes of :.....
practice mentioned in paragraph 2? :.....
3. Analog Inputs of the relay:
a. Rated current :
- b. Rated voltage :
4. Auxiliary supply voltage :
5. Auxiliary supply voltage tolerance :
6. Are the relays protected by :
- electromagnetic interference? :
- Is CE conformity marking available? :
7. Temperature and humidity tolerance range :
8. Does the measurement algorithm of :
- differential function offer sensitivity :
- to low current faults and stability for :
- external faults? :
9. Are the features of differential function :
- compliant with the properties mentioned :
- in § 4? :
10. Operating (response) time of the :
- differential protection :
11. Do the distance protection ensure clearance :
- of all types of phase or ground faults in the :
- protected zone and direction by providing :
- selective three phase tripping ? :
12. Criteria used for fault detection of :
- distance protection. :
- :

13. Type of measurement characteristic of distance protection. :
14. Are the zones of distance protection selectable? :
15. Number and description of the zones :
Reach of the zones? :
16. How many groups of settings can be stored in the relay ? :
Are they selectable ? :
17. Is the Switch-on-to fault (SOTF) function available ? :
18. Are the relays equipped with back-up overcurrent - time protection function ? :
19. Are the offered relays equipped with autoreclosure feature :
20. Is the offered relay equipped with synchrocheck? :
21. Is the offered relay equipped with fault locator? :
22. - Is the offered relay equipped with disturbance recording? :
- Can the fault data be read remotely via modem? :
23. How many faults can be stored in the memory of the disturbance recorder and what is the time length of fault? :
:
24. Is the offered relay equipped with real-time measurement feature (V, I, P, Q) ? :

25. Is the offered relay equipped with directional earth fault protection function (DEF) ? :
26. Is the offered relay equipped with self monitoring (checking) feature? :
27. Describe how the breaker failure protection feature operates :
:
:
:
28. Is the offered relay equipped with power swing detection? :
29. Is the offered relay equipped with overvoltage and undervoltage protection? :
30. Is the offered relay equipped with thermal overload protection? :
31. In the offered relay equipped with trip circuit monitoring? :
32. Is the offered relay equipped with sensitive earth fault protection? :
33. Degree of protection of the relay case :
34. Is the offered relay of the modular design type? :
35. Is the offered relay suitable for panel flush mounting? :
36. Is the relay equipped with screw type terminals suitable for 2.5mm^2 conductors :
37. Is automatic short-circuiting of the current contacts available in the case where the current input unit is of the draw out type? :
38. How many current and voltage inputs are available in the relay? :

39. Number of push-buttons on the relay :
40. 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 :
41. 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 (L/R<40ms):
42. Digital Inputs:
- a. Rated voltage :
 - b. Number of inputs :
43. Is the offered relay equipped with digital communication ports?
One for connection to a PC, the other for connection to a digital computerized substation control system? :
44. Can the relay be set by PC? :
45. Can the software be used for parameter settings, analysis of fault data and record and commissioning? :
46. What is the communication protocol used for the connection of the relay to the digital computerized substation control system? :
47. Is the offered relay equipped with internal synchronization clock? :
.....
48. Can the offered relay be synchronized via a master clock (GPS) belonging to a substation automation control system?
What is the integrated time synchronization interface? :

49. Is the device equipped with a protection data transmission interface, acc to § 6.4? :
50. Communication channels that can be used by linked differential relays: :
:
:
51. Is the required number of cables for the communication of the relay with PC provided? :
52. Is the relay equipped with an integral keypad and display for parameter setting? :
53. Is software provided according to the requirements of paragraph 7? :
:
54. Type of the software? :
55. Is guarantee of good operation for a period of at least five (5) years provided ? :
56. Have the additional requirements of paragraph 9 taken under consideration at the offer ? :
57. -Have the offered devices been certified by conformance test performed in accordance with IEC 61850-10? :
-Are certificates provided? :