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Title

Technical requirements Relay protection line bay 52-72,5 kV

Table of contents

1 General

1.1 Scope

These requirements cover the general demands of E.ON Elnät Sverige AB in respect of relay protection in the distribution line bay, 52–72.5 kV. The line bay can have overhead line and/or cable connection.

Facility Directive for the Regional Network forms the basis for this document. Requirements that deviate from that document are specified in these Technical requirements.

These requirements are a translation to the Swedish requirements D10-00116465. If the content of this document differs from the Swedish version, the Swedish requirements shall prevail.

1.2 Standards

The relay protection must be designed, manufactured and tested in accordance with the most recent edition of applicable Swedish standards. In the absence of such standards, the European Standard (EN) and IEC publications apply.

In the event of disparities between this document and the relevant standard, these Technical Regulations shall apply.

1.3 Labelling

Rating plates shall include rating data for manufacturer and type, supply and operating voltage, manufacturing number, serial number and version number.

2 Changes relative to previous issue

Changes are marked with a vertical line in the right-hand margin.

3 Electrical and mechanical requirements

See ”Facility Directive Regional Network”.

4 Functional requirements

4.1 General

Only functions specified in the technical specification by the client for protection and automatic systems shall be activated. All other functions shall be deactivated.
Information from protection and automatic systems shall be possible to obtain via contact functions and via station bus (IEC61850-8).
Protection/automatic systems shall be capable of communications via service-LAN. The data communication protocol shall be adapted to the applicable station control system specified in the technical specification.
Information can be divided up: information to operators via potential-free contacts and information for analysis (disturbance analysis) via data communications.

Protection functions in subsystem 1 (HS1/SUB1) can be integrated in the same physical unit. However, they may not be integrated in the same physical unit in subsystem 2 (HS2/SUB2). The same applies to protection functions fed from subsystem 2.
Automatic systems can be integrated in the same physical unit as the protection. Automatic systems are typically grouped to subsystem 1.

For IO-functions, see appendix 1 and TR Signals for indications, operation and measurement values. Tripping and closing are specified in TS.
Time synchronised event and disturbance recorder shall be included.
Start and tripping signals according to TR Signals for indications, operation and measurement values to be indicated on terminal fronts via LEDs. Fault status indications for the terminal shall also be indicated via LEDs.
Event and disturbance recorder shall be possible to obtain from the protection according to TR STINA.

4.2 Requirements for Relay protection functions

4.2.1 Distance protection

The protection shall trip its own circuit-breaker and start auto-reclosing according to TS. The protection shall detect all combinations of short circuits:
The protection shall have polygon characteristics with the possibility to limit the reach of the zones in the load range.

The distance protection shall have correct direction determination for all faults, i.e. also for adjacent three-phase short-circuits.

The protection shall have at least four zones. This includes a possible start zone
Fastest possible operate time for Switch-on-to-fault (SOTF)
The parallel protection in subsystem 2 shall be likewise those of the ordinary protection. If there is a need of protection in subsystem 2 there shall be a circuit-breaker failure protection.

The distance protection shall be able to interact with the protection at the line's remote ends. See the teleprotection chapter in this document.
In TS it is indicated whether the function for weak fault current in-feed and logic for fault current reversing are required.

The protection shall have fuse failure supervision of the voltage inputs. It should be possible to alarm block the distance protection in the event of a measurement voltage outage and automatically activate the backup protection function.

4.2.1.1 Settings

- Protection's operate time zone 1 shall be <40 ms
- The protection's operate time for other zones shall be adjustable between <0.10-30 s with a maximum of 0.05 s between adjustable values.
- Activation time Switch-on-to-fault (SOTF) adjustable 1-5 s with a maximum of 0.05 s between adjustable values
- Protection's operate time Switch-on-to-fault shall be <50 ms
- Set impedance on the protection shall give the same reach irrespective of fault type.
- Reach of zones
- Each zone's direction
- Load shielding

4.2.2 Overcurrent protection

The line bay's overcurrent protection shall trip its own circuit-breaker and start auto-reclosing if stated in the TS. The protection shall have possibility to block the overhead overcurrent protection. It cases where it is established that the overhead overcurrent protection can not completely provide backup protection for the line in question, this line shall have local parallel overcurrent protection. The parallel protection may not be integrated in the same physical unit as the ordinary protection. The parallel protection's functions shall be likewise those of the ordinary protection. If there is a need of parallel protection there shall be circuit-breaker failure protection. The overcurrent protection shall measure the phase currents in all 3 phases.

The overcurrent protection shall have at least two time steps. Parameters for the time step shall be individually adjustable for current settings and time delay.

4.2.2.1 Setting options for the low current step:

Current and time characteristics shall be selectable with the following alternatives available:

- Constant time delay
- Inverse-time delay according to IEC60255-3
  - Normal Inverse (NI)
  - Very Inverse (VI)
  - Extremely Inverse (EI)

The start current (pick-up) shall be adjustable within at least the range: 0.5-4 times the current transformer's secondary rated current. The greatest step between adjustable current values must not exceed 5 % of the current transformer's rated current.
The dropout ratio shall be greater than 0.90
The dropout time shall be less than 50 ms.
Range for the time setting:

- Constant time delay: 0.03–5.00 s with a maximum of 0.05 s between adjustable values
- Inverse time according to IEC 60255-3: k = 0.05–1.1 s with a maximum of 0.05 s between adjustable values

The "k" factor shall be independent of changes to the protection's configuration.

4.2.2.2 Setting options for the high current step:

The current-time characteristic shall have a constant time delay.
The operating current shall be adjustable within at least the range: 2 – 25 times the current transformer's secondary rated current. The greatest step between adjustable current values must not exceed 5 % of the current transformer's rated current.
The dropout ratio shall be greater than 90 %.
The dropout time shall be less than 50 ms.
Minimum range for the time setting:

- Constant time delay: At least 0.03–1.00 s with a maximum of 0.05 s between adjustable values (typical instantaneous operation, i.e. no time delay).

Operate time with minimum set delay shall be a maximum of 40 ms, provided that the fault current exceeds 1.3 times the set operate value, and a maximum of 25 ms provided that the fault current exceeds 5 times the set operate value.
The transient reach than shall be less than 10 % at fully developed direct current component with 60 ms time constant of the short-circuit current.

4.2.3 Earth fault protection

The earth fault protection shall trip its own circuit-breaker and start auto-reclosing if stated in TS.

The earth fault protection shall measure the zero sequence current (3I0) on the line. . The 3I0 must be from the total coupling of the three phase current transformers. Total coupling shall be carried out outside of the protection. The protection shall be thermally dimensioned so that functionality is not affected by a double earth fault.

4.2.3.1 Directed fundamental measuring earth fault protection

The function of the protection shall be based on the fundamental component of the zero sequence current. The directed function of the protection uses the zero sequence voltages (3U0) as the directional reference.Voltage shall be taken from a voltage transformer group's open delta coupling of the secondary voltages, calculated values from phase voltages are not accepted.

4.2.3.1.1 Setting options for the directed step:

The directed step of the earth fault protection shall be designed with a current stepping with a time delay. The function of the protection shall be based on the fundamental component of the zero sequence current and zero sequence voltage.
The current setting shall be possible to make within an interval corresponding to a primary current of 1 A–50 A (with current transformer ratio 200/1 this corresponds to 5 mA–250 mA).
The dropout ratio shall be greater than 90 %.
Minimum range for the time setting: At least 0.03 s–10.00 s with a maximum of 0.05 s between adjustable values.
The earth fault protection shall have a directed function according to the principle: $I \cdot \cos(\varphi - \alpha)$ where φ is the appropriate angle between the zero sequence current and zero sequence voltage to the protection. α is the protection's characteristic angle. $\alpha = 0°$ for networks with neutral-point resistance and $\alpha = -90°$ for isolated distribution networks.
Only cos phi-measuring protection is accepted
α shall be adjustable at least between -90° to 0°.
Protection shall detect 5000 ohms up to +/-86 degree earth fault angle. The functional range shall be possible to limit for earth fault angles over +/-86 degrees.

The directed earth fault protection shall be released by a zero sequence voltage that shall be adjustable within an interval corresponding to at least 5–25 % of the zero sequence voltage at a fully developed short-circuit to earth. This is equivalent to, with a typical ratio on the voltage transformer, an interval of approx. 5–30 V with a resolution between adjustable values of maximum 1 V.

4.2.3.2 Undirected earth fault protection

The undirected earth fault protection shall detect double earth faults in the network. The function of the protection shall be based on the fundamental component of the zero sequence current.

4.2.3.2.1 Setting options for the undirected step:

The current setting shall be possible to make within an interval corresponding to a primary current of 0.5–500 A.
The dropout ratio shall be greater than 90 %.
Minimum range for the time setting: At least 0.03–5.00 s with a maximum of 0.05 s between adjustable values.

4.2.3.3 Transient earth fault protection

The transient earth fault protection shall be designed to give correct function for transient and intermittent short-circuiting to earth in the network. This involves:

- Correct directional determination shall be obtained for transient short-circuiting to earth.
- The transient earth fault protection shall be possible to time delay.
- The protection shall dropout when the zero sequence voltage drops below an adjustable level.

4.2.3.4 Setting options and other performance for the transient earth fault protection

The time delay shall be possible to set between 0 s and 10 s with the resolution 0.1 s.
The protection's dropout ratio shall be possible to adjust within an interval corresponding to at least 5–25 % of the zero sequence voltage at a fully developed short-circuit to earth. Resolution shall be better than 1 percentage point.

4.2.4 Neutral displacement voltage protection

The neutral displacement voltage protection shall trip circuit-breakers specified in TS. The neutral displacement protection shall measure voltage from open delta on voltage transformers specified in TS. The backup protection (SNUS) shall measure the voltage from the neutral-point reactor's measurement winding.

4.2.4.1 Setting options for the neutral voltage displacement protection

The voltage setting shall be possible to make within an interval corresponding to
10 – 80 % of the neutral displacement voltage for a fully developed short-circuit to earth.

The voltage transformer ratio shall be selected so that the voltage fed to the protection at a fully developed short-circuit to earth is 110 V.

Minimum range for the voltage setting:

- 10.0 – 80.0 V with a maximum of 0.5 V between adjustable values

Minimum range for the time setting:

- 0.5 – 10.00 s with a maximum of 0.05 s between adjustable values

4.2.5 Auto-reclosing

Reclosing shall close the circuit-breaker. The reclosing function shall be possible to enable and disable from remote or local operation.
Reclosing shall be possible to select from distance protection, earth fault protection, overcurrent protection according to the two alternatives:

- Only after zone1 distance protection, step 1 overcurrent and earth fault protection.
- After up to 1 s delayed function of the line protection (zone/step 1 and 2).

Automatic reclosing shall be possible to activate according to the following two alternatives:

- Start pulse from the line protection's start pulse and release from the line protection's tripping pulse. (recommended)

- Start pulse only from the line protection's tripping pulse.

Reclosing shall not be possible after busbar protection trip or circuit-breaker failure trip.

The automatic reclosing system shall be activated from distance protection, earth fault protection and overcurrent protection in the bay. This means that the automatic reclosing system, belonging to HS1, shall be activated from the line protection in both HS1 and possibly HS2.
If a new fault occurs within a set time, after the completed reclosing cycle, no reclosing shall be performed.

Reclosing shall be blocked when the circuit breaker is open and immediately after the closing operation. Blocking shall be activated up to an adjustable time after the closing operation.

For remaining tripping signal from the line protection, the automatic reclosing system must not emit repeated closing pulses (pumping).

No further reclosing attempts shall be performed for reclosing against remaining faults.

4.2.5.1 Setting options for the automatic reclosing system

Closing pulse shall have an adjustable duration within an interval 50–200 ms with 50 ms increments and shall be dropped off after circuit-breaker closure.
Auto-reclose open time: At least 0–60 s with increments of 0.1 s
Dropout time: 0–30 s with increments of 0.1 s.
Blocking time: 5–30 s with increments of 1 s

4.2.6 Over/Underfrequency protection

The protection shall measure phase to phase voltage. The line bay's frequency protection shall trip the ircuit-breaker.

4.2.6.1 Setting options for the over/underfrequency protection

The over/underfrequency protection shall have at least two time steps each. Parameters for the time step shall be individually adjustable for the frequency and time delay.

- Frequency range 45-55 Hz
- Measurement accuracy max +/-0.03 Hz
- Setting range 45-50-55 Hz in increments of 0.1 Hz
- Operate time 0.15 s (including measuring time and circuit-breaker time)
- Dropout ratio >99.9% of the operate value
- Dropout time Closing <0.07 s
- Measuring voltage range 60-120 % of the rated voltage
- Undervoltage blocking <60% of the rated voltage
- Time delay 0-20 s

4.2.7 Over/Undervoltage protection

The protection shall measure phase to phase voltage. The line bay's voltage protection shall trip the circuit-breaker. Manual opening of the circuit breaker must block the protection from auxiliary contacts from the circuit-breaker.

4.2.7.1 Setting options for the over/undervoltage protection

The overvoltage and undervoltage protection shall have at least two time steps each. Parameters for the time step shall be individually adjustable for the voltage and time delay.

- Setting range 70 - 125 % of Un
- Operate time <0.10 s
- Time delay 0.3-10 sec with a resolution of 50 ms
- Zero voltage range 20 – 80 % of Un
- Dropout ratio 99.5 and 100.5 % respectively
- Accuracy in operating values 1 %
- Rated voltage 110 V AC

4.2.8 Parallel protection (HS2)

See "Specification Overcurrent protection and Distance protection".

4.2.9 Circuit-breaker failure protection

The circuit-breaker failure protection shall start from the tripping function in the distance protection (parallel protection, HS2) and overcurrent protection (parallel protection, HS2).

The circuit-breaker failure protection shall trip the back-up circuit-breaker.

4.2.9.1 Setting options for the circuit-breaker failure protection

The tripping delay shall have an adjustable duration. The pulse time shall be 0.5 seconds.
Minimum range for the time setting: At least 0.00 – 1.00 s with a maximum of 0.05 s between adjustable values.

4.2.10 Thermal overload protection.

Line protection shall according to TS, be able to have thermal overload protection. This protection function shall continuously estimate the thermal content in the protected bay (line/cable). The protection shall trip its own circuit-breaker or only give an alarm signal.

4.2.10.1 Setting options for the thermal overload protection

- Time constant 0.10-60 min
- Temperature 50-150 %
- Current value 0.10-2A
- Signal level current 0.10-2.0 A
- Operate time constant 0.1-10 min
- Signal level temperature 50-100 %
- Blocking of closing after tripping 1-240 min

4.2.11 Syncrocheck (PSH)

Closing of circuit-breaker (also AR) shall use syncrocheck, if stated in TS.

Syncronising (Frequency difference)
Δ u, Δ f and Δ fi are measured for paralleling. Δ f shall be less than 0.01-0.10 Hz.

Energizing
When energizing, one of the sides of the circuit-breaker is live and the other one is dead. PSH shall measure the absolute values of the two voltages.
The dead bus blocking function is used when power generation is connected to the bay.

Interconnecting dead bus with dead line
Supervision of the measuring voltage.
The measuring voltages shall have fuse failure supervision.

4.2.11.1 Setting options for the PSH PDI automatic system

Function	Syncronising	Energizing
Volt. diff."ΔU" %	0 - 55% Max difference	-------
Angle difference "Δφ" degrees	5 - 90 degrees Max difference	--------
freq. difference Δfmax-Δfmin	--------	--------
Minimum detect-able freq. diff "Δf" Hz	0.01-0.5 Hz	--------
Voltagelevel for live bus/line Umin	-------	> 60 -100%
Voltagelevel for dead bus/ line Umax	-------	<20 - 60%
Operate time	Minimum measuring time + "t"	0 - 20 sec
Closing pulse	50-300 ms	50-300 ms

5 Testing

Unless otherwise specified, testing must conform to the scope and requirements for test results set down in applicable standards.

6 Appendix

Appendix 1 - Inputs TR Relay protection for Line bay 52-72.5kV

Appendix 1 -Inputs TR Relay protection for Line bay 52-72.5kV

Signal	Typ	Distansskydd	Överströmsskydd Ism	Jordströmskydd Jsr	Parallellit Överströmskydd	Brytarfelsskydd	Frekvensskydd	Över/Undespänningsskydd	Termiskt Överlastskydd	Nollpunktsspänningsskydd	Tillkopplingsspänningsspärr	Längsdifferentialskydd	Synkrocheck PSH	Al-Automatik	Anmärkning
Ström L1	AI	x	x		x	x			x			x			
Ström L2	AI	x	x		x	x			x			x			
Ström L3	AI	x	x		x	x			x			x			
Ström N	AI	x		x		x						x			
Spänning L1	AI	x	x		x		x	x							*)
Spänning L2	AI	x	x		x		x	x					x		*)
Spänning L3	AI	x	x		x		x	x							*)
Spänning 3U0	AI	x		x						x					
Spänning L2(annat objekt)	AI												x		
Brytarläge Till	DI	x												x	
Brytarläge Från	DI	x												x	
Start Al	DI	x	x	x	x							x			
Start BFS	DI				x										
Al Till	DI													x	
Al Från	DI													x	

Not
Spänning anges normalt till 110 V sekundärt
Ström anges normalt som 1A, 2 A eller 5 A sekundärt

*) Endast för Produktionsfack

AI = Analog ingång (Input)
DI = Digital ingång (Input)