सत्यमेव जयते

उत्तर क्षेत्रीय विद्युत समिति

NORTHERN REGIONAL POWER COMMITTEE

Protection Philosophy of Northern Region

(Developed in compliance of IEGC 2023)

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Contents

1. Transmission line & Cable

S.N.	Protection Setting/ Protocol	Mandated Setting for transmission lines
1	**Protection Scheme**	**220kV and above:** Independent Main-I and Main-II protection (of different make OR different type/different algorithm) of non-switched numerical type is to be provided with carrier aided scheme. **132kV and below:** One non-switched distance protection scheme and, directional over current and earth fault relays, should be provided as back up.
2	**Distance Protection Zone-1**	Reach: 80% of the protected line; 110% of the protected line (In case of radial lines) TimeSetting: Instantaneous.
3	**Distance Protection Zone-2**	Reach: Single Circuit Line: 120% of length of principle line section. Double circuit line: 150% coverage of line to take care of underreaching due to mutual coupling effect. Time setting: i. 0.35 second *(considering LBB time of 200mSec, CB open time of 60ms, resetting time of 30ms and safety margin of 60ms)* ii. 0.5-0.6 second *(For a long line followed by a short line)*

4	**Distance Protection Zone-3**	Reach: Zone-3 should overreach the remote terminal of the longest adjacent line by an acceptable margin (typically 20% of highest impedance seen) for all fault conditions. Time Setting: 800-1000 msec If zone-3 reach transcends to other voltage level, time may be taken upto 1.5 sec.
5	**Distance Protection Zone- 4**	The Zone-4 reverse reach must adequately cover expected levels of apparent bus bar fault resistance. Time may be coordinated accordingly. Where Bus Bar protection is not available, time setting: 160 msec.
6	**Power Swing Blocking**	Block tripping in all zones, all lines. Out of Step tripping to be applied on all inter-regional tie lines. Deblock time delay = 2s
7	**Protection for broken conductor**	Negative Sequence current to Positive Sequence current ratio more than 0.2 (i.e. I2/I1 ≥ 0.2) Alarm Time delay: 3-20 sec. Tripping may be considered for radial lines to protect single phasing of transformers.
8	**Switch on to fault (SOTF)**	Switch on to fault (SOTF) function to be provided in distance relay to take care of line energization on fault.
9	**VT fuse fail detection function**	VT fuse fail detection function shall be correctly set to block the distance function operation on VT fuse failure.
10	**Carrier Protection**	To be applied on all 220kV and above lines with the only exception of radial feeders.

11	**Back up Protection**	1. On 220kV and above lines with 2 Main Protections: • Back up Earth Fault protections alone to be provided. • No Over current protection to be applied. 2. At 132kV and below lines with only one Main protection: • Back up protection by IDMT O/C and E/F to be applied.
12	**Auto Reclosing with dead time.**	AR shall be enabled for 220 kV and above lines for single pole trip and re-closing. Dead time = 1.0s. Reclaim time = 25.0s Auto-recloser shall be blocked for following: i. faults in cables/composite ii. Breaker Fail Relay iii. Line Reactor Protections iv. O/V Protection v. Received Direct Transfer trip signals vi. Busbar Protection vii. Zone 2/3 of Distance Protection viii. Circuit Breaker Problems. CB Pole discrepancy relay time:1.5 sec; for tiebreaker: 2.5 sec

13	Line Differential	For cables and composite lines, line differential protection with built in distance back up shall be applied as Main-I protection and distance relay as Main-II protection. For very short line (less than 10 km), line differential protection with distance protection as backup (built- in Main relay or standalone) shall be provided mandatorily as Main-I and Main-II. Differential protection may be done using dark fiber (preferably), or using bandwidth.

14	**Over Voltage Protection**	FOR 765kV LINES/CABLE: Low set stage (Stage-I): 106% - 109% (typically 108%) with a time delay of 5 seconds. High set stage (Stage-II): 140% - 150% with a time delay of 100 milliseconds. 400kV LINES/CABLE: Low set stage (Stage-I): 110% - 112% (typically 110%) with a time delay of 5 seconds. High set stage (Stage-II): 140% - 150% with a time delay of 100 milliseconds. FOR 220 KV LINES: High set stage: 140% - 150% with a timedelay of 100 milliseconds. (OPTIONAL) FOR 220 KV CABLE/COMPOSITE: Low set stage (Stage-I): 110% - 112% (typically 110%) with a time delay of 5 seconds. High set stage (Stage-II): 140% - 150% with a time delay of 100 milliseconds. Drop-off to pick-up ratio of overvoltage relay: better than 97% Grading: Voltage as well as time grading may be done for multi circuit lines/cable.
15	**Resistive reach setting to prevent load point encroachment**	Following criteria may be considered for deciding load point encroachment: • Maximum load current (Imax) may be considered as 1.5 times the thermal rating of the line or 1.5 times the associated bay equipment current

		rating (the minimum of the bay equipment individual rating) whichever is lower. (Caution: The rating considered is approximately 15minutes rating of the transmission facility). • Minimum voltage (Vmin) to be considered as 0.85pu (85%).
16	**Direct Inter-trip**	To be sent on operation of following: i. Overvoltage Protection ii. LBB Protection iii. Busbar Protection iv. Reactor Protection v. Manual Trip (400 kV and above) vi. Cable Fault (in composite lines)
17	**Permissive Inter-trip**	To be sent on operation of Distance Protection

2. Series Compensated lines

1	**Lines with Series and other compensations inthe vicinity of Substation**	• Zone-1:FSC end: 60% of the protected line. Time: Instantaneous; Remoted end: 60% of the protected line with 100ms-time delay. POR Communication scheme logic is modified suchthat relay trips instantaneously in Zone-1 on carrierreceive. • Zone-2: 120 % of uncompensated line impedance for single circuit line. For Double circuit line, settings may be decided on basis of dynamic study in view of zero sequence mutual coupling. • Phase locked voltage memory is used to copewith the voltage inversion. Alternatively, an intentional time delay may be applied to overcome directionality problems related to voltage inversion. • over-voltage stage-I setting for series compensated double circuit lines may be kept higher at 113%.

3. Busbar protection

1	**Busbar protection**	To be applied on all 220kV and above sub stations with the only exception of 220kV radial fed bus bars.

4. Local Breaker Back-up

1	**Local Breaker Backup (LBB)**	For 220 kV and above level substations as well as generating stations switchyards, LBB shall be provided for each circuit breaker. LBB Current sensor I > 20% In LBB time delay = 200ms In case of variation in CT ratio, setting may be done accordingly.

5. Power Transformer

5.1 Differential Protection

1	Id min (sensitivity) i.e. multiple of trans. HV side rated current	Default: 0.2 pu Or If tap range is -X% to +Y%, then (X+Y)% may be kept as setting.
2	First Slope	0 - 10%. In case of differential relay with only two slopes, this slope is considered as zero.
3	Second Slope	20% to 40%
4	Third Slope	60% to 80%
5	Unrestrained operation level	Unrestrained differential current ≤ 1/(% impedance at nominal tap)
6	Max. ratio of 2nd harm. to fundamental harm dif. curr. in %	I2/I1Ratio = 10 - 15%
7	Max. ratio of 5th harm. to fundamental harm dif. curr. in %	I5/I1Ratio = 25%
8	Second and fifth harmonics restrain feature	Enabled
9	Cross block feature	Enabled

5.2 Restricted earth fault (REF) protection

1	Pick up current (IREF)	10 – 15 % of Full load current (IFL).
2	Stabilizing resistor (RSTAB)	stabilizing resistor (RSTAB) is obtained by dividing stabilizing voltage (VSTAB) by pick-up current. Stabilizing voltage VSTAB = IF x (RCT + 2RL) RSTAB = (VSTAB / IREF)*k Where: IF = Maximum through fault current, RCT = CT resistance, RL = CT circuit lead resistance, k = Multiplying factor (1-1.5)

5.3 Over Current Protection

1	Scheme	To be implemented on both sides of ICT
2	Low set Directional	Pick up: 110-150% of full load currentCharacteristics: IDMT Co-ordination: to be coordinated with distance relay zone 3 settings of outgoing feeders.
3	High Set Non-Directional	Pick Up: 100-110% of the through fault level of the transformer Characteristics: DT; 0 to 50 msec For IV side of 220 kV transformer only Pick Up: 70-100% of the through fault level of the transformer Characteristics: DT; 100 to 150 msec

5.4 Earth Fault Protection

1	Scheme	To be implemented on both sides of ICT
2	Low set Directional	Pickup: 20-80% of rated full load current Characteristics: IDMT Co-ordination: to be coordinated with earth fault relay setting of outgoing feeders.
3	High Set Non-Directional	Pick Up: 100-110% of the through fault level of the transformer Characteristics: DT; 0 to 50 msec For IV side of 220 kV transformer only Pick Up: 70-100% of the through fault level of the transformer Characteristics: DT; 100 to 150 msec

5.5 Overexcitation protection:

In case of non-availability capability curve by OEM, Shall be provided on both HV and LV sides as below:

U/F %	Time set (s)
110	9000
118	90
126	49.5
134	18
142	4
150	1

***Over excitation setting curve should be as per capability curve provided by OEM. The setting should be well below capability curve and continuous operating limit. However, it must be ensured that Over excitation setting provided by OEM are not be over-sensitive.

6. Shunt Reactor protection

6.1 Differential Protection

1	Id min (sensitivity)	Default: 0.2 pu
2	First Slope	0 - 10%. In case of differential relay with only two slopes, this slope is considered as zero.
3	Second Slope	20% to 40%
4	Third Slope	60% to 80%
5	Unrestrained operation level	2 pu
6	Max. ratio of 2nd harm. to fundamental harm dif. curr. in %	I2/I1Ratio = 15%
7	Max. ratio of 5th harm. to fundamental harm dif. curr. in %	I5/I1Ratio = 25%
8	Second and fifth harmonics restrain feature	Enabled
9	Cross block feature	Enabled

6.2 Impedance/ Zone protection

1	Setting	60% of reactor impedance
2	Time setting	1.2 sec

6.3 Phase overcurrent

1	DT	setting of 6-10 times rated current with a time delay of 0.1s

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