North East Regional Power Committee

PROTECTION PROTOCOL OF NORTH EAST REGION

Prepared in Compliance to

Clause 12(2) and Clause 13 of Central Electricity Regulatory Commission Indian Electricity Grid Code Regulations, 2023

By

NERPC Secretariat

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Contents

PROTECTION PROTOCOL OF NORTH EAST REGION

1. Background

1.1. The Protection Protocol of North East region is prepared in accordance with Clauses 12(2) & 13 of the Indian Electricity Grid Code, 2023 (IEGC 2023) notified by the Central Electricity Regulatory Commission.

1.1.1. The clause 12(2) of the IEGC 2023:

"There shall be a uniform protection protocol for the users of the grid:

a) for proper co-ordination of protection system in order to protect the equipment/system from abnormal operating conditions, isolate the faulty equipment and avoid unintended operation of protection system;

b) to have a repository of protection system, settings and events at regional level;

c) specifying timelines for submission of data;

d) to ensure healthiness of recording equipment including triggering criteria and time synchronization; and

e) to provide for periodic audit of protection system."

1.1.2. The clause 13 of the IEGC 2023:

"13. Protection protocol

(1) All users connected to the integrated grid shall provide and maintain effective protection system having reliability, selectivity, speed and sensitivity to isolate faulty section and protect element(s) as per the CEA Technical Standards for Construction, the CEA Technical Standards for Connectivity, the CEA (Grid Standards) Regulations, 2010, the CEA Technical Standards for Communication and any other applicable CEA Standards specified from time to time.

(2) Back-up protection system shall be provided to protect an element in the event of failure of the primary protection system.

(3) RPC shall develop the protection protocol and revise the same, after review from time to time, in consultation with the stakeholders in the concerned region, and in doing so shall be guided by the principle that minimum electrical protection functions for equipment connected with the grid shall be provided as per the

CEA Technical Standards for Construction, the CEA Technical Standards for Connectivity, the CEA Technical Standards for Communication, the CEA (Grid Standards) Regulations, 2010, the CEA (Measures relating to Safety and Electric Supply) Regulations, 2010, and any other CEA standards specified from time to time.

(4) The protection protocol in a particular system may vary depending upon operational experience. Changes in protection protocol, as and when required, shall be carried out after deliberation and approval of the concerned RPC.

(5) Violation of the protection protocol of the region shall be brought to the notice of concerned RPC by the concerned RLDC or SLDC, as the case may be."

1.2. The Protection Protocol of North Eastern Region stipulates General Protection Philosophy of Protection System, Protection Schemes for Generators & various Transmission Elements in Power System, Protection Settings & their Coordination among entities, Disturbance Monitoring, Analysis and Reporting, Time Synchronization of Protection Systems, Protection Audit Plan, Performance of Protection Systems & Compliance Monitoring.

2. Applicability

The Protection Protocol of North Eastern Region shall be applicable to all North Eastern Regional entities, State/Central/Private Generating Companies/ Generating Stations including REGs, RHGS, integrated RE with Pumped Storage Plant (PSP), SLDCs, NERLDC, CTU, STUs, Transmission Licensees and NERPC.

3. Definitions

Words and expressions used in this Protection Protocol are defined in the Act or any other regulations specified by the Central Commission or Central Electricity Authority shall, unless the context otherwise requires, have the meanings assigned to them under the Act or other regulations specified by the Central Commission, as the case may be.

4. General Philosophy of Protection System

4.1. Protection philosophy shall be in accordance with below mentioned objectives, design criteria and other details. However, protection design in a particular system may vary depending upon judgment and experience in the broad contours of the protection philosophy. Consideration must also be given to the type of equipment to be protected as well as the importance of this equipment to the system. Further, protection must not be defeated by the failure of a single component.

4.1.1. **Objectives**:

The basic objectives of any protection schemes should be to:

(i) Automatically isolate the faulty element.

(ii) Mitigate the effect of short circuit and other abnormal conditions in minimum possible time and area.

(iii) Indicate the location and type of fault and

(iv) Provide effective tools to analyse the fault and decide remedial measures.

4.1.2. Design Criteria:

To accomplish the above objectives, the four design criteria for protection that should be considered are:

(i) fault clearance time/speed;
(ii) selectivity;
(iii) sensitivity and
(iv) reliability (dependability and security)

4.1.2.1. **Fault clearance time/speed**: In order to minimize the effect on customers and maintain system stability, Fault clearance time shall be as per CEA Grid Standard Regulations 2010, as amended to date.

4.1.2.2. **Selectivity:** To ensure Selectivity, coordination shall be ensured with the adjacent protection schemes including breaker failure, transformer downstream relays, generator protection and station auxiliary protection.

4.1.2.3. **Sensitivity**: To ensure Sensitivity, the settings must be investigated to determine that they will perform correctly for the minimum fault current envisaged in the system, yet remain stable during transients and power swings from which the system can recover.

4.1.2.4. **Reliability**: To ensure Reliability, two independent auxiliary direct current-supplies shall be provided for Main-I and Main-II relays. The Main-I and Main-II relays should be from two different makes or operating with different algorithm. The CB´s shall have two independent trip coils and two independent trip circuits. Each protection device should trip at least one of them by independent auxiliary DC- supplies.

4.1.2.5. **Security**: To ensure Security, the protection shouldn't limit the maximum transmission capacity of the element. Distance protection in particular could

cause spurious tripping due to specific grid conditions, in case of high load operation. Therefore, any special topologies must be known and considered for protection parameterization. For parallel Over Head Lines it is necessary to consider the rapid increase of load current in the healthy line when the faulty line trips and the protection operation must allow such conditions The load encroachment detection function of the relays must be used, when the highest distance zone resistance reach conflicts with the maximum transmitted load on the protected element.

4.2. All generating units shall have standard protection system to protect the units not only from faults within the units and within the Station but also from faults in sub-stations and transmission lines.

4.3. The generator, generator transformer, unit auxiliary transformer shall be provided with protection systems connected to two independent channels or groups, such that one channel or group shall always be available for any type of fault in the generator and these transformers;

4.4. Protection relays shall be configured in such a way that digital input points shall not pick up due to stray voltages.

4.5. Protective relays shall be used to detect electrical faults, to activate the alarms and disconnect or shut down the faulted apparatus to provide for safety of personnel, equipment and system.

4.6. Electrical faults shall be detected by the protective relays arranged in overlapping zones of protection.

4.7. The protection relays for the generators, motors, transformers and the transmission lines shall generally be of numerical type.

4.8. The protection system for 400kV and higher voltage transmission line and the line compensating equipment shall have one hundred percent back up communication channels i.e. two channels for tele- protection in addition to one channel for speech plus data for each direction. Provided that, for 220 kV, 132 kV, 110 kV and 66 kV lines, the channel for speech plus data can also be used for tele-protection

4.9. All relays used shall be suitable for operation with CTs secondary rated for one ampere or five amperes as per relevant Indian Standards or International Electrotechnical Commission or Institute of Electrical and Electronics Engineers standards.

4.10. Relevant Indian Standards or International Electrotechnical Commission or Institute of Electrical and Electronics Engineers standards shall be applied for protection of generators, transformers and motors.

5. Protection Schemes

The electrical protection functions for equipment connected with the grid shall be provided as per the Central Electricity Authority (Technical Standards for Construction of Electrical Plants and Electric Lines) Regulations 2022 amended to date, the CEA (Technical Standards for connectivity to the Grid) Regulations 2007 amended to date, the CEA

(Technical Standards for Communication System in Power System Operation) Regulations 2020 amended to date, the CEA (Grid Standards) Regulations 2010 amended to date, the CEA (Measures relating to Safety and Electric Supply) Regulations 2023 amended to date, and any other CEA standards specified from time to time.

5.1. Thermal Generating Units

The electrical protection functions for generator, generator transformer, unit auxiliary transformer and station transformer shall be provided in accordance with but not limited to the list given in **SCHEDULE-I** of CEA (Technical Standards for Construction of Electrical Plants and Electric Lines) Regulations 2022 amended to date.

For the generating units with a rating of more than one hundred megawatt, protection system shall be configured into two independent sets of protection (Group A and B) acting on two independent sets of trip coil fed from independent

DC supplies, using separate sets of instrument transformers, and segregated cables of current transformers and voltage transformers

5.2. Hydro Generating Units

The protection functions for Generator, Excitation Transformer, Generator Transformer, Generator and Generator Transformer, Unit Auxiliary Transformer, and Station Auxiliary Transformer shall be provided in accordance with but not limited to the list given in SCHEDULE-IV of CEA (Technical Standards for Construction of Electrical Plants and Electric Lines) Regulations 2022 amended to date except for variable speed units which will have specializedprotection functions.

5.3. REGs/RHGS/BESS

Protection Schemes for Renewable Energy (RE) Power Plants of Solar power generation, Wind power generation, Battery Energy Storage System (BESS) and Hybrid of these connected with grid at voltage level above 650 volts shall be in accordance with the Central Electricity Authority (Technical Standards for Construction of Renewable Energy Power Plants) Regulations, 2023 from the date as & when these regulations are notified (Presently the finalization of these Standards by CEA is under progress).

5.4. Substations & Transmission System Elements

5.4.1. All major protection relays for the Voltage levels 66 kV and above shall be of numerical type.

5.4.2. Grouping of Protection systems for the voltage level 66 kV and above:

i. The protection circuits and relays shall be electrically and physically segregated into two groups each being independent and capable of providing uninterrupted protection even in the event of one of the protection group fails or taken out for maintenance.

ii. Interconnection between these two groups shall not generally be attempted.

However, such interconnection shall be kept to the bare minimum, if found absolutely necessary.

5.4.3. The protections required in respect of transmission lines, transformers, reactors and bus bars but not limited to shall be in accordance with **SCHEDULE-V** of CEA (Technical Standards for Construction of Electrical Plants and Electric Lines) Regulations 2022 amended to date.

5.4.4. Bus Bar Protection and Local Breaker Backup Protection (breaker failure protection):

i) Bus bar protection and local breaker backup protection shall be provided in 220 kV and higher voltage interconnecting sub- stations as well as in all generating station switchyards.

ii) Duplication of bus bar protection shall be done for all main buses of 400kV and above voltage class.

iii) The bus bar protection scheme shall be centralized or distributed type and have provision for planned future expansion.

5.5. HVDC Terminals/ Stations

5.5.1. Classical HVDC Terminals/ Stations

i) HVDC system protection shall consist of two parts:

(A) AC side protection:

AC side protection function shall cover the zone for converter transformer, AC filters, shunt capacitors, shunt reactors, and bus bars. These protections shall generally follow the same philosophy as in a typical substation i.e. detection of fault by relay and tripping of circuit breaker.

(B) DC side protection:

DC side protection shall cover the zones consisting of the valve hall, DC switchyard including smoothing reactor and DC filters, DC line, DMR line / electrode line and ground electrode. The protection equipment shall be designed to be fail safe and shall ensure high security to avoid mal-operation/ unwanted shutdown due to protection equipment failures.

ii) Following a DC Line fault, the HVDC System shall have the facility to restart, one or more times, the faulted pole at a variable pre-selected DC voltage level(s), not below 80% of the nominal voltage rating. The DC transmission system shall be capable of recovery in a controlled and stable manner without commutation failures during recovery following ac and dc system faults. The post fault power order shall be equal to the pre-fault power order unless AC/ DC systems dictate otherwise.

iii) Protection system required in respect of Classical HVDC Terminals/ Stations but not limited to shall be in accordance with 13 (b) of Part A of **SCHEDULE-VI** of CEA (Technical Standards for Construction of Electrical Plants and Electric Lines)

Regulations 2022 amended to date.

iv) Software based controls and protection shall be used to permit flexibility in effecting modifications. Protection and controls shall be duplicated for reliability. The control & protection shall provide fast controllability of the HVDC system.

5.5.2. Voltage Source Converter (VSC) based HVDC Terminals/Stations

i) The protection equipment shall be designed to be fail-safe and shall ensure high security to avoid mal-operation/ unwanted shutdown due to protection equipment failures.

ii) Protection system required in respect of Voltage Source Converter (VSC) based HVDC Terminals/ Stations but not limited to shall be in accordance with 8 (b) of Part B of **SCHEDULE-VI** of CEA (Technical Standards for Construction of Electrical Plants and Electric Lines) Regulations 2022 amended to date.

iii) Software based controls and protection shall be used to permit flexibility in effecting modifications. Protection and controls shall be duplicated for reliability. Protection shall be provided by numerical relays to suit the requirement of the HVDC system.

5.6. Philosophy of Transmission Line Protection

5.6.1. Transmission circuit construction can be considered in three main categories viz.: Overhead construction, Underground cable construction and Composite (overhead plus underground) construction.

5.6.2. Transmission circuit Main protection is required to provide primary protection for the line and clear all type of faults on it within shortest possible time with reliability, selectivity and sensitivity. Transmission circuit back-up protection shall cater for failure of any main protection system to clear any fault that it is expected to clear. A protection function that offers back-up for most faults may also provide main protection for some fault conditions. Combinations of main and back-up protection systems should be used to address the main and application specific requirements for transmission circuits.

5.6.3. Protection system of Transmission line shall have following features:

i) The systems applied must be capable of detecting all types of faults, including maximum expected arc resistance that may occur at any location on the protected line.

ii) The protection should be set not to trip under system transient conditions, which are not short circuits. Conversely where the short circuit current is low due to local grid conditions (weak network) or due to high resistance of the arc, this must be taken into consideration to trip the relay by using the most appropriate criterion, without jeopardizing the unwanted tripping during heavy load conditions.

iii) The design and settings of the transmission line protection systems must be such that, with high probability, operation will not occur for faults

external to the line or under non-fault conditions.

iv) Distance relay shall be capable to protect the series compensated lines from voltage inversion, current inversion phenomenon. Special measures must be taken to guard against these phenomenon

v) On 220kV and above transmission lines, 2 Main Protections (Main I and Main II), Inverse Definite Minimum Time (IDMT) directional back up Earth Fault protections alone to be provided. No back up over current protection to be applied.

vi) The Main-I and Main-II protection shall be numerical relays of different makes or employ different fault detection algorithm. They should be provided carrier aided tripping and powered by two separate DC sources

vii) Both Main-Main-II and I shall send initiation signal to Breaker Failure Relay (BFR) /LBB protection system.

viii) Internal DEF (Directional earth fault) function shall be set to trip the line in case of high resistive earth fault.

ix) The internal overvoltage function shall be used to protect the line against over voltages. Two stage over voltage protection for the transmission lines (Stage-I as Voltage and Time graded & Stage-II @ 140% of Nominal Voltage with time delay 100 ms) shall be implemented for the transmission lines of voltage levels 400kV and above only. The lines emanating from same substation shall be provided with pick-up as well as time grading to avoid concurrent trippings. The overvoltage relay shall have better than 98% drop-off to pick-up ratio (the ratio of the limiting values of the characteristic quantity at which the relay resets and operates). For over voltage detection, though Ph-to-N voltage is preferable to Ph-to-Ph voltage, to achieve required discrimination for OVR grading because of limitation imposed by voltage resolution of the relay, Ph-to-Ph voltage to be used for Over Voltage detection.

x) On 132kV and lower voltage transmission lines, only one Main protection and Back up protection by Inverse definite Minimum time (IDMT) directional O/C and E/F to be applied. Main protection should be suitable for single or three phase tripping. Additionally, auto-reclose relay suitable for 1 ph or 3 ph (with dead line charging and synchro-check facility) reclosure shall be provided.

xi) For very short lines less than (10) ten kilometers (any voltage level 132kV and above), cables, and combination of cable and overhead line, Differential protection (segregated phase type) has to be provided as Primary protection with distance protection as back up protection (built-in Main relay or standalone). Zone-I protection feature shall get automatically enabled in case of communication failure observed by the differential relay for built in Main and in case of LDP relay

failure/communication failure for stand alone The current differential protection should a reliable type (preferably digital). The protection should be of the segregate phase type, i.e. it should be able to detect the phase in fault and therefore for the case of single line-ground (SLG) faults to trip only the phase in fault (also to establish single phase A/R). The synchronization of the measured values is done via a communication system. The communication system for differential line protection should be based on fibre optic and any equipment should comply with the IEC 60834.

5.6.4. 33kV outgoing feeder setting philosophy

Note: Trend analysis (observation of events over a period) should also be incorporated during calculation of time gradient settings with Distribution Substations at Grid Substation end.

1. The protection functions to be activated are:

   a. Non-directional Overcurrent Protection (IDMT Normal Inverse Curve)

   b. Non-directional Earth fault Protection (IDMT Normal Inverse Curve)

   c. Non-directional Definite Time Overcurrent and Earthfault Protection

   d. Under/Over-frequency, df/dt, Under/Over voltage should only be enabled if there is any case special case of system requirement

2. The TMS for overcurrent and earthfault may be kept at 0.1 (fixed). The downstream DISCOM Substations should maintain a time gradient with respect to observed average fault current and TMS kept at Grid Sub-station end.

3. If long network of LILO DSS (Distribution SS) are present, extreme inverse, very inverse curve may be followed at DSS end.

4. The Highset for OC and EF at Grid SS (GSS) side should be kept at 50ms. The Distribution SS (DSS) should keep their Highset at instantaneous. This would allow a time gradient of 50ms in case of Highset pickups at both GSS and DSS ends. The Highset delay at GSS may be increased only in case when Highset overlapping is observed in the feeders. (This may arise when the CB opening time and arc extinguishing time at DSS end is increased due to wear and tear)

5. The Highset may be kept between 3A to 5A (As per trend analysis).

6. Harmonic Restraint feature is to be enabled.

7. The pickup of overcurrent should be kept at least 1.1 times the CT ratio. Basically, 400/1A ratio is adopted at 33kV Level outgoing feeders. (The maximum demand being 20MW). The OC pickup should be kept at 440A

8. The pickup for earth fault protection is normally kept at 80A (20% of CT ratio). However, the special case may be taken into account:

If a 33kV Feeder is kept at less load most of the times (say, 2MW). The maximum load current in the line will be 40A (Approx.) In case of open circuit fault (no earth path), the feeder will not trip, as the zero-sequence current read by the relay will be 40A and the pickup of earth fault is kept at 80A. Such cases may be hazardous in case the line travels through city area. In that case, the earthfault pickup should be kept at a lower value (say 35 to 40A). Open circuit fault in such cases, will lead the relay to issue a trip on earth fault IDMT.

The Time gradient between 33kV Feeder at GSS end and Transformer LV side should generally be maintained at 300ms. The time gradient may be kept lower in order to save the transformer and it will be decided on case-to-case basis

5.6.5. Philosophy for protection settings:

Sl. No.	Protection setting		Reach and time
1.	Distance protection	Zone 1(Forward)	80% of the protected line, instantaneous. 60% if the line is series compensated If FSC present at remote end then time delay should be 100msec otherwise no time delay
		Zone 2(Forward)	120% of the protected SC line (150% in case of D/C line). Time delay: 350msec (generally) and 500msec in case 20% of the protected line is greater than 60% of the shortest line at remote end
		Zone 3(Forward)	Reach - 120% of (the protected line + of the longest line at remote bus). Timedelay: 800msec (132kV and 220kV) 1 sec for 400kV and 765kV
		Zone 4 (Reverse)	• For lines < 100 km 20% of the protected line or 50% of adjacent shortest line, whichever is larger • For lines > 100 km 10% of the protected line or 50% of adjacent shortest line, whichever is larger Time delay: 500mesc
2.	Line differential protection		Primary protection for lines less than 10KM. Time delay: instantaneous
3.	LBB protection and Bus Bar Protection (for 220kV and above as well as all Generating stations)		Two stage: Stage-I: (Re-Trip) time delay of 100 msec to trip own CB Stage-II: LBB time delay: 200msec to trip all CBs connected to the respective bus, LBB Current sensor I >20% In (for CT ratio < 1000A) I>10% for CT ratio >1000A Bus bar protection time delay: instantaneous
4.	O/C back up protection (for 132kVand below)	IDMT	For I>1 Ib = 150% of current rating of the line. Time delay: to be coordinated with Z2 for three phase fault at remote bus (500msec). Forward directional Proviso- For networks involving load radial feeders, fault currents may not be sufficiently high and following the above rule may not be practically feasible. So,

			in such cases constituents may adopt settings as required with the prior approval of RPC **<u>For I> 2 (and above)</u>** **Generally disabled unless decided otherwise by NERPC for special scenario**
5.	**E/F backup protection(for 132kV and above lines)**	**IDMT**	**<u>For In>1</u>** **Ib= 20 % of current rating of the line. Time delay: to be coordinated with Z3 for single phase to ground fault at remote bus (900msec). Forward directional** **<u>For In>2 (and above)</u>** **Generally disabled unless decided otherwise by NERPC for special scenario**
6.	**Broken conductor protection (alarm only)**		**Negative Sequence current to Positive Sequence current ratio more than 0.2(I2/I1 ≥ 0.2)** **Only for alarm: Time delay = 3-5 sec**
6.	**Allowable Load impedance encroachment**		**Imax = 150% of current rating of line or 150% of terminal equipment rating whichever is lower** **Vmin = 0.85pu (85%)** **30 degrees for load blinder**
7.	**Power swing Blocking function**		**Block all zones except Zone-1 or** **Block all zones and trip with OOS function**
8	**Carrier Aided Protection**		**To be provided on 132kV and above lines (PLCC or DTPC)**
9.	**Single/Three phase auto reclosure**		**To be provided on 132kV and above lines on Zone 1 and Zone 2 with carrier aided protection or differential relay operation** **Dead time =** **For 220kV and 400kV : 1.0s for Main CB, 2 sec for Tie CB.** **For 132kV : 1.5 sec to 2.5 sec on case to case basis** **Reclaim time = 25.0s**
10.	**Over voltage protection (two stage, for 400kV and above only)**	**Stg I***	**V>110%. Time delay: 5 seconds**
		Stg II	**V>140%. Time delay: 100msec**
11.	**Carrier Aided Protection**		**Mandatory for Distance protection**
12.	**Antitheft Charging of line**		**Distance setting: Time delay for Z-1/2/3 should be made instantaneous which will help to trip immediately during fault and would not disturbed the remote end setting of other lines connected from the substation.** **Dir EF: Pickup to be 20 % of rated current and TMS as minimum as possible.**

		O/V setting: Stage-1 pickup should be minimum of that of all lines connected from the charging substation with minimum time delay and grading as possible.
13.	**Switch on to fault (SOTF)**	**SOTF function to be provided in distance relay to take care of line energization on fault**
14.	**VT fuse fail detection function**	**VT fuse fail detection function shall be correctly set to block the distance function operation on VT fuse failure**
15.	**Direct inter-trip**	**To be sent on operation of the following:** **Overvoltage protection** **Reactor protection** **DEF** **LBB** **Busbar protection** **Manual Trip**

*** The OVR grading, Voltage and Time graded, for the Stage-I over voltage protection shall be as recommended by NERPC/NERLDC**

6. Protection Settings & Coordination

The purpose is to ensure system protection is coordinated among the grid connected entities. The Protection systems coordination comprises the following:

i) Each Transmission licensee shall coordinate its Protection System schemes with concerned transmission system, sub-transmission system and generators.

ii) Each Generating Company shall coordinate its Protection System schemes with concerned transmission system and station auxiliaries.

iii) Utilities may seek assistance of NERPC and NERLDC also for ensuring coordination

iv) Each Transmission Licensee and Generation Company shall be responsible for settings calculations for protection of elements under its ownership. It shall be the responsibility of the respective asset owner to obtain the inputs (adjacent line settings, infeed values etc.) from STU/Generating Company/ Transmission Licensee necessary for calculation of the settings.

v) STU/Generating Company/Transmission Licensee shall provide the infeed values/latest network model to the requesting entity, within one week of receipt of such a request from the entity.

vi) Each user, for voltage levels 132kV and above, shall submit the protection settings as per the format prescribed, along with the calculation sheets, co-ordination study reports and input data, in advance, to NERPC/NERLDC for every new/modified element to be commissioned. The mentioned information shall be submitted to the NERPC/NERLDC **fifteen** days in advance for all the elements proposed to be commissioned. The user has to obtain relay setting **approval by NERPC** before FTC can be provided.

vii) FTC will only be issued after complete relay setting coordination is ensured by the applicant. It is the responsibility of the utility, which is applying for the FTC of any element, to coordinate with concerned utilities to ensure that they complete the relay coordination before applying for FTC

viii) The PCCM of NERPC shall review the settings to ensure that they are properly coordinated with adjacent system and comply with the existing guidelines. The forum may issue proper directions to utilities in this regard.

ix) All users connected to the grid shall obtain approval of the NERPC for any revision in settings, and implementation of new protection system

x) All users connected to the grid shall ensure correct and appropriate settings of protection as specified by the NERPC and intimate to the NERPC about the changes implemented in protection system or protection settings within a fortnight of such changes

xi) In case of failure of a protective relay or equipment failure, the Generating Company and Transmission Licensee shall inform appropriate LDC/NERLDC/NERPC. The

Generating Company and Transmission Licensee shall take corrective action as soon as possible.

xii) NERPC in consultation with the NERLDC & Regional entities shall undertake review of the protection settings, assess the requirement of revisions in protection settings and revise protection settings, from time to time and at least once in a year. The necessary studies in this regard shall be carried out by the NERPC & NERLDC. The modifications/changes, if any, in protection settings shall be advised to the respective users and STUs.

xiii) NERPC shall maintain a centralized database and update the same on periodic basis in respect of their respective region containing details of relay settings for grid elements connected to 132 kV and above. NERLDC also shall maintain such database.

xiv) Respective entities are responsible for ensuring to make available the implemented protection settings in the centralized database before obtaining FTC.

xv) If System Protection Schemes (SPS) is recommended to be implemented by the appropriate forum/Sub-Committee of NERPC on account of operational & system constraints, the same shall be implemented by the concerned Transmission licensee/ Generating Company/Entities within the specified timelines.

7. Disturbance Monitoring, Analysis and Reporting

The Purpose is to ensure that adequate disturbance data is available to facilitate Grid event analysis. The analysis of power system disturbances is an important function that monitors the performance of protection system, which can provide information related to correct behaviour of the system, adoption of safe operating limits, isolation of incipient faults,

7.1. The Disturbance Monitoring Requirements include the following:

i) Each Transmission Licensee and Generating Company shall provide Sequence of Event (SOE) recording capability by installing Sequence of Event recorders or as part of another device, such as a Supervisory Control and Data Acquisition (SCADA) Remote Terminal Unit (RTU), a generator plants Digital (or Distributed) Control System (DCS) or part of Fault recording equipment. This capability shall be provided at all substations and at locations to record all the events in accordance with CEA Grid Standard Regulations, 2010 amended to date.

ii) Each line shall be provided with facility for distance to fault locator.

iii) Each Transmission Licensee/Generating Company/Users shall provide Disturbance recording capability for the following Elements at facilities:

- All transmission lines (Each line shall be provided with facility for distance to fault locator)
- Autotransformers or phase-shifters connected to busses.
- Shunt capacitors, shunt reactors.
- Individual generator line interconnections.
- Dynamic VAR Devices.
- HVDC terminals.
- Bus Bars

iv) The Disturbance recording feature shall be enabled and configured in all the numerical relays installed. Disturbance recording system shall have minimum recording time of 3 seconds (0.5 seconds for pre-fault and 2.5 seconds for post fault).

v) Each Transmission Licensee and Generating Company shall record for Faults, sufficient electrical quantities for each monitored Element to determine the following:

- Three phase-to-neutral voltages. (Common bus-side/line side voltages may be used for lines.)
- V sync(for Three phase Auto reclose scheme)Three phase currents and neutral currents.
- Mutual compensation current (in case of double circuit line)
- Polarizing currents and voltages, if used (As applicable).

- Frequency (As applicable).
- Real and reactive power (As applicable).

The Minimum parameters to be monitored in the Fault record shall be specified by the PCC of NERPC.

vi) Each Transmission Licensee and Generating Company shall provide Disturbance recording with the following capabilities:

- The Disturbance recorders shall have time synchronization and a standard format for recording analogue and digital signals (DR labels to be standardized as per the Report of **FOLD Working Group - 3 on DR Parameter Standardization as per 59th PCCM**). The data files shall be capable of being viewed, read, and analyzed with a generic COMTRADE analysis tool as per the latest revision of IEEE Standard C37.111.
- Each Fault record duration and the trigger timing shall be settable and set for a minimum 3 second duration including 0.5 seconds for pre-fault and 2.5 seconds for post fault
- Each Fault recorder shall have sampling frequency of 1 kHz or better.
- Each Fault recorder shall be set to trigger for at least the following:

  Internal protection trip signals, external trigger input and additional triggers may be assigned as necessary.

vii) Each Transmission Licensee and Generating Company shall keep the recording instruments (disturbance recorder and event logger) in proper working condition and shall establish a maintenance and testing program for Disturbance Recorder (DR) that includes

- Maintenance and testing intervals and their basis.
- Summary of maintenance and testing procedures.
- Monthly verification of communication channels used for accessing records remotely (if the entity relies on remote access and the channel is not monitored to a control centre staffed around the clock, 24 hours a day, 7 days a week (24/7)).
- Monthly verification of time synchronization (if the loss of time synchronization is not monitored to a 24/7 control centre).
- Monthly verification of active analog quantities.
- A requirement to return failed units to service within 90 days. If a Disturbance Recorder (DR) will be out of service for greater than 90 days, the Transmission Licensee and Generating Company shall keep a record of efforts aimed at restoring the DR to service.

viii) The time synchronization of the disturbance recorders shall be corroborated with the PMU data or SCADA event loggers by NERLDC. NERLDC shall list out for

Disturbance recorders which are non- compliant for discussion in PCC meetings of NERPC.

ix) Each Transmission Licensee and Generating Company shall submit the data files to the NERLDC conforming to the following format requirements:

- The data files shall be submitted in COMTRADE and PDF format.
- File shall have contained the name of the Relay, name of the Bay, station name, date, time resolved to milliseconds, event point name, status.

The DR archives shall be retained for a period of **three years**.

x) A separate work-station PC, powered through UPS (Uninterrupted Power Supply) shall be identified with access to all the relays for extraction of DR. Auto-Download facility shall be established for automatic extraction of the DR files to a location on the work- station PC.

xi) Time Synchronization Equipment

a) Time Synchronizing Equipment complete with antenna, all cables and processing equipment shall be provided to receive synchronizing pulse through Global Positioning System or Indian Regional Navigation Satellite System Navic compatible for synchronization of event logger, disturbance recorder, Phasor Measurement Units, and Supervisory Control and Data Acquisition System or Substation Automation System.

b) Each substation shall have time synch equipment to synchronize all the numerical relays installed. Before any extension work, the capability of the existing Time-sync equipment shall be reviewed to ensure the synchronization of upcoming numerical relays.

c) The status of healthiness of the time-sync device shall be wired as "Alarm" to SCADA and as an "Event" to Event Logger.

d) The time synch status of all the installed numerical relays and event logger shall be monitored monthly and recorded. The Monthly records for relays not in time-sync shall be reported to NERLDC and NERPC. This record shall be archived for a period of three years by each concerned agency.

e) Remedial action shall be taken by the concerned substation/ Protection department immediately to make the relays in time synchronization with reference to external time source.

f) All the new Grid elements/Bay extension shall have accurate and precise Time synchronization equipment.

7.2. Disturbance Analysis and Reporting

i) Immediately following an event (grid disturbance or grid incidence as defined in the CEA Grid Standards) in the system, the concerned user or SLDC shall inform NERLDC through voice message.

ii) Written flash report shall be submitted to NERLDC and appropriate SLDC by the concerned Transmission Licensee/Generating Company/User within eight (8) hours from Grid event.

iii) Disturbance Recorder (DR), station Event Logger (EL), Data Acquisition System (DAS) shall be submitted by the respective Transmission licensee and Generating Company within twenty-four (24) hours from Grid event. These records shall be uploaded by the respective Transmission licensee and Generating Company in the Web Based Tripping Portal of NERLDC.

iv) NERLDC shall classify the grid incidents and grid disturbances according to CEA (Grid Standards) Regulations, amended to date. NERLDC shall report the event (grid disturbance or grid incidence) to CEA, NERPC and all regional entities within twenty-four (24) hours of receipt of the flash report.

v) After a complete analysis of the event, the Transmission licensee and Generating Company/User shall submit a detailed report in the case of grid disturbance or grid incidence within one (1) week of the occurrence of event to NERLDC and NERPC.

vi) NERLDC shall prepare a draft report of each grid disturbance or grid incidence including simulation results and analysis which shall be discussed and finalized in the PCC meetings of NERPC as per the timeline specified in Table below.

Sl. No	Grid Event (GD/GI Classification as per the CEA Grid Standards)	Flash report submission deadline (Users/ SLDC)	Disturbance record and station event log submission deadline by Users/ SLDC)	Detailed report and data submission deadline by Users/ SLDC)	Draft report submission deadline by NERLDC	Discussion in PCC and final report submission deadline by NERPC
1	GI-1/GI-2	8 hours	24 hours	+7 days	+7 days	+60 days
2	Near miss event	8 hours	24 hours	+7 days	+7 days	+60 days
3	GD-1	8 hours	24 hours	+7 days	+7 days	+60 days
4	GD-2/GD-3	8 hours	24 hours	+7 days	+21 days	+60 days
5	GD-4/GD-5	8 hours	24 hours	+7 days	+30 days	+60 days

vii) The analysis reports submitted by NERLDC shall be discussed in the Protection Coordination Sub-Committee (PCC) meetings of the NERPC. The PCC shall identify the lessons learnt during the events being discussed. The PCC shall scrutinize the correctness of operation of subject protection systems put in place by the concerned Constituents and the final analysis repot along with the recommendations shall be concluded. It shall also recommend the appropriate remedial measures for system improvement.

viii) The implementation of the recommendations of the final report shall be monitored by the PCC of NERPC.

ix) Any additional data such as

- Single line diagram (SLD)
- Protection relay settings,
- HVDC transient fault record,
- Location of fault with distance
- Fault details with type & relay indications
- CT/PT/CVT rating details with location
- Bus-bar arrangement/ Configuration of feeders
- CB positions (OPEN/ CLOSE) at the time of fault
- Isolator & Earth-switch positions (OPEN/CLOSE)
- Voltage, frequency & power flows with direction at the time of fault
- DR&EL records
- switchyard equipment

and any other relevant station data required for carrying out analysis of an event by NERPC, NERLDC and concerned SLDC shall be furnished by the Users including NERLDC and respective SLDC, as the case may be, within forty- eight (48) hours of the request. All Users shall also furnish high-resolution analog data from various instruments including power electronic devices like HVDC, FACTS, renewable generation (inverter level or WTG level) on the request of NERPCs, NLDC, NERLDCs or SLDCs.

x) Triggering of STATCOM, TCSC, HVDC run-back, HVDC power oscillation damping, generating station power system stabilizer and any other controller system during any event in the grid shall be reported to the NERLDC and NERPC if connected to ISTS and to the concerned SLDC if connected to an intra-state system. The transient fault records and event logger data shall be submitted to the NERLDC or concerned SLDC within 24 hours of the occurrence of the incident. Generating stations shall submit 1 second resolution active power and reactive power data recorded during oscillations to NERLDC or concerned SLDC within 24hours of the occurrence of the oscillations.

xi) A monthly report on events of unintended operation or non-operation of the protection system shall be prepared and submitted by each user/owner of important elements in the regional grid, as identified by the appropriate forum of NERPC including those in the State grids that are critical for regional grid operation to NERPC and NERLDC within the first week of the subsequent month.

xii) The detailed analysis reports shall be archived periodically. The archive shall be retained for a period of three years by each concerned agency.

8. Protection Audit Plan

8.1 All Users/Entities connected at 132 kV and above, shall conduct internal audit, as per the prescribed audit checklist, of their protection systems annually, and any shortcomings identified shall be rectified and informed to NERPC. The audit report along with action plan for rectification of deficiencies detected, if any, shall be shared with NERPC.

8.2 All users shall also conduct third party protection audit of each sub-station at 132 kV and above once in five years or earlier as advised by the respective RPC.

8.3 After analysis of any event, PCC of NERPC may identify a list of substations / and generating stations where third-party protection audit is required to be carried out and accordingly advise the respective users to complete third party audit within three months.

8.4 The third-party audit report shall contain all the information as in Annexure-1(Third Party Protection System Checking & Validation Template for a Substation) of CERC (Indian Electricity Grid Code), Regulations 2023). The protection audit reports, along with action plan for rectification of deficiencies detected, if any, shall be submitted to the respective NERPC and NERLDC or respective SLDC, as the case may be, within a month of submission of third-party audit report. The necessary compliance to such protection audit report shall be followed up regularly in the PCC meetings of NERPC.

8.5 Annual audit plan for the next financial year shall be submitted by the users to NERPC by 31st October every year. The users shall adhere to the annual audit plan and report compliance of the same to NERPC.

9. Performance Monitoring of the Protection Systems

9.1. Users/Entities shall submit the following protection performance indices of previous month to NERPC and NERLDC on monthly basis for 132 kV and above by 10th of the subsequent month and the same shall be reviewed in the ensuing PCC meeting of NERPC.

a) The Dependability Index defined as: D=(NC+NF)

Where, NC is the number of correct operations at internal power system faults and

NF is the number of failures to operate at internal power system faults.

b) The Security Index defined as: S=(NC+NU)

Where, NC is the number of correct operations at internal power system faults and

NU is the number of unwanted operations.

c) The Reliability Index defined as: R=(NC+NI)

Where, NC is the number of correct operations at internal power system faults and

NI is the number of incorrect operations and is the sum of NF and NU

9.2. Users/Entities shall furnish the reasons for performance indices less than unity of individual element wise protection system to the NERPC and action plan for corrective measures. The action plan will be followed up regularly in the PCC Meeting of NERPC

10. Compliance Monitoring

10.1. The Protection Protocol of NER shall be reviewed as and when required, in consultation with the stakeholders of the North Eastern Region.

10.2. Violation of the Protection Protocol of the North Eastern Region shall be brought to the notice of NERPC by the NERLDC or concerned SLDC, as the case may be.

10.3. In case any User/Entity fails to comply with the Protection Protocol or fails to undertake remedial action identified by the PCC of NERPC within the specified timelines, the NERPC would approach the Commission with all relevant details for suitable directions.

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SCHEDULE- I

[See sub-regulation (10) of regulation 10]

List of Electrical Protection Functions for Thermal Generating Units

1. Generator

Sl. No.	Protection Function	Remarks
(a)	Generator differential protection (87G)	
(b)	100% stator earth fault protection (64G)	For units of 100 MW and above.
(c)	95% stator earth fault protection (64G1)	For units less than 100 MW.
(d)	Standby stator earth fault protection (64G2)	
(e)	Inter-turn fault protection (87TG)	Applicable where split winding in Stator is provided and if six terminals are available.
(f)	Loss of field protection (40G)	To be duplicated for units of 500 MW and above.
(g)	Negative phase sequence current protection (46G)	
(h)	Low-forward power and Reverse power interlock for steam turbine generator (37/ 32G)	Preferably 3-phase power relays shall be provided. Both the relays shall be duplicated for units of 500 MW and above.
(i)	Rotor earth fault protection - two stages (64F1/F2)	
(j)	Definite time over-voltage protection (59G)	
(k)	Generator under frequency protection (81G)	
(l)	Over-fluxing protection for generator (99G)	To be provided for units of 500 MW and above in duplicate.
(m)	Overload protection for generator (51G)	
(n)	Back- up impedance protection, 3 pole (21G)	
(o)	Overheating (winding and/ or bearing) (49G)	Alarm only.
(p)	Instantaneous and time delayed over current protection on high voltage side of excitation transformer (51)	
(q)	Generator pole slipping protection (98G)	
(r)	Accidental back energisation protection (50GDM)	
(s)	Generator circuit breaker failure protection (50ZGCB)	To be provided for GCB scheme only.

Note: In case digital multifunctional generator protection system is provided, the protection systems for generator shall be duplicated for units of one hundred mega watt and above. Each MGPS shall preferably be provided with individual inputs from CTs and VTs and connected to the independent set of hand-reset trip relays, such that one set is always available in case of testing and mal-operation of the other set. If the MGPS does not include any protection mentioned in the table above, separate discrete protection shall be provided for the same. The MGPS shall preferably have continuous self-monitoring and testing facilities.

2. Generator Transformer

Sl. No.	Protection Function	Remarks
(a)	Overall differential protection (87OA)	
(b)	Generator transformer differential protection (87GT) for single phase bank	
(c)	Restricted earth fault protection for generator transformer (87NGT)	
(d)	Over head line connection differential protection (87L)	For 3 single phase banks, if 87L

		includes HV winding, separate 87NGT is not mandatory.
(e)	Back- up earth fault protection on generator transformer HV neutral (51NGT)	
(f)	Over-fluxing protection for generator transformer (99GT)	To be duplicated for units of 500 MW and above.
(g)	Back- up non-directional over-current protection in all phases on HV side of generator transformer (51GT)	
(h)	Generator transformer oil temperature indicator (OTI) trip (49Q) and winding temperature indicator (WTI) trip (49T)	
(i)	Generator transformer Buchholz (63), Pressure relief valve (PRV)/ other mechanical protections	
(j)	Pole discrepancy protection of generator transformer breaker (162)	To be provided, if single pole breakers are used.
(k)	Breaker failure protection of generator transformer breaker (50Z)	
(l)	Start-up earth fault protection for LV and HV winding of generator transformer and UATs (64T)	To be provided for GCB scheme only.

3. Unit Auxiliary Transformer(s)

Sl. No.	Protection Function
(a)	Differential protection (87UAT)
(b)	LV back-up earth fault protection (51NUAT)
(c)	LV restricted earth fault (87NUAT)
(d)	Back-up over-current protection (51UAT)
(e)	OTI(49Q) and WTI (49T) trip
(f)	Buchholz (63), PRV/ other mechanical protections

4. Station- Transformer(s)

Sl. No.	Protection Function
(a)	Differential current protection (87)
(b)	Restricted earth fault protection for LV winding (87NLV)
(c)	Restricted earth fault protection for HV winding (87NHV)
(d)	Back-up over-current protection on HV side (51)
(e)	Back-up earth-fault protection (51N)
(f)	Over-fluxing protection (99)
(g)	Buchholz protection (63)
(h)	Winding temperature high (49T)
(i)	Oil temperature high (49Q)
(j)	Pressure relief valve trip (PRV)
(k)	Breaker failure protection (50Z)

SCHEDULE-II

[See sub-regulation (3) of regulation 12]

Design Requirements for Ash Handling System

A. Design Requirements for Ash Handling System of Pulverised Fuel Steam Generators

1. The capacity of ash handling systems, as a percentage of maximum ash generated corresponding to firing of worst coal or lignite at boiler maximum continuous rating, shall not be less than the following:

		-	100% standby blowers for intermediate and storage silos;
		-	50% standby for air compressors to be used for transporting ash.
(c)	Ash slurry disposal	-	One pump stream as operating standby and one pump stream as maintenance standby for wet slurry system;
		-	One standby stream for high concentration slurry system.

SCHEDULE-III

[See sub-regulation (7) of regulation 36]

The minimum Load for Continuous Operation for Various Types of Hydraulic Turbines

Sl. No.	Type of turbine	Minimum load for continuous operation (percent)
(a)	Pelton or Kaplan or Bulb	30
(b)	Deriaz	40
(c)	Francis	50
(d)	Propeller	85

SCHEDULE-IV

[See clause(f) of sub-regulation (12) of regulation 40]

Minimum Protections to be provided for Hydro- electric Generating Units

1. Generator

Sl. No.	Protection functions	Size of generating unit		
		Small (<10 MVA)	Medium (10-100 MVA)	arge (> 100 MVA)
(a)	Differential (87G)	Y	Y	Y
(b)	95 % stator earth fault (64G1)	Y	Y	Y
(c)	100 % stator earth fault (64G2)	N	Y	Y
(d)	Backup impedance (21G)	N	Y	Y
(e)	Voltage controlled over current (51)	Y	N	N
(f)	Negative phase sequence (46G)	Y	Y	Y
(g)	Loss of excitation (40G)	Y	Y	Y
(h)	Reverse power (37/32G)	Y	Y	Y
(i)	Pole slipping (98G)	N	N	Y
(j)	Stator overload (49S)	Y	Y	Y
(k)	Over voltage (59G)	Y	Y	Y
(l)	Under frequency (81G)	Y	Y	Y
(m)	Dead machine (27/50G)	N	N	Y
(n)	Rotor earth fault (64R)	Y	Y	Y
Note: Y- Required; N- Not required.				

2. Excitation Transformer

Sl. No.	Protection functions	Size of generating unit		
		Small (< 10 MVA)	Medium (10-100 MVA)	Large (> 100 MVA)
(a)	Restricted earth fault (64)	Y	Y	Y
(b)	Instantaneous and IDMT over current (50/ 51)	Y	Y	Y
(c)	Winding temperature (49)	Y	Y	Y
Note: Y- Required.				

3. Generator Transformer

(a) Generator transformer differential protection (87T)
(b) Restricted earth fault protection (64GT)
(c) IDMT over current protection (51)
(d) Neutral grounding back-up earth fault protection (51NGT)
(e) Over head line connection differential protection (87L)
(f) Overfluxing protection (99GT)
(g) Monitoring of Insulation of low voltage bushing (59T)
(h) Buchholtz relay (63)
(i) Winding temperature protection (49T)
(j) Oil temperature protection (49)
(k) Pressure relief valve (PRV)

4. Generator and Generator Transformer

(a) Overall differential protection (87OA)
(b) Breaker Failure Protection (50Z)

5. Unit Auxiliary Transformer

(a) Restricted earth fault protection (64)
(b) Instantaneous and IDMT over current protection on high voltage winding (50/51)
(c) Neutral grounding back-up E/F protection (51NGT)
(d) Winding temperature protection (49T)

6. Station Auxiliary Transformer

(a) Restricted earth fault protection (64)
(b) Instantaneous and IDMT over current protection on high voltage winding (50/51)
(c) Neutral grounding back-up earth fault protection (51NGT)
(d) Winding temperature protection (49T)

SCHEDULE-V

[See sub-regulation (3) of regulation 48]

Protection Details of Transmission Lines, Transformers, Reactors and Bus Bars

1. Transmission Line Protection

No.	Protection	765 kV	400 kV	220 kV/230 kV	132 kV/110 kV/ 66 kV
(a)	Main l- Distance protection*	Y	Y	Y	Y (for 132 kV/110 kV) Y/N (for 66 kV)
(b)	Main Il- Distance protection* or directional comparison protection or phase segregated line	Y	Y	Y/N 'N' if Directional IDMT over	N

	differential protection			current and earth fault back up protection is provided otherwise 'Y'	
(c)	Directional inverse definite minimum time (IDMT) type earth fault relay	Y	Y	'Y' if both Main-I & Main-Il are distance protections otherwise 'N'	N
(d)	Directional IDMT over current and earth fault back up protection	N	N	'Y' if Main-II is not provided otherwise 'N'	Y
(e)	Two stage over voltage protection	Y	Y	Y/N	Y/N
(f)	Auto reclosing#	Y (Single phase and three phase)	Y (Single phase and three phase)	Y (Single phase and three phase)	Y/N (three phase)

***For short line (less than 10 km) or cable or combination of overhead line and cable, line differential protection shall be used with built-in backup distance protection.**

 # For cable or combination of overhead line and cable, autoreclosing shall not be provided.

Note: (1) Y- Required; N- Not required; Y/N- Optional.

(2) Transmission lines with distance protection shall, in general, have carrier aided or fibre optic based inter-tripping or blocking feature.

(3) Separate cores of current transformer and voltage transformer shall be used for Main-I and Main-ll.

2. Transformer Protection

Sl. No.	**Protection**	**765 kV**	**400 kV**	**230 kV/220kV/ 132 kV/110 kV**	**66 kV**
(a)	Differential protection	Y	Y	Y	Y
(b)	Over fluxing protection	Y	Y	Y	N
(c)	Restricted earth fault (REF) protection	Y	Y	Y	Y
(d)	Backup directional over current and earth fault protection (HV and LV side) or impedance protection	Y	Y	Y	Y
(e)	Buchholz, WTI and OTI (for 1 MVA and above), MOG with low oil level alarm, OSR for OLTC, PRD, SA on both primary and secondary sides of transformers located outdoors and connected to over head lines	Y	Y	Y	Y
(f)	Tertiary winding protection	Y	Y	Y	N

Note: (1) Y- Required; N- Not required.

(2) WTI- winding temperature indicator; OTI- oil temperature indicator; OLTC- on load tap changer; PRD- pressure relieve device; OSR- oil surge relay; MOG- magnetic oil gauge; SA- surge arrester.

3. Reactor Protection

Sl. No.	Protection	765 kV	220kV /400 kV
(a)	Differential protection	Y	Y
(b)	REF protection	Y	Y
(c)	Reactor backup protection (impedance type or definite time over current (O/C) and earth fault (E/F) protection)	Y	Y
(d)	Buchholz, WTI, OTI, MOG with low oil level alarm, SA (if required)	Y	Y

Note: (1) Y- Required.

(2) WTI- winding temperature indicator; OTI- oil temperature indicator; MOG- magnetic oil gauge; SA- surge arrester.

4. Bus Bar Protection and Local Breaker Backup Protection (breaker failure protection)

Bus bar protection and local breaker backup protection shall be provided in 220 kV and higher voltage interconnecting sub- stations as well as in all generating station switchyards. Duplication of bus bar protection shall be done for all main buses of 400kV and above voltage class. The bus bar protection scheme shall be centralized or distributed type and have provision for planned future expansion.

SCHEDULE-VI

(See regulation 49)

PART-A

Technical Details of Classical HVDC Terminals/ Stations

1. **General:** The conventional Thyristor (Gate Turn On device) based HVDC converter technology or Line Commuted Converter technology or Current Source Converter technology shall be used for back to back and long distance bulk power HVDC transmission system. Gate Turn Off devices / other better devices capable of handling similar or higher quantum of power may also be considered.
2. **Design Consideration:** (a) The converter configuration and rating for HVDC installation shall be based on following considerations:
   (i) The amount of power to be transmitted
   (ii) The transmission distance
   (iii) Staging consideration of the project
   (iv) Location of converter station
   (v) The amount of power to be transmitted at the different stages of the project
   (vi) Reliability and availability requirements
   (vii) Loss evaluation
   (viii) Size and weight of the Converter transformers for transport
   (ix) Electrical characteristics of sending and receiving end power system to which HVDC transmission system is connected

Note: The DC power rating shall include nominal, reverse, forward and overload power levels, specific loading cycle and weightage factor to calculate load losses.

(b) Electric design of HVDC transmission lines shall take into account the following considerations:

(i) Corona performance (Corona loss, Radio Interference, Audible Noise, Electric field and ion current in the vicinity of the line)

(ii) Air Characteristic

(iii) Insulator performance

(c) The minimum conductor height above Ground level shall be selected mainly on the basis of ensuring human safety, Ground level electric field and ion current density level. The corona loss with I^2R losses

harmonic injection and self-excitation. Sub Synchronous Damping (SSD) Controller shall be provided for converter Stations near Generating stations.

(A) Load frequency controller (LFC)

(B) Current margin controller

(C) Excessive reactive power consumption controller

(D) AC system stability function, such as power swing damping function.

(E) Run back / Run up controller with provision to be linked to SPS of System Operator

(iv) The pole control, converter control, and valve control modules shall also be provided.

(v) The control shall be designed to give fast stable and proper response to normal control actions as well as during disturbances such as AC & DC faults.

(b) Protection System

(i) HVDC system protection shall consist of two parts:

(A) AC side protection:

AC side protection function shall cover the zone for converter transformer, AC filters, shunt capacitors, shunt reactors, and busbars. These protections shall generally follow the same philosophy as in a typical substation i.e. detection of fault by relay and tripping of circuit breaker.

(B) DC side protection:

DC side protection shall cover the zones consisting of the valve hall, DC switchyard including smoothing reactor and DC filters, DC line, DMR line / electrode line and ground electrode. The protection equipment shall be designed to be fail safe and shall ensure high security to avoid mal-operation/ unwanted shutdown due to protection equipment failures.

(ii) Following a DC Line fault, the HVDC System shall have the facility to restart, one or more times, the faulted pole at a variable pre-selected DC voltage level(s), not below 80% of the nominal voltage rating. The dc transmission system shall be capable of recovery in a controlled and stable manner without commutation failures during recovery following ac and dc system faults. The post fault power order shall be equal to the pre-fault power order unless AC/ DC systems dictate otherwise

(iii) Protection system shall have two redundant systems with following protections.

(A) Converter differential protection;

(B) DC over current protection;

(C) DC differential protection;

(D) AC conductor ground fault protection;

(E) Commutation failure protection;

(F) DC filter protection#;

(G) DC smoothing reactor protection;

(H) DC line ground fault protection with restarts#;

(I) DC line differential protection#;

(J) DC under voltage/ over voltage protection;

(K) Ground Return mode / Dedicated Metallic Return (DMR) protection#

(L) AC filter protections

(M) Electrode line monitoring and protection#

(N) Thyristor Failure Monitoring

not applicable for back to back schemes

(iv) DC online fault locators shall be provided to monitor the entire DC line length and give location of the fault with good accuracy in the range of $\pm$ 1000 meters

(c) Software based controls and protection shall be used to permit flexibility in effecting modifications. Protection and controls shall be duplicated for reliability. The control & protection shall provide fast controllability of the HVDC system. Operation of the HVDC bipole system shall be possible in the following modes:

(i) Balanced/ unbalanced bipolar operation;

(ii) Monopolar operation with pole metallic return:

(iii) Monopolar operation with ground return / with Dedicated Metallic Return (DMR) mode;

(iv) Reduced voltage operation;

(v) Power reversal mode.

(d) The 'Sequence of events' recorder, transient fault recorder, on-line DC Line fault locator, GPS system, visual display system, operator control protection and monitoring system shall be a part of the HVDC system.

14. Telecommunication- For smooth operation of the HVDC system, communication network with high reliability and availability shall be provided for transmission of control and protection signals between the two or more (in case of multi-terminal DC) HVDC terminals. There shall be main and back up communication link. The main communication link shall be through OPGW and back up communication link shall be either through OPGW or PLCC.

15. Valve Hall: The valve hall shall mainly contain thyristor valves, its associated structure, & cooling and arresters. No oil filled equipment shall be present inside the valve hall. In case the turret of converter transformers (having oil) is protruding inside the valve hall, suitable fire barrier matching with adjacent valve hall wall fire rating shall be provided. The valve halls shall be provided with interference screening. In addition, the control cable and cable termination rooms shall be suitably screened to minimize radio interference. Two nos. scissor lift for erection and maintenance of valve modules shall be provided per station. Proper cable sealing shall be provided for cable entry into valve hall and control room to avoid entry of water and moisture. Necessary measures shall be taken to take care of high frequency noise emission from valves.

16. Valve Hall Ventilation: Suitable ventilation systems and filters with adequate redundancy shall be provided in the valve hall. The valve hall shall be kept at a positive pressure under all conditions.

17. Grounding & Safety

(a) The design of the grounding system shall be based on relevant IS/ IEEE.

(b) In order to prevent adverse effect (overheating due to induced circulating current) of magnetic field of air core reactors, special care shall be taken such that no closed loops are formed by the earthing conductors and in reinforcement bars of the foundation. Air core reactor manufacturer's guidelines shall be followed.

(c) The electrical safety clearances for the dc side shall not be less than the clearances applicable for an ac switchyard at the equivalent BIL level.

(d) The total electric field excluding space charge at ground level shall be as prescribed in relevant standards.

(e) Fencing and electrical & mechanical key interlocking arrangements shall be provided for valve halls, smoothing reactor area, AC and DC filter areas, DC LFL Capacitor Area and for equipment mounted directly on ground without suitable height of steel structure.

18. Dedicated Metallic Return (DMR) / Earth Electrode

The current return path of a bipolar configuration shall be either via a Dedicated Metallic Return (DMR) conductor or via earth return using earth electrodes at both converter terminals. DMR mode shall be preferred if it is difficult to identify a suitable site for earth electrode station.

If earth electrodes are to be used the following requirements shall also be considered:

(a) The earth electrode station shall be connected to the terminal by means of an overhead transmission line. The earth electrode shall be located at a minimum distance of approximately 25 km (radial distance) away from the converter station. It shall be designed to operate continuously at nominal load and overload as per the requirement. The electrodes shall be designed for both types of operation, anodic and cathodic.

(b) The thorough soil investigation shall be carried out for shallow and deep resistivity, thermal conductivity and moisture content etc. at the proposed location.

(c) The earth electrode station shall have sub-electrodes. The maximum current density at the sub-electrode surface, i.e. the boundary between backfill (coke) and soil shall not exceed 0.5 A/m2 in clay soils. The number of sub-electrodes shall be determined considering that 30% of the sub-electrodes are not available. The amp hour rating for earth electrode shall be selected based on the study for duration of earth electrode current and the service life of the earth electrode station.

(d) The earth electrode station shall not affect the nearby electrical installation, buried metallic pipelines, oil & gas pipelines, and railway lines etc.

(ii): The above values of creepage distance are applicable for an altitude upto 1000m above sea level. For altitude above 1000m above sea level, necessary altitude correction factor as per relevant IS/IEC shall be considered.

(c) **DC wall bushing -**DC wall bushings, used for electrical connection between the equipment inside the valve hall and the outdoor DC yard shall be of polymer housing as per relevant standards.

(d) **DC Reactors -** The DC reactors (if used) shall be of air core type. The reactors shall generally comply with relevant standards and shall also have beensubjected to DCtests as pertheir application.

(e) **DC Voltage and Current Measuring Devices-** The DC voltage measuring equipment shall be installed at each pole. The DC measuring equipment at pole and neutral bus shall be suitably located based on the control philosophy and different protection zones such that complete pole and neutral equipment are protected.

(f) **DC Filters-** If required DC harmonic filters shall be provided in DC yard to limit harmonic voltages present on the DC lines (pole lines and electrode lines).

8. Control and Protection

(a) Control

(i) DC converter terminals shall be either manned by operator or controlled by remote Operation of SCADA system. The control system hierarchy shall be as follows:

(A) Station/ Bipole* Control (*only for bipolar arrangements, functionality offered as part of station control also acceptable);

(B) Converter /Pole Control;

(C) MMC control;

(ii) The HVDC converter shall have control features including but not limited to the following:

(D) Active power control

(E) Reactive power control;

(F) AC Voltage control

(G) DC Voltage control

(H) Frequency controller (if applicable);

(I) Power modulation control (if applicable);

(J) Runback and run-up functions (if applicable);

(K) Power Oscillation Damping (POD)

(L) Sub synchronous torsional interaction dampingcontrol (if applicable);

(b) Protection

(i) The protection equipment shall be designed to be fail-safe and shall ensure high security to avoid mal-operation/ unwanted shutdown due to protection equipment failures.

(ii) HVDC system protection shall consist of following protection zones:

(A) AC System Protection zone

(B) Converter or Interface Transformer Protection Zone

(C) Secondary Busbar Protection Zone

(D) Converter Protection Zone

(E) DC Busbar Protection Zone

(F) DC line & cable Protection Zone

(iii) Protection system shall have two redundant systems including the following protections.

(A) AC over- and under-voltage protection

(B)Over- and under-frequency protection

(C)AC busbar differential protection;

(D) Insertion resistor overload protection

(E)AC overcurrent protection

(F) Converter overcurrent protection

(G) Converter overload protection

(H) Converter module differential protection

(I) Converter current differential protection

(J) DC voltage imbalance protection

(K) DC busbar differential protection

(L) DC link differential protection

(M) DC over- and under-voltage protection

(N) Electrode line monitoring and protection (if applicable)

(O) DC filter protection (if applicable)

(P) AC filter protection (if applicable)

(Q) AC connection Harmonic protection

(R)Phase current unbalance

(S) Protection.Block Failure or Repetitive Blocking failure protection

(T)Converter arm harmonic protection

(U) DC Line + cable Overcurrent Protection

(V) DC Line + cable harmonic protection

(c) Software based controls and protection shall be used to permit flexibility in effecting modifications. Protection and controls shall be duplicated for reliability. Protection shall be provided by numerical relays to suit the requirement of the HVDC system.

(d) For bipolar schemes the following operation modes shall be possible:

(i) Balanced/ unbalanced bipolar operation;

(ii) Monopolaroperation with metallic return;

(iii) Monopolar operation with ground return / DMR

(e) The 'Sequence of events' recorder, transient fault recorder, on-line DC Line fault locator, GPS system, visual display system, operator control protection and monitoring system shall be a part of the HVDC system.

9. Telecommunication- For smooth operation of the HVDC system, communication network with high reliability and availability shall be provided for transmission of control and protection signals between the two or more (in case of multi-terminal DC) HVDC terminals. There shall be main and back up communication link. The main communication link shall be through OPGW and back up communication link shall be either through OPGW or PLCC.

10. Grounding & Safety

(a) The design of the grounding system shall be based on relevant IS/ IEEE.

(b) In order to prevent adverse effect (overheating due to induced circulating current) of magnetic field of air core reactors, special care shall be taken such that no closed loops are formed by the earthing conductors and in reinforcement bars of the foundation. Air core reactor manufacturer's guidelines shall be followed.

(c) The electrical safety clearances for the dc side shall not be less than the clearances applicable for an ac switchyard at the equivalent BIL level.

(d) The total electric field excluding space charge at ground level shall be as prescribed in relevant standards.

(e) Fencing and electrical & mechanical key interlocking arrangements shall be provided for valve halls, smoothing reactor area, AC and DC filter areas, DC LFL Capacitor Area and for equipment mounted directly on ground without suitable height of steel structure.

11. Dedicated Metallic Return (DMR) or Earth Electrode –The current return path of a bipolar configuration shall be either via a Dedicated Metallic Return (DMR) conductor or via earth return using earth electrodes at both converter terminals. DMR mode shall be preferred if it is difficult to identify a suitable site for earth electrode station. If earth electrodes are to be used the following requirements shall also be considered:

(a) The earth electrode station shall be connected to the terminal by means of an overhead transmission tine or underground cable. The earth electrode shall be located at a minimum distance of approximately 25 km (radial distance) away from the converter station. It shall be designed to operate continuously at full load as per the requirement. The electrodes shall be designed for both types of operation, anodic and